

## Parenchyma-sparing pancreatectomies for benign or border-line tumors of the pancreas

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### Abstract

Standard pancreatic resections, such as pancreaticoduodenectomy, distal pancreatectomy, or total pancreatectomy, result in an important loss of normal pancreatic parenchyma and may cause impairment of exocrine and endocrine function. Whilst these procedures are mandatory for malignant tumors, they seem to be too extensive for benign or border-line tumors, especially in patients with a long life expectancy. In recent years, there has been a growing interest in parenchyma-sparing pancreatic surgery with the aim of achieving better functional results without compromising oncological radicality in patients with benign, border-line or low-grade malignant tumors. Several limited resections have been introduced for isolated or multiple pancreatic lesions, depending on the location of the tumor: central pancreatectomy, duodenum-preserving pancreatic head resection with or without segmental duodenectomy, inferior head resection, dorsal pancreatectomy, excavation of the pancreatic head, middle-preserving pancreatectomy, and other multiple segmental resections. All these procedures are technically feasible in experienced hands,

with very low mortality, although with high morbidity rate when compared to standard procedures. Pancreatic endocrine and exocrine function is better preserved with good quality of life in most of the patients, and tumor recurrence is uncommon. Careful patient selection and expertise in pancreatic surgery are crucial to achieve the best results.

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**Key words:** Middle pancreatectomy; Pancreatic head resection; Pancreas; Pancreatectomy; Limited pancreatectomy

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### INTRODUCTION

Conventional surgical procedures to remove neoplastic lesions of the pancreas are basically represented by pancreaticoduodenectomy (PD), distal pancreatectomy (DP) with or without splenectomy, or total pancreatectomy (TP), depending on the tumor's location. Although these operations are now performed with low mortality and morbidity rates<sup>[1]</sup>, they result in an important loss of normal pancreatic parenchyma and surrounding structures. Although such procedures are mandatory for malignant diseases, they seem excessive for benign or border-line conditions,

especially in young, otherwise healthy, subjects. Enucleation represents the best option to remove a neoplasm and to preserve pancreatic function<sup>[2]</sup>, but it is not advisable when the risk of main pancreatic duct injury occurs or when the tumor is not clearly benign and the margins could be involved. In the last decade, there has been an increasing interest in organ-sparing pancreatic surgery for benign, border-line or low-malignant tumors involving isolated or multiple segments of the pancreas, with the aim of preserving exocrine and endocrine pancreatic function, and achieving a better quality of life after surgery.

## SURGICAL TECHNIQUES

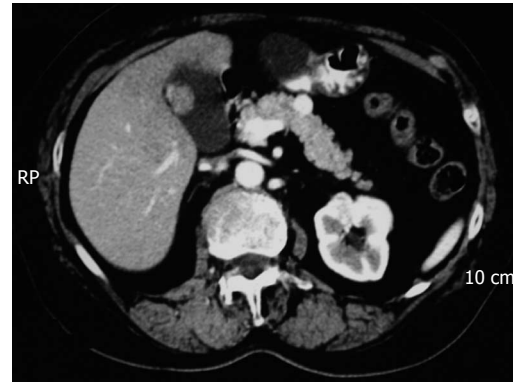
Excluding enucleation, the more conservative surgical options for managing benign or borderline lesions of the pancreas include: central pancreatectomy (CP)<sup>[3,4]</sup>, duodenum-preserving pancreatic head resection (DP-PHR)<sup>[5,6]</sup> and pancreatic head resection with segmental duodenectomy (PHRSD)<sup>[7]</sup>, inferior head resection<sup>[8]</sup>, dorsal pancreatectomy<sup>[9]</sup>, pancreatic head excavation<sup>[10]</sup>, middle-preserving pancreatectomy (MPP)<sup>[11,12]</sup>, and other multiple segmental resection of the pancreas<sup>[13]</sup>.

## INDICATIONS

The main indications for parenchyma-sparing pancreatectomies are: (1) benign or low-grade malignant tumors (endocrine tumors, serous and mucinous cystadenomas, non invasive branch-type intraductal papillary mucinous tumors, small solid-pseudopapillary tumors; (2) non-neoplastic cysts (simple, lymphoepithelial, hydatid cyst) not suitable for enucleation; and (3) isolated metastases to the pancreas (especially from renal cancer) and pancreatic endocrine tumors with metastases undergoing multimodality treatment.

## CP

Neoplasms of the midportion of the pancreas (Figure 1) not suitable for enucleation can be treated with CP<sup>[14]</sup>, also known as medial pancreatectomy<sup>[15]</sup>, middle segment pancreatectomy<sup>[16]</sup>, and median pancreatectomy<sup>[17]</sup>. CP is the most attractive and frequent segmental resection performed worldwide. This is due to standardization of the technique and to the increasing number of benign pancreatic lesions recognized in young, often asymptomatic, patients. The operation was firstly described in 1957 by Guillemain *et al*<sup>[18]</sup> to treat a patient with chronic pancreatitis. Dagradi *et al*<sup>[19]</sup> two Italian surgeons, performed the first CP in 1982 to resect an insulinoma of the pancreatic isthmus, and described the technique in 1984. In a literature review performed nine years ago<sup>[17]</sup>, we collected data on a total of 85 patients who underwent CP for pancreatic tumors. In December 2009, a review of the English literature<sup>[20-44]</sup> from 2001 to 2009 (including 25 reports with at least 5 patients each and sufficient



**Figure 1** Contrast-enhanced tomography of the abdomen showing a neoplasm in the midportion of the pancreas (neuroendocrine tumor).

clinical details), shows a total of 529 CP, confirming the increasing interest of pancreatic surgeons in such procedures.

The surgical technique of CP is well defined<sup>[14,17]</sup>: after midline laparotomy, the lesser sac is entered and the anterior face of the pancreas is exposed (Figure 2A); operative ultrasonography is carried out to localize the tumor, to exclude other additional lesions, and to verify the relationship with vascular structures and the main pancreatic duct. The superior mesenteric and the portal veins are cleared from the posterior aspect of the pancreas, and the splenic vessels are preserved. The pancreas is transected with a resection margin at least 1 cm from the lesion on both sides (Figure 2B). Frozen section examination of surgical margins is routinely performed. The proximal stump of the pancreas is sutured with interrupted stitches or with a stapler (Figure 2C), with particular attention to the closure of the main pancreatic duct. The distal stump is generally anastomosed end-to-end or end-to-side with a Roux-en-Y jejunal loop (Figure 2D) although a double pancreaticojejunostomy of the two stumps on the same jejunal loop is also described<sup>[28]</sup>. As alternative reconstruction, a pancreaticogastrostomy can be performed<sup>[24,33,34,37,42,44]</sup>, according to the surgeon's preference whilst CP without pancreatic anastomosis is also reported<sup>[22,43]</sup>.

Besides the above mentioned indications, CP is also performed for: (1) tumors sized between 2 and 5 cm, when enucleation is not advisable; and (2) focal chronic pancreatitis with Wirsung's duct stenosis.

The main problem of CP is the high rate of complications associated with the procedure, particularly pancreatic fistulas. This encourages some authors<sup>[27,45]</sup> to perform limited pancreatectomy instead of a standard resection. Indeed, both the pancreaticojejunal anastomosis and the closed resection margin of the head of the pancreas are at risk of leakage, since most of the patients have a normal pancreas and small main pancreatic duct.

Among 529 patients collected from the literature from 2001 to 2009 (Table 1), there was a morbidity rate of 48% (254 patients) (range 0%-92%) and pancreatic fistula was the most common complication (31.6%, 167 patients) with

Table 1 Complications and outcome after central pancreatectomy in published series from 2001 to 2009

Author	Year	Period	n	Mortality		Morbidity		Pancreatic fistula		Reoperation		Diabetes		Exocrine insufficiency	
				%	n	%	n	%	n	%	n	%	n	%	n
Celis <i>et al</i> <sup>[20]</sup>	2001	1997-2000	5	0		0		0		0		0		0	
Sauvanet <i>et al</i> <sup>[21]</sup>	2002	1990-1998	53	2	1	59	31	30	16	6	3	2	1	8	4
Balzano <i>et al</i> <sup>[22]</sup>	2003	1990-2000	32	0		62	20	50	16	3	1	10	3	6	2
Goldstein <i>et al</i> <sup>[23]</sup>	2004	1999-2002	12	0		25	3	0		0		0		0	
Efron <i>et al</i> <sup>[24]</sup>	2004	1999-2002	14	0		50	7	36	5	14	2	0		0	
Su <i>et al</i> <sup>[25]</sup>	2004	1989-2002	10	0		40	4	40	4	0		0		0	
Iacono <i>et al</i> <sup>[26]</sup>	2005	1982-2003	20	0		35	7	25	5	0		0		0	
Roggin <i>et al</i> <sup>[27]</sup>	2006	1993-2005	10	0		60	6	30	3	10	1	10	1	0	
Christein <i>et al</i> <sup>[28]</sup>	2006	1998-2004	8	0		87.5	7	63	5	25	2	0	1	0	
Müller <i>et al</i> <sup>[29]</sup>	2006	2001-2005	40	2.5	1	27.5	11	7.5	3	5	2	3		46	18
Johnson <i>et al</i> <sup>[30]</sup>	2006	2000-2005	8	0		37.5	3	0		0		0		0	
Brown <i>et al</i> <sup>[31]</sup>	2006	1999-2004	10	0		60	6	40	4	0		0		0	
Crippa <i>et al</i> <sup>[32]</sup>	2007	1990-2005	100	0		58	58	44	44	0		4	4	5	5
Allendorf <i>et al</i> <sup>[33]</sup>	2007	1999-2005	26	0		31	9	7.7	2	0		7.7	2	0	
Sa Cunha <i>et al</i> <sup>[34]</sup>	2007	2003-2007	6	0		33	2	33	2	0		0		0	
Ocuin <i>et al</i> <sup>[35]</sup>	2008	2000-2007	13	7.7	1	92	12	62	8	NR		11	1	10	1
Shimada <i>et al</i> <sup>[36]</sup>	2008	2000-2007	14	0		43	6	35.7	5	0		0		0	
Adham <i>et al</i> <sup>[37]</sup>	2008	1987-2005	50	0		38	19	8	4	12	6	0		22	11
Rotellar <i>et al</i> <sup>[38]</sup>	2008	2005-2007	9	0		44	4	22	2	22	2	NR		NR	
Lavu <i>et al</i> <sup>[39]</sup>	2008	1998-2007	10	0		50	5	40	4	0		NR		NR	
Zhou <i>et al</i> <sup>[40]</sup>	2009	1990-2007	8	0		37.5	3	37.5	3	0		0		0	
Hirono <i>et al</i> <sup>[41]</sup>	2009	1999-2008	24	4	1	29	7	63	15	0		5	1	0	
Sudo <i>et al</i> <sup>[42]</sup>	2009	1996-2008	19	0		53	10	47	9	0		0		5.26	1
Wayne <i>et al</i> <sup>[43]</sup>	2009	2005-2009	10	0		40	4	0		0		0		0	
Shikano <i>et al</i> <sup>[44]</sup>	2009	1991-2006	26	0		38	10	31	8	11	3	0		3.8	1
Total			529	0.76	4	48	254	31.6	167	4.2	22	2.6	14	8.1	43

NR: Not reported.

a range from 0% to 63%. It is remarkable that most fistulas closed spontaneously or with conservative treatment. Reoperation was performed in only 22 patients (4.2%), perioperative mortality was 0.7% (4 patients), and median hospital stay was 11 d (range 5-30 d). On the other hand, the pancreatic fistula rate of the DP that is performed as the alternative to CP is 32.1%<sup>[46]</sup>. In any case, the risk of developing a pancreatic fistula should be taken into account when CP is considered. Extensive experience not only in pancreatic surgery, but also in the management of complications is crucial to improving early results of this type of surgery.

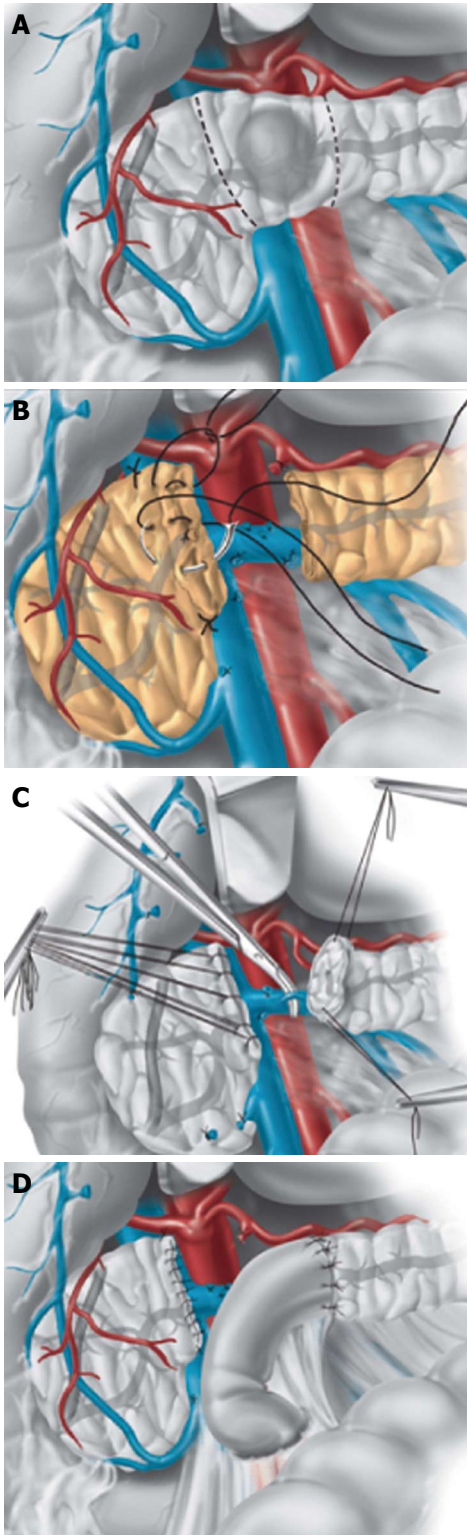
Recently, laparoscopic CP has been reported in small series of patients<sup>[34,38]</sup>, with acceptable morbidity rate (33% and 44%, respectively) and pancreatic fistula occurrence of 33% and 22%, respectively. One study<sup>[38]</sup> reported a median hospital stay of 5 d although, these encouraging results obviously need to be validated in larger series of patients.

Our experience at the University of Padua includes 36 patients who underwent CP. The most common indication for CP was cystic neoplasms (50%), followed by endocrine tumors (33%). One patient had pancreatic metastasis from renal cell cancer. Operative morbidity was 52% with no mortality or reoperation. Overall pancreatic fistula rate was 44%, all of which were resolved with conservative treatment or drainage under radiologic guidance. Only one patient (metastasis from renal cancer) experienced

tumor recurrence at the head of the pancreas and near to the pancreaticojejunal anastomosis, 7 years after CP. She underwent pylorus-preserving PD (PPPD) and partial resection of the remaining body-tail.

Crippa *et al*<sup>[32]</sup> performed CP in 100 patients. 7 were resected for malignant tumors, and 5 of them had positive resection margin (all were IPMN on pathologic examination). Two patients developed recurrence in the head of the pancreas 67 and 9 mo after CP respectively. The first of them underwent a Whipple operation and he is still alive after 53 mo. The second patient underwent only surgical palliation and died 10 mo later. Recurrence in the remnant pancreas or distant metastases after CP for IPMNs are also reported by other authors<sup>[29,37]</sup>, emphasizing the importance of a correct preoperative diagnosis and a frozen section examination of surgical margins. It should be remembered that CP is not an adequate operation to resect malignant tumors, as lymph node dissection is not performed, and the risk of understaging or mistreating malignant tumors is quite high. The most important advantage of CP seems to be the excellent endocrine and exocrine pancreatic function after operation: only 14 (2.7%) out of 310 evaluable patients reviewed from the literature (Table 1) had impaired endocrine function, while 43 (8.4%) had impaired exocrine function and required pancreatic enzyme supplementation. Better functional results have been reported previously in patients undergoing CP compared to patients undergoing PD or DP<sup>[22,47,48]</sup>. In our experience, after a median follow-





**Figure 2 Surgical technique of central pancreatectomy<sup>[83]</sup>.** A: Exposure of the anterior aspect of the pancreas and limits of resection; B: Transection of the pancreas including the lesion; C: Suture of the cephalic stump and partial dissection of splenic vessels; D: Anastomosis of the distal pancreatic stump with a jejunal loop.

up time of 8 years, no impairment of exocrine pancreatic function occurred, although 4 patients (11%) became diabetic.

In conclusion, CP is a valid option for young or middle-aged patients with benign or border-line tumors of the pancreas as long-term endocrine and exocrine function is preserved in the majority of the patients. Postoperative morbidity is high even in experienced hands. An accurate preoperative evaluation of the neoplasm and selection of the patients are necessary.

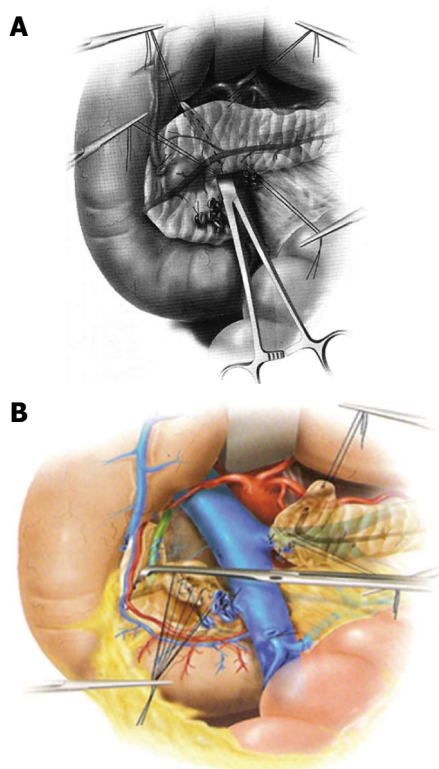
## DPPHR

Surgical options for managing benign or border line lesions of the pancreatic head include tumor enucleation, standard PD or PPPD, and new limited procedures, such as DPPHR. Since Beger *et al*<sup>[49]</sup> introduced DPPHR for patients with chronic pancreatitis and inflammatory mass in the head of the pancreas, a modified technique has been applied to remove benign or low grade malignant tumors of the pancreatic head, such as endocrine or cystic neoplasms and IPMNs<sup>[6,50]</sup>. Increasing numbers of benign or premalignant tumors have been diagnosed in recent years in asymptomatic patients because of the widespread availability of high resolution imaging techniques<sup>[51,52]</sup>. In these situations, DPPHR offers the opportunity to treat the lesion with a more conservative surgery. On the other hand, DPPHR is a complex and more demanding procedure, and it is used in only few centers. The indications for DPPHR include benign, borderline or low malignant tumors that should be resected according to international rules<sup>[53]</sup>.

In the literature, several surgical procedures, differing in the amount of pancreatic head resected, are referred as DPPHR. We identified three types of DPPHR<sup>[5]</sup>, depending on the size and site of the pancreatic head remnant.

### Type-1

After tunneling the pancreas over the mesenteric-portal vein, the pancreas is divided over the portal vein (Figure 3A). The subtotal resection of the pancreatic head is done from the cut edge at the portal vein towards the prepapillary common bile duct. The gastroduodenal artery and the posterior superior pancreaticoduodenal artery are preserved, while the anterior superior pancreaticoduodenal artery is usually transected. Preservation of the posterior arcade of the pancreaticoduodenal vessels which is located in the mesoduodenum is necessary to maintain good blood flow in the duodenum. A rim of pancreatic tissue (5-10 mm) remains between the duodenal wall and the common bile duct, which is skeletonized on the left semi circumference (Figure 3B) until the Wirsung's duct is encountered, ligated and sectioned. A rim of pancreatic tissue is also left on the inner surface of the duodenum distal to Vater's papilla (Figure 4A). While the uncinate process of the pancreas is resected, the inferior pancreaticoduodenal artery should be preserved, and the pancreatic branches of the anterior inferior pancreaticoduodenal artery are ligated and divided one by one toward the papilla of Vater, preserving the branches to the duodenum.



**Figure 3 Duodenum-preserving pancreatic head resection (DPPHR)<sup>[84]</sup>.**  
A: The superior mesenteric and the portal veins are cleared from the posterior aspect of the pancreas, and transection along the broken line is made; B: A rim of pancreatic tissue is left between the duodenal wall and the common bile duct that is skeletonized on the left side.

### Type-2

The procedure is the same as Type-1 DPPHR until the Wirsung's duct is ligated and transected. All the pancreatic tissue on the inside surface of the duodenum distal to Vater's papilla is then removed (Figure 4B), carefully preserving the inferior pancreaticoduodenal vessels. Kocher's maneuver is usually avoided.

### Type-3

After performing a Type-1 DPPHR until the bile duct is identified where it enters the head of the pancreas, the bile duct is entirely skeletonized until Vater's papilla and the total pancreatic head is excised, leaving the bile duct intact (Figure 4C). The connective tissue membrane on the posterior aspect of the pancreatic head is left intact, and the Wirsung's duct is ligated and sectioned at its junction with the bile duct. The inferior pancreaticoduodenal vessels are accurately preserved. Intraoperative frozen section examination of the resected specimen and surgical margins are essential for a better surgical strategy. In all these procedures, the distal stump of the pancreas is anastomosed to a Roux-en-Y jejunal loop. In other cases<sup>[6]</sup>, a jejunal Roux-en-Y loop is placed between the left side of the pancreas and the rim of the head of the pancreas, or the pancreatic stump is anastomosed to the duodenum<sup>[50]</sup>. Duodenum-preserving TP with or without splenectomy has been suggested for multicentric

disease of the pancreas<sup>[54,55]</sup>.

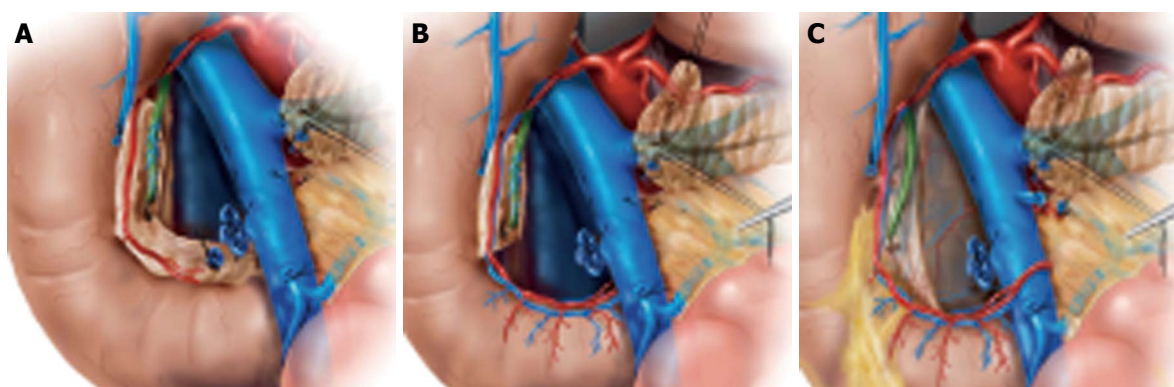
DPPHR is performed mainly in patients with normal pancreas, and the expected complication rate is usually high. In our previous experience<sup>[5]</sup>, among a total of 13 patients, 9 (69%) had complications without operative mortality: a pancreatic fistula was observed in 4 patients (31%), a biliary fistula in 3 (23%), fluid collection in 3 (23%), a pancreatic abscess and gastrointestinal hemorrhage in one, and a sudden spleen rupture in one patient. Two patients required reoperation. There were no impairments of endocrine function at follow-up, and only one patient required supplementation of pancreatic enzymes. The complication rate reported by other authors<sup>[56-61]</sup> in 47 patients was 46% (range 24%-55%), without operative mortality.

The use of DPPHR is burdened with two major problems. The first concern is oncological radicality when the procedure is performed for a potentially- or already-malignant lesion. This is particularly true for main duct IPMNs, which are multifocal in up to 30% of cases, and are often closely related to the duodenal wall. The second problem is the risk of ischemic lesion of the duodenum and Vater's papilla, especially when a Type-3 DPPHR is performed. The preservation of posterior superior and posterior inferior pancreaticoduodenal artery is essential.

A DPPHR with segmental duodenectomy (PHRSD) was recommended by Nakao *et al*<sup>[62]</sup> in 1994 to overcome both the oncological and the ischemic problems. Since then, 93 such operations have been reported in the English literature<sup>[63-66]</sup>, with a complication rate of 34.4% and no mortality. The operating time for DPPHR and PHRSD is the same, because the time for vessel preservation in DPPHR is balanced by the time for multiple anastomoses in PHRSD (pancreaticojejunostomy or pancreaticogastrostomy, choledochoduodenostomy, and duodenoduodenostomy). PHRSD is a reasonable alternative to DPPHR when ischemia or positive margin, as shown by frozen section examination, mitigates against pursuing a DPPHR.

In our experience, none of the patients experienced tumor recurrence. Recurrent IPMN after subtotal DPPHR has been sporadically reported<sup>[64]</sup>, as has the recurrence of metastases from renal cancer<sup>[67]</sup>. Careful patient selection and intraoperative assessment of frozen sections from surgical margins are needed to prevent tumor relapse.

Long-term results of DPPHR are satisfactory, and both exocrine and endocrine pancreatic function are better than with standard PPPD<sup>[59,68]</sup>. Early postoperative pancreatic exocrine function impairment was seen after PD but not after DPPHR, suggesting that DPPHR is less invasive than standard resection<sup>[69]</sup>. When pre- and postoperative pancreatic exocrine function and postprandial cholecystokinin secretion were measured in patients who had undergone pancreatic head resection, preservation of the whole duodenum proved to be a statistically significant factor in maintaining pancreatic function<sup>[70]</sup>. In addition, gastric motility is delayed and motilin levels are significantly reduced after resection of the pancreatic head without preserving the duodenum<sup>[50]</sup>.



**Figure 4** Residual head of the pancreas after (A) type-1, (B) type-2, and (C) type-3 DPPHR<sup>[84]</sup>. The residual rim of pancreatic tissue is located both superiorly and inferiorly to the major duodenal papilla of Vater in (A) type-1, only superiorly in (B) type-2, and totally removed in (C) type-3.

The DPPHR preserves the entire duodenum and the extra hepatic bile duct, structures which play an important role for hormonal control of exocrine and endocrine function.

In conclusion, DPPHR for benign or border-line tumors is a complex procedure that carries a high complication rate. It may be the treatment of choice for pancreatic head lesions in young patients, but it should be performed at centers with extensive experience of pancreatic surgery.

## INFERIOR HEAD RESECTION

Tumors arising in the ventral pancreas (uncinate process) may be removed by segmental resection, because a fusion plane between dorsal and ventral pancreas is preserved. Briefly, the uncinate process and pancreatic tissue around the Wirsung's duct are removed, with careful preservation of arterial arcades, partial exposure of the common bile duct, and ligation of the pancreatic duct to the uncinate process. The most important step in this procedure is the preservation of blood supply to the duodenum bile duct and residual pancreas. In order to preserve blood flow the mesoduodenum is preserved and the Kocher maneuver is not performed. Care must be taken to preserve the anterior inferior and posterior inferior pancreaticoduodenal artery along the duodenum. After resection of the inferior head of the pancreas, the Wirsung's duct is anastomosed to the duodenum<sup>[71]</sup>. The main indication of this type of operation is for IPMNs.

In a recent report by Nakagohri *et al*<sup>[72]</sup>, 15 patients underwent inferior head resection for IPMNs branch-duct type, with a morbidity rate of 67% and no mortality. Pancreatic fistula occurred in 7 patients (47%) and two patients underwent reoperation. Surgical margin was positive for carcinoma in one patient, and subsequent PD was performed. Four other patients showed histological findings of adenocarcinoma (two invasive), and one of them died from recurrent disease. Careful patient selection, and intraoperative frozen section analysis of surgical margins, may avoid the performance of oncologically inadequate surgical procedures. No impairment of exocrine

and endocrine pancreatic function occurred after operation. Excluding this large study, inferior pancreatic head resection has been only sporadically reported in the literature<sup>[73-76]</sup>. Successful laparoscopic resection of the uncinate process of the pancreas for solid-pseudopapillary tumor has been recently reported<sup>[76]</sup>.

## DORSAL PANCREATECTOMY

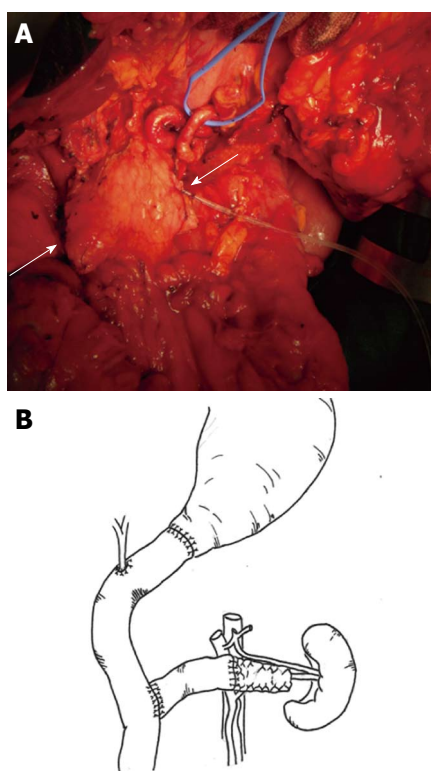
In 2002 Thayer *et al*<sup>[9]</sup> performed a complete dorsal pancreatectomy for IPMN in a patient with pancreas divisum. This anatomical variant, with a persistent fusion plane between dorsal and ventral pancreas, allowed surgical segmental resection of the pancreas. Ischemic injury of the first duodenum required combined resection of the gastric antrum and proximal duodenum. The patient experienced normal pancreatic exocrine function, and diabetes was easily controlled with diet and small amounts of insulin. Two other cases of dorsal pancreatectomy (both in pancreas divisum) have been reported<sup>[77,78]</sup> with complete preservation of the duodenum. Both patients had diabetes well controlled by diet and insulin but not exocrine insufficiency.

During resection of the dorsal pancreas, the pancreatic branches of the posterior inferior pancreaticoduodenal artery are ligated and divided, preserving the pancreatic posterior membrane, because this artery runs under the posterior membrane.

## PANCREATIC HEAD EXCAVATION

Andersen *et al*<sup>[10]</sup> described, in 2004, a modification of DPPHR in which the proximal pancreatic duct and the central core of the pancreatic head is excised by ultrasonic dissection and the cavity is then drained into the jejunum by a side-to-side Roux-en-Y pancreaticojejunostomy. The advantage of this operation is a radical resection of the lesion with surrounding pancreatic tissue, and a complete preservation of duodenum and biliary tract. A total of 15 patients (10 cystic neoplasms, 3 pseudocysts, and 2 endocrine tumors) who underwent this operation, were recently reported by the same author<sup>[79]</sup>. Five patients (33%)





**Figure 5 Middle-preserving pancreatotomy.** A: Intraoperative picture of remnant pancreas (arrows) after pylorus-preserving pancreaticoduodenectomy and pancreatic tail resection with preservation of splenic vessels and spleen; B: Final result of the operation with double jejunal loop reconstruction.

had postoperative complications without mortality but no patients developed exocrine or endocrine insufficiency. However, one patient with a main duct IPMN and one patient with mucinous cystadenoma were found to harbor multifocal IPMN at subsequent follow-up, and underwent completion pancreatectomy.

## MPP

TP is usually the treatment of choice for multicentric neoplasms of the pancreas. However, severe endocrine and exocrine pancreatic insufficiency is to be expected after total removal of the pancreas. IPMNs are multifocal in up to 64% of patients<sup>[80]</sup>, and endocrine tumors in MEN 1 syndrome are typically multicentric<sup>[81]</sup>. Choosing between TP and more limited resection may be difficult when the diagnosis of benign tumor is suggested, and the balance between radical resection and postoperative quality of life has to be considered. When the lesion involves only the head and the tail of the pancreas, the body may be spared by surgical procedure, the so called “MPP”, in order to decrease the loss of pancreatic parenchyma<sup>[11,12]</sup>. We recently performed such an operation in a man with a preoperative diagnosis of IPMN of the head and the tail of the pancreas. The patient underwent a PPPD and resection of the tail of the pancreas, preserving the spleen (Figure 5A). The remnant pancreas was proximally anastomosed end-to-end with a Roux-en-Y jejunal loop, and the distal margin

was sutured (Figure 5B). Eight months after surgery, the patients’ glucose metabolism is well controlled with diet although he requires enzyme supplementation. In the English literature we identified only 9 other patients who underwent MPP<sup>[11,12,82]</sup>. Three who were treated with two-stage procedure (2 with IPMNs and one with adenocarcinoma) developed an adenocarcinoma after the first operation. Only one of these patients became diabetic and none had malabsorption. The other 6 patients<sup>[11,12]</sup> who were treated in a single stage procedure. Among these, pathologic examination of the head of the pancreas showed IPMNs in 3, endocrine tumor in 2, and retention cyst in one patients. In the tail of the pancreas there were IPMNs in 3 cases, endocrine tumor in two, and chronic pancreatitis in one. Two patients experienced pancreatic fistula but none of the patients died. At a median follow-up of 16 mo (range 6-118 mo) all patients were alive, with no recurrent disease; 3 patients had insulin-dependent diabetes (one had diabetes preoperatively) easily controlled by administration of small amounts of insulin, and four had exocrine pancreatic insufficiency. Although the number of reported MPPs is low and the follow-up is short, the results suggest that this procedure is safe and feasible, with acceptable morbidity, and pancreatic function preserved in half of patients. When present, diabetes appears easier to treat than after TP.

Another technique for multiple segmental pancreatectomies was reported by Takada *et al*<sup>[13]</sup>. They performed resection of the uncinate process of the pancreas combined with CP for multicentric mucinous cystadenoma of the pancreas localized in the uncinate process and in the body of the pancreas. The cut end of the head was sutured and the distal pancreas was anastomosed to a Roux-en-Y jejunal loop. At 2-year follow-up no impairment of exocrine or endocrine pancreatic function was noted.

## CONCLUSION

Parenchyma-sparing pancreatectomies are safe and technically feasible surgical options for treating benign, borderline or low-grade malignant tumors of the pancreas. In experienced hands, these procedures are performed with low mortality, low recurrence rate but a significantly high complication rate. Long-term results are good, and pancreatic function is preserved in most of the patients. Careful selection of the patients, accurate pre- and intraoperative evaluation of the lesion, and expertise in pancreatic surgery are essential to obtain the best outcome. We recommend that these complex operations should be performed in high-volume pancreatic surgery centers.

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