Limited Surgery for Benign Tumours of the Pancreas: A Systematic Review

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Abstract

Background Limited surgical procedures for benign cystic neoplasms and endocrine tumours of the pancreas have the potential advantage of pancreatic tissue sparing compared to standard oncological resections.

Methods Searching PubMed/MedLine, Embase and Cochrane Library identified 86 full papers: 25 reporting on enucleation (EN), 38 on central pancreatectomy (CP) and 23 on duodenum-preserving total/partial pancreatic head resection (DPPHRt/p). The results are based on analysis of data of 838, 912 and 431 patients for EN, CP and DPPHRt/s, respectively.

Results The indication for EN for cystic neoplasms and neuro-endocrine tumours to EN was 20.5 and 73 %; for CP 62.9 and 31 %; and for DPPHRt/p 69.6 and 10.2 %, respectively. The estimated mean tumour sizes were in EN-group 2.4 cm, in CP-group 2.9 cm and in DPPHRt/p-group 3.1 cm (DPPHRt/p vs EN, $p = 0.035$). Postoperative severe complications developed after EN, CP and DPPHRt/p in 9.6, 16.8 and 11.5 % of patients; pancreatic fistula in 36.7, 35.2 and 20.1 %; and reoperation was required in 4.7, 6.5 and 1.8 %, respectively. Hospital mortality after EN was 0.95 %; after CP 0.72 %; and after DPPHRt/p 0.49 %. Compared to EN and CP, DPPHRt/p exhibited significant lower frequency of reoperation ($p = 0.029$, $p < 0.001$) and lower rate of fistula ($p < 0.001$; $p = 0.001$).

Conclusion EN, CP and DPPHRt/p applied for benign tumours are associated with low surgery-related early postoperative morbidity, a very low hospital mortality and the advantages of conservation of pancreatic functions. However, the level of evidence for EN and CP compared to standard oncological resections appears presently low. There is a high level of evidence from prospective controlled trials regarding the significant maintenance of exocrine and endocrine pancreatic functions after DPPHRt/p compared to pancreato-duodenectomy.

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Introduction

The most frequent benign lesions of the pancreas are cystic neoplasms and endocrine tumours. Due to routine use of MD-CT, MRI, PET scan and EUS/US investigations of the abdomen, benign tumours of the pancreas are increasingly detected with and without clinical symptoms [1, 2]. Surgeons requested to treat patients with benign tumours using standard oncological resections are challenged by unnecessarily sacrificing pancreatic and extrapancreatic tissues. Tumour enucleation (EN), central pancreatectomy (CP) and duodenum-preserving total or subtotal pancreatic head resection (DPPHRt/p) are limited surgical procedures offering the potentials of low early postoperative morbidity and conservation of metabolic functions in long-term outcome of patients [3–5]. The aim of this report was to evaluate the level of evidence of these limited surgical procedures for benign pancreatic tumours using methods of systematic review.

Methods

We conducted comprehensive literature search of the PubMed/Medline, Embase and the Cochrane Data Base. For PubMed, a search for medical subject headings (Mesh-Terms) was used; for Embase, a search with Emtree-terms and for Cochrane, a search with Mesh-terms as well as performing a text word search for surgical techniques. A total of 2,715 references were retrieved, of which 460 abstracts were read; in total 249 of these 460 abstracts were excluded because they dealt with clinical symptoms, radiomorphology, pathophysiologic aspects of the tumour and outcomes of observational protocols. The remaining 211 full papers were analysed.

The indexed items for the complete search and search results are presented in Table 1.

Two authors (HGB and BP) evaluated all titles identified as relevant articles. Reports were included only if they were on original series reporting a full set of pre-specified data. Excluded from further consideration were case reports and reports with small case series, CP and DPPHR reports including more than a few patients with surgery for inflammatory tumours. Detailed numbers of publications and reasons for exclusion are given in Table 1.

Definitions of surgical techniques

Enucleation

Local tumour dissection along a tiny wall without resection of surrounding normal pancreatic tissue. Drainage but no

intestinal anastomosis of the pancreatic tissue excavation is recommended.

Central pancreatectomy

CP involves resecting a pancreatic segment of up to 5 cm of the left pancreas (neck, body or tail of the pancreas). Two pancreatic transection surfaces with an open pancreatic main duct are necessary for surgical management by anastomosis using the excluded jejunal loop or stomach, respectively, stump closure is performed by using suture techniques.

Duodenum-preserving pancreatic head resection

Duodenum-preserving total pancreatic head resection (DPPHRt) involves resection of the pancreatic head conserving the pancreatic neck; the peripapillary segment of the duodenum and the intrapancreatic common bile duct segment are resected. Three anastomoses are performed: end-to-end duodenum to duodenum, end-to-side common bile duct (CBD) to postpyloric duodenum and an end-to-side pancreatico-intestinal anastomosis, in addition to Roux-en-Y jejunostomosis. Total pancreatic head resection preserving duodenum and CBD requires resection of the pancreatic tissue, while conserving the CBD and duodenum (DPPHRt). Partial pancreatic head resection (DPPHRp) preserves duodenum and CBD and parts of the ventral or dorsal pancreatic head tissue or resection only of the tumour bearing tissue of the uncinate process. An anastomosis between the pancreatic head and an excluded jejunal loop is necessary.

Data extraction

The presented data are based on selective evaluation of 25 publications dealing with enucleation, 38 with central pancreatectomy and 23 reports about duodenum-preserving DPPHRt/p published between 1/1997 and 1/2014. Data extraction from each study was carried out independently by two authors (HGB and BP) according to the list of the pre-specified criteria regarding tumour entity, surgical techniques and early surgery-related postoperative complications [6, 7]. Data extraction about tumour size and location, postoperative overall and severe morbidity, reoperation, hospital mortality, recurrence, rehospitalisation and surgical techniques are listed separately four times from each report by the authors. Severe early postoperative morbidity was defined by the use of Clavien–Dindo classification as ≥3 score points [8]. Many of the reports include data on rehospitalisation, but the time between

Table 1 Data extraction process from Pub Med/MedLine, Embase and Cochrane Library Search for Benign pancreatic tumors 1980 – 3/2014 for enucleation, central pancreatectomy, Duodenum-preserving total/partial pancreatic head resection

Enucleation[a]	401 titles
Central Pancreatectomy[b]	802 titles
Duodenum-preserving pancreatic head resection[c]	1512 titles

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| Title search results | 2715 |

⇩

| Abstracts read | 460 |
| Full papers read | 211 |

⇩

	Enucleation	Central pancreatectomy	DPPHRt
Total full publications read	53	86	72
Excluded			
Case reports (<2cases)	14	25	9
Small clinical series (<5 EN/DPPHR; <9 CP)	7	8	5
Chronic pancreatitis	-	6	27
Incomplete core data	4	5	4
To avoid double counting	3	4	4
Publications included for final analysis	25	38	23

Search items:

[a] Enucleation pancreatic TM, pancreatic tumor enucleation, extirpation pancreatic tumors, local tumor extirpation

[b] Segmental resection of the pancreas, central pancreatectomy, middle segment resection of the pancreas, middle pancreatectomy, pancreas middle segment resection

[c] Duodenum-preserving pancreatic head resection, organ-preserving pancreatic head resection, segmental resection of the pancreas Inferior pancreatic head resection, duodenum-preserving pancreatic head resection, pancreatic head resection with segmental duodenum, limited pancreatic head resection, uncinatus resection

discharge and rehospitalisation has been rarely specified. All publications presented the frequency of pancreatic fistula (POPF); however, less than half of them classified POPF A, B and C according to the ISGPF definition [9]. The presence of each criterion is given in relation to the total group of patients reported. The variations in denominators of the patients in the tables reflect reports missing the specific criteria listed and are therefore not included in statistical calculations. Data extracted from the 86 remaining publications entered the final statistical analysis of 838 patients after EN, 912 patients after CP and 431 patients having DPPHRt/p.

Statistical analysis

The systematic review was performed according to recommendations for the preferred reporting of items of the systematic review. (PRISMA) [10–13].

A p value of <0.05 (two-sided) was considered to be statistically significant using students t-test and Fishers exact calculation. Pearson's coefficient was used for the correlation analyses.

Results

Indications to surgery and surgical techniques

Twenty five reports dealt with tumour enucleation. Except one controlled cohort study, all these publications are retrospective and uncontrolled reports. Details of 838 patients who had EN indication to surgery and early postoperative outcome are given in Tables 2 and 3. The mean age was 55.1 ± 7.1 years and the sex ratio m/f was 0.8–1.2. 59.1 % of patients had a tumour location in head and neck, while 40.9 % had it in body and tail of pancreas.

Table 2 Patient populations, tumour size and pathology, indications to enucleation, central pancreatectomy and duodenum-preserving total/partial pancreatic head resection

	Analysed reports	Patients N	Patients (N) TM-size cm (mean ± SD)	Cystic neoplasm Patients n/N	Neuro-endocrine TM's patients n/N	Others Patients n/N
Enucleation 1991–2013	25[a]	838	702[b]	162/788	575/788	51/788
			2.4 ± 0.83 cm	**20.6 %**	**73 %**	**6.4 %**
Central pancreatectomy 1992–2013	38[c]	912	550	566/899	240/773	57/774
			2.9 ± 0.98 cm	**63.0 %**[d]	**31.0 %**[d]	**7.4 %**[d]
Duodenum-preserving total head resection 1997–2014	23[e]	431[e]	156[b]	300/431	44/431	87/431
			3.1 ± 0.75 cm	**69.6 %**	**10.2 %**	**20.2 %**

Bold values indicate percent share of subgroup patients to denominator patients in each field

[a] Ref. [15–39]

[b] EN versus DPPHR $p \leq 0.038$

[c] Ref. [24, 34, 39–74]

[d] Total not 100 % because of different denominators

[e] Ref. [5, 76–97]

EN was performed predominantly for pancreatic neuroendocrine tumours (PNETs). Four institutions performed multiple enucleations in one patient. Of the 838 patients, 22.5 % had a minimal-invasive laparoscopic access procedure. To identify the lesion more accurately, the use of intraoperative US was reported in 19 of 25 studies.

Thirty five retrospective and 3 prospective studies reported 912 patients treated by central pancreatectomy (CP). The mean age was 53.7 ± 7.7 years; the m/f ratio ranged from 0.8 to 2.8. CP was applied for cystic neoplasms and for PNETs in 62.9 % and 31.0 % respectively. Three of the CP publications analysed were prospective cohort studies, two of which included a control group.

For CP, most of the 912 patients received an open surgical treatment, whereas a laparoscopic approach was used in only one institution. The tumour-bearing segment was resected preserving splenic vessels, tail of pancreas and spleen. The length of resected pancreatic segment was reported to be of 3–7 cm. A dunking technique for pancreatic tail anastomosis with two suture lines using single stitches was performed. A pancreato-gastrostomosis was applied in six studies to resolve the left cut surface of the pancreas. The stump of the proximal pancreas was closed mostly using stapling devices or isolated closure of the main duct and additionally by compressing the parenchyma using U-sutures. All patients had, at the level of closure of the proximal pancreatic stump, a special drainage tube in position.

Twenty three trials reported 431 patients who had undergone DPPHRt/p, 6 of which were prospective and controlled cohort studies, three were retrospective and controlled studies, and the others were retrospective studies. The mean age of the patients was 58.4 ± 5.3 years with an m/f ratio ranging from 1.3 to 0.8. 69.6 % of the patients had surgery for cystic neoplastic lesions and 10.2 % for PNETs. DPPHRt/p was performed in all patients as an open procedure, while 48 % had a duodenum-preserving total pancreatic head resection with segment resection of the peripapillary duodenum and resection of the intrapancreatic segment of common bile duct. Two additional anastomoses—duodenum to duodenum (e–e) and CBD to jejunum (e–s)—were applied. In 52 % of the patients there was a complete preservation of duodenum and common bile duct. 28 % experienced a full resection of the pancreatic head and 24 % a partial pancreatic head resection preserving the pancreatic head parenchyma between the CBD and duodenal wall, or preserving a small rim of tissue after resecting the uncinate process.

In total 33 % of the patients had a duct-to-mucosa anastomosis with jejunum, whereas 24 % had a pancreato-gastrostomosis. The pancreato-intestinal continuation was restituted in the majority of patients by an excluded jejunal loop performing a Roux-en-Y anastomosis.

Early postoperative outcome

Enucleation (Table 3)

The overall postoperative morbidity was 41.3 %, while 9.6 % of the patients experienced severe postoperative complications. Pancreatic fistula after EN occurred in 36.7 %, the frequency of reoperation was 4.7 %, and hospital mortality was 0.95 %. Hospitalisation time was in mean 13.6 days. A minimal-invasive laparoscopic approach was applied in 22.5 % of the patients.

Tables 3 and 6 present full range of data.

Table 3 Enucleation indication and early postoperative morbidity after laparoscopic and open surgical treatments

Public. 1991–2013	Patients N	Tumour location[b]		Minimal invasive surgery n/N	Postop. morbidity		Reop. n/N	Hospital mortality n/N	Rehospi-talisation n/N	Recurr. n/N
		Head/ Neck n/N	Body/ Tail n/N		Overall n/N	Severe complic. n/N				
25[a]	838	414/701 **59.1 %**	287/701 **40.9 %**	154/684 **22.5 %**	331/801 **41.3 %**	77/801 **9.6 %**	25/531 **4.7 %**	8/828 **0.95 %**	29/230 **12.6 %**	11/431 **2.6 %**

Bold values indicate percent share of subgroup patients to denominator patients in each field

[a] Ref. [15–39]

[b] Cyst. N 20.6 %, MCN 7.2 %, IPMN 6.1 %, SCA 5.6 %, SPsN 1.6 %, Others 6.5 %. PNETs 73 %; of all PNETs 504 Insulinomas (64 %)

Central pancreatectomy (Tables 4, 6)

After CP in 912 patients, the overall morbidity was 47.9 %, while 15.9 % developed severe complications with the need of reoperation, respectively, re-intervention. Postoperative haemorrhage with requiring additional blood transfusion (>2 units in 24 h) or reoperation was observed in 5.3 %. Hospital mortality after CP was 0.76 %. The mean hospital stay was 16.1 days, but 15.1 % of the patients required a rehospitalisation. The fistula rate was 35.2 %.

Duodenum-preserving total/partial pancreatic head resection (Tables 5, 6)

After DPPHRt/s, the overall morbidity was 42.4 %; of these, 11.7 % experienced a severe type of complication. In 2.4 % of patients, a reoperation/re-intervention was performed. Pancreatic fistula developed in 20.1 %. Rehospitalisation was experienced by 3.0 %. The hospital mortality rate after DPPHRt/p was 0.46 %. The mean postoperative hospitalisation time was 21.9 postoperative days. Details of the postoperative course and metabolic functions based on a meta-analysis are being published [14].

Pancreatic fistula (Table 6)

The development of pancreatic fistula was the most frequent surgery-related complication after local pancreatic resections. Pancreatic fistulas of types B and C developed after EN in less than half, and after CP, in more than 50 % of the reported patients. When comparing the frequencies of B and C fistulas, the differences between EN versus DPPHRt/p ($p = 0.732$), DPPHRt/p versus CP ($p = 0.257$) and EN vs CP ($p = 0.089$) were not statistically significant. The frequency of total fistula rate after DPPHRt/p was significantly lower compared to CP ($p < 0.001$) and compared to EN ($p < 0.001$). The comparison between the tumour size and fistula grades B and C exhibited weak correlations for EN $r = -0.274$, CP $r = -0.156$ and DPPHRt/p $r = -0.204$.

Discussion

This systematic review adds substantial data to underline the use of limited surgical treatment techniques for patients suffering benign neoplastic tumours of the pancreas. Benign cystic neoplasms and neuro-endocrine tumours treated surgically by application of tumour enucleation, central pancreatectomy and duodenum-preserving total pancreatic head resection resulted in very low hospital mortality rates and a low frequency of severe early postoperative complications ranging from 9 to 17 %. Conservation of the exocrine and endocrine pancreatic functions is the most important benefit in the long-term outcome, although not determined specifically after EN and CP. The nutritional advantage following DPPHRt/p for the maintenance of pancreatic functions compared to pancreato-duodenectomy was demonstrated in prospective and controlled trials [14]. Tumour EN was predominantly used for neuroendocrine tumours, whereas CP and DPPHRt/s are applied in two-thirds of cystic neoplastic lesions. The comparison of the three limited surgical procedures has limitations, because decision making for application of a local surgical resection technique is determined by tumour location and size and variation of tissue texture surrounding the lesions. Consequently, the use of local resective procedures is in the majority of patients not an alternative technique. In cystic neoplasms, limited surgical procedures are applied most frequently for IPMN, SCA and MCN, and insulinomas. Interestingly, in the group of PNETs, limited surgery methods for benign pancreatic tumours were applied significantly more frequently in females than in males ($p < 0.001$).

Globally, most surgical institutions use for benign cystic lesions of the pancreatic head a Kausch-Whipple type of resection and for benign cystic and endocrine lesion of pancreatic body and tail a spleen-preserving left resection. However, major oncologic surgical resections

Table 4 Central pancreatectomy for benign cystic and endocrine tm's early postoperative morbidity

Publicat. 38[a]	Patients N	Laparosc. approach n/N	Postop. morbidity		Haemorrhage postop. n/N	Reop. n/N	Hospital mortality n/N	Re-admission n/N	Recurr. n/N
			Overall n/N	Severe n/N					
1992–2013	912	11/912	437/912	125/784	39/729	51/822	7/912	55/365	26/665
		1.2 %	**47.9 %**	**15.9 %**	**5.3 %**	**6.2 %**	**0.76 %**	**15.1 %**	**3.9 %**

Bold values indicate percent share of subgroup patients to denominator patients in each field

[a] Refs. [24, 34, 39–74]

Table 5 Early postoperative morbidity after duodenum-preserving total/partial pancreatic head resection for cystic neoplasms and neuro-endocrine tumours

Publications	Patients N	Postop. morbidity			Hospital mortality n/N	Rehospitalisation n/N	Recurr. n/N
		Overall n/N	Severe[a] n/N	Reop. n/N			
23[a]	**431***	163/384	38/326	7/296	2/431	7/235	9/326
1997–2013	**100 %**	**42.4 %**	**11.7 %**	**2.4 %**	**0.46 %**	**3.0 %**	**2.8 %**

Bold values indicate percent share of subgroup patients to denominator patients in each field

IPMN 53.8 %; MCN 6.2 %; SCA 8.4 %; SPsN 2.2 %

PNETs: Insulinoma 6.4 %; Gastrinoma 0.5 %; Iselt cell tumours 0.98 %

[a] Ref. [5, 76–97]

Table 6 Pancreatic fistula after limited surgical procedures for benign pancreatic cystic neoplasm and neuro-endocrine tumours

	POPF	Patients n/N	Fistula rate	Significance Total fistula rate
Enucleation (EN)	**Total**[a]	**298/811**[a]	**36.7 %**	EN v. CP $p = 0.504$
	Fistula A	166/811	20.5 %	EN v. DPPHR $p < 0.001$**
	Fistula B + C	132/811	16.3 %	
Central pancreatectomy (CP)	**Total**	**321/912**[a]	**35.2 %**	CP v.DPPHR $p < 0.001$**
	Fistula A	102/480	21.3 %	
	Fistula B + C	116/499	23.2 %	
Dudodenum preserving total/partial pancreatic head resection (DPPHR)	**Total**	**83/412**[a]	**20.1 %**	DPPHR v. EN $p < 0.001$**
	Fistula A	45/412	10.9 %	
	Fistula B + C	38/412	9.2 %	

Bold values indicate percent share of subgroup patients to denominator patients in each field

** Fistula B + C

[a] POPF graduation reported for 811, 499 and 412 patients after EN, CP and DPPHRt/p, respectively

are burdened with the unnecessary sacrifice of pancreatic and extra-pancreatic tissues and are associated with a substantial level of surgery related postoperative complications.

Indication and limitations of local surgical procedures

Enucleation was applied in two-thirds of patients for neuro-endocrine tumours. Minimal-invasive techniques were used in 22.5 % of the patients for enucleation. Enucleation of cystic tumours, mostly MCN and IPMN neoplasms, necessitates a careful dissection of connective tissue surrounding the lesion providing the surgeon with a frozen section to exclude a pre-malignant or malignant histology [15]. A tumour size >3–4 cm is considered to be borderline for the application of EN technique. [17, 22, 32] The most important point for limitation for EN is the proximity of the tumour to the main pancreatic duct [22,

26]. The frequency of pancreatic fistula of 36.7 %, the frequency of reoperation of 4.7 % and a rehospitalisation of 12.6 % are likely to be related to injury of the pancreatic main ducts during EN-associated tissue dissection and the subsequent development of local complications. However, the high fistula rate is in part related to tissue texture, which tends to be normal in patients undergoing enucleation of endocrine lesions. To achieve a surgical cure, EN of benign tumours has the benefits of a low level of severe surgical morbidity and low hospital mortality and does not involve a procedure-related late postoperative permanent metabolic dysfunctions. Pancreatic tumours above the size of 3 cm, particularly cystic neoplastic lesions located in the pancreatic head, are recommended to be treated surgically by the use of a resective procedure [22, 26, 32, 35]. After surgical exposition of the pancreas, intraoperative US to detect location and size of the tumour has been used. Most importantly, by applying IUS, the proximity of the tumour to the pancreatic main duct can be measured more precisely. An additional advantage of tumour enucleation is associated with the application of laparoscopic surgical techniques.

Central pancreatectomy

Middle segment resection of the pancreas is a demanding surgical procedure for benign tumours which results in two resection lines of the pancreas. Cystic neoplasms but usually not endocrine tumours are surrounded by an inflammatory tissue wall infiltrating towards the vessels behind the pancreas [45, 51, 54]. Complete dissection of the neoplastic tumour sometimes necessitates resection of the vessel wall, increasing the risk of local bleeding and the development of pseudoaneurysm [63]. The 5.3 % of intra-abdominal early or late haemorrhage were explained as procedure-related risk when using a central pancreatic resection. The frequencies of severe postoperative complications of 47.9 % and of pancreatic fistula of 35.2 % were related to the management of the pancreatic stumps [65, 71]. A left-pancreato-jejunostomy was applied at most. Implantation of the left pancreatic stump into stomach is elegant and technically straightforward but infrequently established [42, 46, 47, 57, 67]. The crucial point of central pancreatectomy is the handling of the proximal pancreatic stump. Simple closure by suture or using of mechanical devices causes rather than prevents the local complications like pancreatic fistula or peri-pancreatic fluid collections. The lowest fistula rates of CP were reported when performing two intestinal anastomoses with both pancreatic stumps separately with the excluded jejunal loop [61]. The reoperation rate of 6.2 % may be related to the severity of severe local complications predominantly developing around the proximal pancreatic stump. However, hospital mortality with 0.76 % was very low. Pancreatic middle segment resections are increasingly applied in patients who suffer cystic neoplastic lesions localized in body and tail of the pancreas thus avoiding a pancreatic left resection and its metabolic sequelae. Tumours of sizes up to 5–6 cm, located in pancreatic neck or/and body, are indications to CP [61]. To retain the metabolic advantages of a tissue-sparing resection, the length of the resected pancreatic segment should not exceed 5–6 cm, otherwise the risk of permanent exocrine and endocrine functional insufficiencies will affect the long-term outcome as it was observed after pancreatic left resection [66]. Only a few institutions measured the exocrine and endocrine functions after central pancreatectomy for benign tumours [53]. Late outcome dysfunctions were found in up to 10 % for reduced glucose metabolism and up to 20 % for exocrine insufficiency compared to the preoperative level [91].

Duodenum-preserving total/partial pancreatic head resection has been introduced to clinical practice in 1972 for inflammatory tumours of the pancreatic head [75]. DPPHRt/p techniques are used for benign tumours of the pancreatic head, mostly cystic neosplasms of the IPMN type. A total pancreatic head resection was performed in 75 % of patients, depending on size of tumour and location within the pancreatic head; in 48 % of the patients, a total pancreatic head resection was performed with segment resection of the peripapillary duodenum and the intrapancreatic common bile duct [14]. This surgical procedure requires a step-by-step dissection of the pancreatic head from the duodenal wall [5, 78, 82]. No leak of the duodenal anastomoses was reported. The total pancreatic head resection preserving the duodenum and intrapancreatic common bile duct appeared to be a risk for ischemic lesion of the peripapillary duodenum and for stenosis of the prepapillary common bile duct [14, 78, 79, 82, 87–89, 92]. Interventional treatment of both complications reestablished an early postoperative course without reoperations. The frequency of severe postoperative morbidity, fistula rate, reoperation and hospital mortality are low after DPPHRt/p. The evaluation of pancreatic functions after DPPHRt/s demonstrated significant advantages for short- and long-term outcomes through full conservation of endocrine and exocrine functional capacities, based on controlled prospective cohort studies comparing Whipple-type head resection and DPPHRt/p [14].

Comparing DPPHRt/p with EN, the frequency of pancreatic fistula was significantly higher for EN ($p < 0.001$) as well the frequency of reoperation ($p < 0.029$). Success of DPPHRt/p depends on careful dissection of the supra-papillary and infra-papillary duodenum from the pancreatic head preserving the dorsal superior posterior pancreatico-duodenal artery and the inferior anterior pancreatico-duodenal arcade whenever possible to avoid ischaemic tissue trauma of the peri-papillary duodenum [76, 78, 80, 85, 88]. Dissecting pancreatic tissue around the intrapancreatic

common bile duct demands the careful use of sharp or electro-cautering techniques to avoid a trauma to the bile duct wall. A further advantage of DPPHRt/p is tailoring the amount of head resection by applying a sub-total head resection or isolated resection of the uncinate process, and resecting pancreatic head while preserving the neck of pancreas [14].

The risk of recurrence was in the series of DPPHRt/p 2.8 % [5, 77]. One reason for the recurrence was the incomplete resection of the main-duct IPMN neoplasms. A total of 9.1 % of duodenum-preserving total pancreatic head resections were performed for other final pathologies—considered, with few exceptions—preoperatively and intraoperatively as a benign lesion, most of them carcinoma in situ of cystic neoplasms and local malignant tumours. The application of DPPHRt/p for peripapillary low-risk cancer did not result in any reported cancer recurrence. However, the use of DPPHRt for low-risk T1 periampullary cancer needs to be confirmed by prospective, controlled trials before advocating a local resective procedure.

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