J Hepatobiliary Pancreat Sci (2010) 17:792–797
DOI 10.1007/s00534-009-0221-4

Surgical design and outcome of duodenum-preserving pancreatic head resection for benign or low-grade malignant tumors

Akihiko Horiguchi · Shuichi Miyakawa · Shin Ishihara · Masahiro Ito · Yukio Asano · Koichi Furusawa · Tomohiro Shimizu · Toshiyuki Yamamoto

Received: 1 August 2009 / Accepted: 1 September 2009 / Published online: 6 November 2009
© Japanese Society of Hepato-Biliary-Pancreatic Surgery and Springer 2009

Abstract To apply duodenum-preserving pancreatic head resection (DPPHR) as radical procedure for benign or low-grade malignant tumors, it needs the reconciliation of complete pancreatic head resection and preservation of the bile duct and peripancreatic vessels. Several modifications have been introduced and applied to remove these lesions, however, the techniques have not been made clear in the management of the peripancreatic vessels and the bile duct. The long-term outcomes of the DPPHR have been reported as extremely rare in comparison with pylorus preserving pancreatoduodenectomy (PPPD) in these pancreatic head tumors. The angiograms by multi-detector row CT (MD-CT) can be reconstructed more physiologically than selective angiography. The anterior arcade is predominant in 43% of 64 patients. Therefore, we modified the DPPHR to include a complete resection of the pancreatic head and the preservation of both anterior and posterior arterial arcades. The bile duct is covered by the pancreatic parenchyma in various ways. The techniques of the preservation of the bile duct are also introduced. We performed 21 DPPHRs and 19 PPPDs in the patients with benign or low-grade malignant pancreatic head tumor. There was no significant difference in operative factors. The postoperative death was one patient in PPPD, but none in DPPHR. The postoperative complications of PPPD were more often than that of DPPHR. There is no postoperative recurrence in DPPHR in the follow-up period from 2 to 216 months. Both exocrine and endocrine function and the long-term results following DPPHR were superior to those following PPPD. The DPPHR should be favored over the PPPD in benign or low-grade malignant tumors of the head of the pancreas if there is no compromise with oncologic radicality.

Keywords Duodenum-preserving pancreatic head resection · Preservation of the arterial arcades · Organ preserving pancreatic resection

A. Horiguchi (✉) · S. Miyakawa · S. Ishihara · M. Ito · Y. Asano · K. Furusawa · T. Shimizu · T. Yamamoto
Department of Biliary-Pancreatic Surgery,
Fujita Health University School of Medicine,
1-98 Dengakugakubo, Kutsukake,
Toyoake, Aichi 470-1192, Japan
e-mail: akihori@fujita-hu.ac.jp

Introduction

Since Beger et al. [1] invented duodenum-preserving pancreatic head resection (DPPHR) for patients with an inflammatory mass within the pancreatic head due to chronic pancreatitis, several modifications have been introduced and applied to remove benign or low-grade malignant lesions in the head of the pancreas, such as cystic lesions and intraductal papillary mucinous neoplasm (IPMN), as well as to treat chronic pancreatitis [2–4]. The advantage of the procedure is preservation of the duodenum, which has a key role in the digestive function [5, 6]. When DPPHR applies to patients with benign or low-grade malignancy, it is important to remove completely the pancreatic head to avoid tumor remnant and pancreatic fistula, because the majority of the patients with these tumors have the normal pancreatic exocrine gland, and variation of the branch duct of the head of the pancreas [7]. On the other hand, if complete resection of the head of the pancreas is performed, there is danger of ischemia and perforation of the bile duct and the duodenum.

During resection of the head of the pancreas, therefore, it is absolutely essential to maintain the blood supply to the bile duct and the duodenum in order to prevent early

postoperative complication [3, 4, 8]. DPPHR is technically difficult and time-consuming due to reconciling these antinomic techniques, namely, complete resection in the pancreatic head and preservation of both the bile duct and the pancreaticoduodenal vessels. Takada et al. [3] and Kim et al. [8] documented that preservation of the posterior arcades is enough to keep the duodenum viable. We reported the technique for preservation of both arcades during DPPHR, because of the unbalanced development between the anterior and posterior arterial arcades, which were demonstrated with selective celiac angiography [9]. The blood supply of the duodenum and the bile duct is disturbed after DPPHR in some patients who have a well-developed anterior arterial arcade. The bile duct is covered by the pancreatic parenchyma. The covering is various in human beings [10]. Therefore, the techniques of the preservation of the bile duct also remain as an unsolved problem. We analyzed the blood supply of the pancreaticoduodenal region with multi-detector row CT (MD-CT) which is more physiological than selective celiac angiography, and demonstrated the techniques and results of the preservation of the arterial arcades and the bile duct according to the relationship between the bile duct and the pancreatic parenchyma. An important and presently still controversial topic is which surgical procedure provides the best long-term results following pancreatic head resection for benign or low-grade malignant tumor. The long-term outcome in the patients with IPMN in the head of the pancreas was compared between DPPHR and pancreatoduodenectomy.

Blood supply of the pancreaticoduodenal region

The 3-dimensional angiograms of 84 patients were studied in our institute. The angiograms were reconstructed with MD-CT (TOSHIBA Aquillion, 64 detectors). MD-CT was done by the automatic bolus tracking method. It is possible to reconstruct the angiograms more physiologically in comparison with selective angiography. The arterial arcades of the head of the pancreas were detected in 60 out of 84 patients (Table 1). The anterior arcade was predominant in 26 patients (43%), the anterior and posterior arcade almost equaled in 24 (40%), and the posterior arcade was predominant in 10 (17%) (Fig. 1). The unbalanced development of the arterial arcades was recognized again. Therefore, it is necessary to preserve the blood supply to the duodenum and the bile duct from the both anterior- and posterior- arterial arcades during DPPHR in the patients who have predominant anterior arterial arcade. The posterior superior pancreaticoduodenal artery (PSPDA) and the bile duct were demonstrated in the patient with endoscopic retrograde biliary drainage due to papillary cancer (Fig. 2). The PSPDA crosses the distal bile duct anteriorly and

Table 1 The evaluation of the arterial arcades in the head of the pancreas with MD-CT

	Number of the patients (%)
Total number of patients	84
Detection	60 (71%)
Ant > Post	26 (43%)
Ant ≒ Post	24 (40%)
Ant < Post	10 (17%)

Ant anterior arcade, *Post* posterior arcade

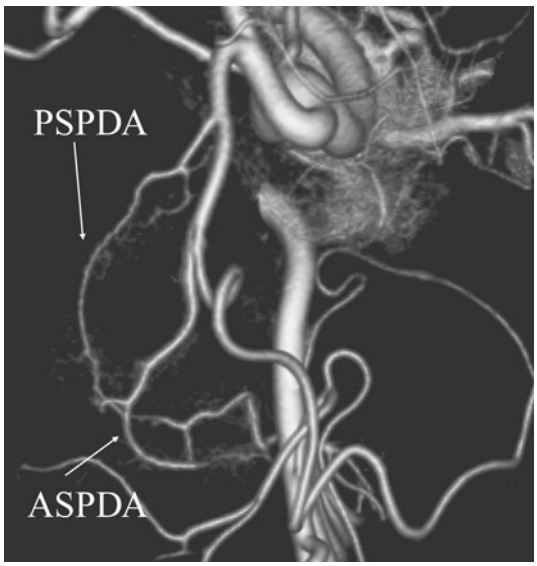

Fig. 1 Lateral view of the 3-D angiogram of the arterial phase reconstructed with MD-CT. The anterior arcade is predominant in comparison with the posterior arcade

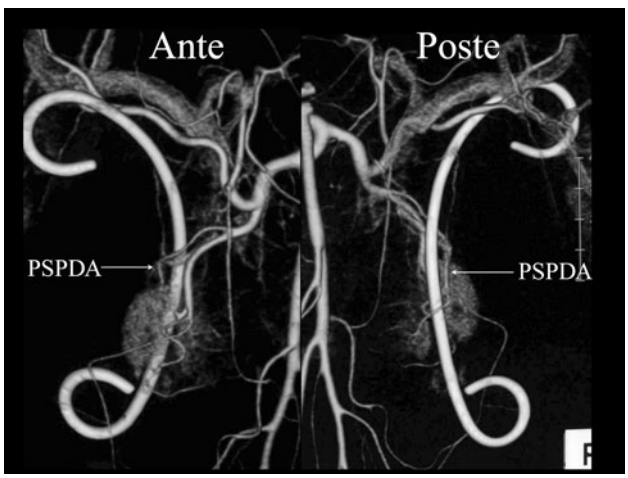

Fig. 2 Anterior (*Ante*) and posterior (*Poste*) views of the 3-D angiogram of the arterial phase of the patient with endoscopic retrograde biliary drainage (ERBD). The PSPDA and the bile duct (ERBD tube) were demonstrated

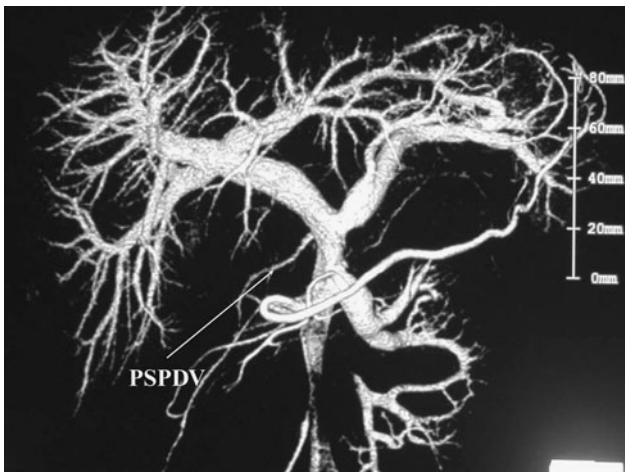

Fig. 3 Anterior view of the 3-D angiogram of the venous phase. The posterior superior pancreaticoduodenal vein (*PSPDV*) have to be preserved to avoid the congestion of the duodenum during DPPHR

descend along the right border of the bile duct and crosses again posteriorly at the level of the papilla. The separation between the bile duct and the duodenum causes a damage of the PSPDA during DPPHR. The posterior superior pancreaticoduodenal vein (PSPDV) has to be preserved to avoid the congestion of the duodenum (Fig. 3).

Surgical techniques of the DPPHR

Preservation of both anterior and posterior arterial arcade

After laparotomy, both gastro- and duodeno-colic ligaments are dissected without performing Kocher's maneuver to make use of the adhesion to the retroperitoneum and to preserve the venous drainage from the duodenum and the bile duct. Then the right gastroepiploic vein is ligated and divided on the anterior surface of the pancreas. The superior mesenteric vein is exposed from the inferior border of the pancreas to the anterior of the third portion of the duodenum. Next, the common hepatic artery and the gastroduodenal artery (GDA) are dissected from the superior part of the pancreas. After these maneuvers, the resection itself begins with the division of the pancreas over the portal vein. After careful hemostasis at the divided edge of the left side of the pancreas with bipolar electric coagulation of the vessels, a polyvinyl tube is inserted into the main pancreatic duct. During resection of the uncinate portion, the inferior pancreaticoduodenal artery is taped, and the pancreatic branches of the anterior inferior pancreaticoduodenal artery (AIPDA) are ligated and divided one by one toward the papilla of Vater, preserving the branches of the AIPDA to the duodenum. While ligating

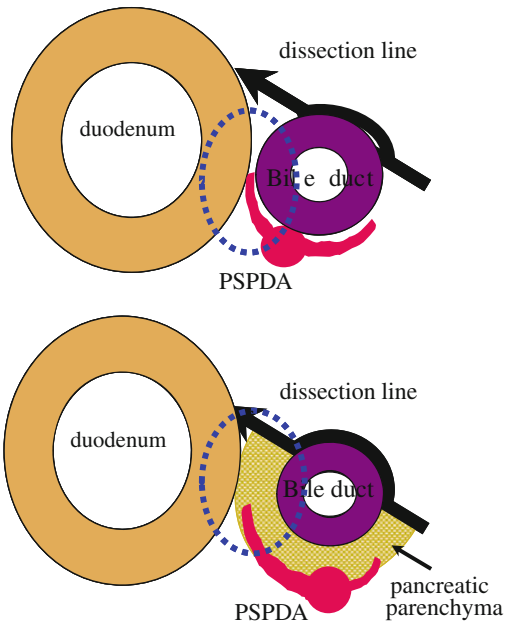

Fig. 4 The safe dissection from the bile duct. The pancreatic parenchyma of the right-latero-dorsal side of the bile duct had better remain to avoid injury of the PSPDA in case of covering the bile duct by the pancreatic parenchyma

and dividing the pancreatic branches of the GDA and the ASPDA toward the papilla of Vater, the duodenal branches are preserved. During resection of the dorsal side of the head of the pancreas, the pancreatic branches of the posterior inferior pancreaticoduodenal artery (PIPDA) are ligated and divided as preserving the pancreatic posterior membrane, while placing several traction sutures at the divided edge of the pancreas, because the PIPDA run under the posterior membrane.

Dissection between the bile duct and the duodenum

After taping the bile duct at the upper margin of the pancreas, the head of the pancreas is dissected at the anterior wall of the bile duct toward the papilla of Vater, and then the confluence of the pancreatic duct is noted. The pancreatic tissue of the right-latero-dorsal side of the bile duct had better remain to avoid injury of the PSPDA and its branches in case of covering the bile duct by the pancreatic parenchyma (Fig. 4). The main pancreatic duct is ligated and divided. When dissecting between the pancreatic tissue and the bile duct, it is important for the preservation of the blood supply to the bile duct from the PSPDA to dissect the pancreatic tissue at the level of the anterior wall of the bile duct, because the PSPDA and its bile duct branches run between the bile duct and the duodenum from the cranial side to the dorsal side. The pancreas is dissected from the duodenum while preserving the accessory papilla. The head of the pancreas is removed after dividing accessory

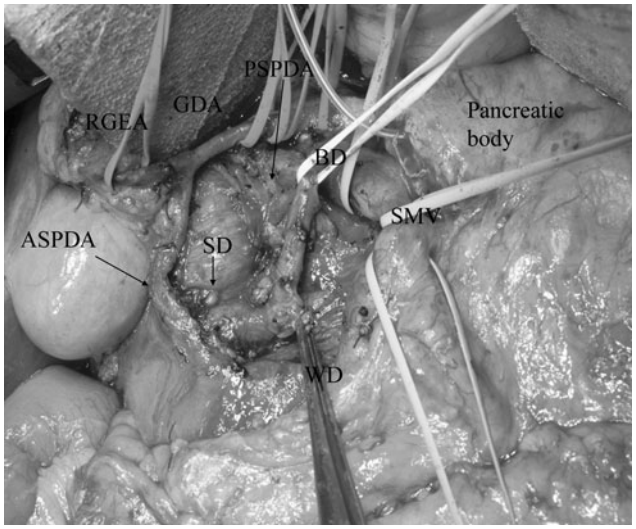

Fig. 5 The intraoperative photograph after removing the pancreatic head. The preserved arteries and organs retain good color. *BD* bile duct, *WD* Wirsung duct, *SD* Santorini duct, *SMV* superior mesenteric vein, *GDA* gastroduodenal artery

Table 2 Background of the subject

	PPPD ($n = 19$)	DPPHR ($n = 21$)
Age (year)	67.2 ± 7.2	59.5 ± 13.6*
Sex (M/F)	11/8	11/10
Diagnosis		
IPMN	16	17
ECT	3	2
SCT	0	1
SPT	0	1

* $p < 0.05$; All others: p = NS

IPMN intraductal papillary mucinous neoplasm, *ECT* endocrine tumor, *SPT* solid pseudopapillary tumor, *SCT* serous cystic tumor

pancreatic duct. The preserved arteries and organs were shown in Fig. 5. The duodenum and the bile duct had remained good color. Reconstruction is accomplished by an end-to-side pancreatico-jejunostomy using a Rouxen-Y jejunal loop to avoid the injury of the preserved arterial arcades.

Clinical experiences and results

DPPHR with both arterial arcades was performed on 21 patients with tumor of the pancreatic head; 17 IPMN, 2 endocrine tumor (ECT), 1 solid pseudopapillary tumor (SPT), 1 serous cystic tumor (SCT), PPPD 19 patients; 16 IPMN, 3 ECT (Table 2). All patients had normal pancreatic parenchyma. There was no significant difference in operative factors; operative time and blood loss, postoperative hospital stay, between PPPD and DPPHR (Table 3). The postoperative death was one patient in PPPD, but none in DPPHR. The postoperative complications of PPPD were more often than that of DPPHR. As for the morbidity of PPPD and DPPHR, pancreatic fistula 3 and 2, anastomotic insufficiency 1 and 1, duodenal bleeding 0 and 1, delayed gastric emptying 2 and 0, common bile duct stenosis 0 and 1 (Table 4). These conditions improved after conservative treatment in DPPHR.

Table 3 Operative and postoperative findings of PPPD and DPPHR

	PPPD ($n = 19$)	DPPHR ($n = 21$)	
Operative time (min)	563 ± 127	510 ± 124	NS
Blood loss (g)	923 ± 482	710 ± 362	NS
Postoperative hospital stay (day)	40.7 ± 17.6	42.9 ± 22.6	NS

Table 4 Postoperative mortality and morbidity of PPPD and DPPHR

	PPPD ($n = 19$)	DPPHR ($n = 21$)
Mortality	1	0
Morbidity		
Pancreatic fistula	3	2
Anastomotic insufficiency	1	1
Duodenal bleeding[a]	0	1
DGE	2	0
Common bile duct stenosis	0	1

DGE delayed gastric emptying

[a] Patients requiring more than 3 units of blood later than 24 h after the operation or reoperation

The DPPHR was better than PPPD in the pancreatic exocrine functions which were analyzed by ^{13}C-labeled trioctanoin breath test (Fig. 6). There were no significant changes of the hemoglobin A1c values in the endocrine functions (Fig. 7) and the pre-and postoperative body weights ratio in the patients who underwent DPPHR (Fig. 8). The three patients who underwent PPPD died of vascular disease with diabetes. There is no postoperative recurrence in all patients who underwent DPPHR in the follow-up period from 2 to 216 months, although one patient was lost to senile decay 10 years after operation.

Discussion

When the DPPHR is indicated in patients with benign or low-grade malignant tumors, such as IPMN, the procedure should be a DPPHR without the pancreatic rim [2–4]. The total resection of the head of the pancreas might be incompatible with the preservation of the blood supply. Takada et al. [10] and Kim et al. [8] reported the blood

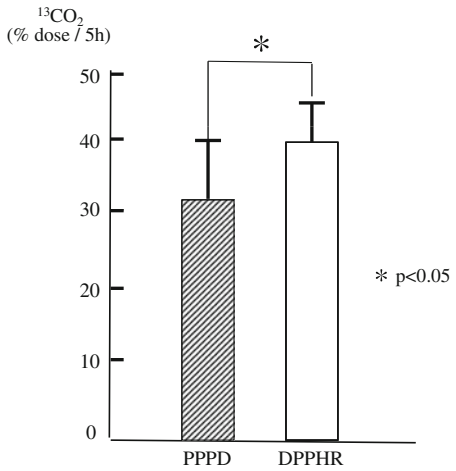

Fig. 6 Results of ^{13}C-trioctanoin breath test

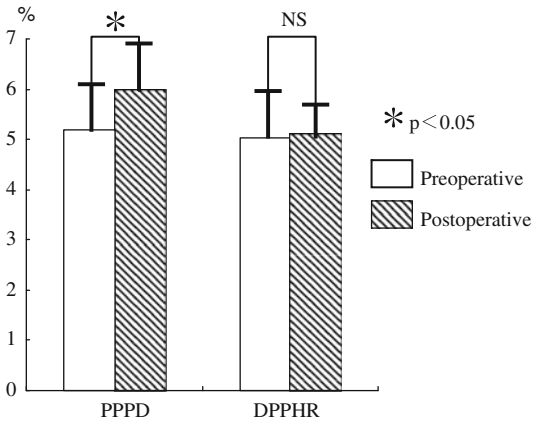

Fig. 7 Changes in pre- and postoperative Hb A1c

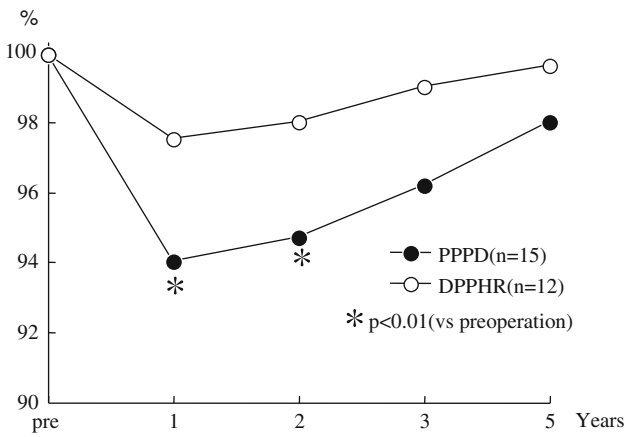

Fig. 8 Changes in pre- and postoperative body weight ratio

flow in the duodenum was based on an intact duodenal blood supply from the mesoduodenum which covers the AIPDA, and from the PSPDA. In reporting their own techniques, however, the blood supply to the duodenum and bile duct is restricted, since it is provided only by the duodenal branches the posterior arcade. If the anterior arcade predominates the posterior arcade on the blood supply to the duodenum, as reintroduced our study of the three-dimensional angiograms obtained the more physiological condition with MD-CT, ischemia of the preserved organs is ascribed to the resection of the anterior arcade. To avoid ischemia of the papilla of Vater, the duodenum and the bile duct, it is especially important to preserve the PSPDA which runs between the bile duct and the duodenum. In patients who have a well-developed anterior arterial arcade, however, it is also necessary to preserve the anterior arterial arcade during dissection of the anterior pancreatic head.

As to the anatomical relationship between the bile duct and the pancreas at the 3 cm portion from the papilla of Vater, Kato et al. [11] reported that the extra-pancreatic bile duct is 11.3%, the less than half around bile duct 11.3%, the half around bile duct 25.8%, and the more than half around bile duct 51.6%. In case of a covered bile duct, the safe dissection of the bile duct is not only to take notice of the relation of the bile duct and pancreatic parenchyma, but also to retain more than half around the pancreatic parenchyma at the dorsal side of the bile duct [12]. In case of less than half around the bile duct, the knack of safe dissection of the bile duct is not to separate between the bile duct and the duodenum.

The PSPDV runs at the dorsal side of the bile duct, between the bile duct and the duodenum, and provides drainage of the blood flow of the duodenum. The preservation of the PSPDV is also very important to avoid the congestion of the duodenum. These maneuvers lead consequently to the preservation of the PSPDA and the PSPDV. The new techniques for the preservation of the arterial arcades and the bile duct during DPPHR can be applied in the patients with benign or low-grade malignancy of the head of the pancreas, and free from early postoperative complications. The new DPPHR compares favorably with PPPD in the operative factors and postoperative complications.

To avoid the disadvantages of stomach resection following the SPD, classic Whipple resection, PPPD was introduced again primarily for cancer [13]. Because standard pancreatoduodenectomy gives unsatisfactory long-term results with regard to life quality, digestion and the high rate of postoperative diabetes mellitus, it has been consistently replaced by the PPPD and DPPHR in patients with chronic pancreatitis, and in those with benign or low-grade pancreatic tumor. The DPPHR is better than the PPPD in the ^{13}C-labeled trioctanoin breath test, and the hemoglobin A1c values. The long-term results of the PPPD are also unsatisfactory in comparison with those of the DPPHR in the patients with benign or low-grade malignant tumors in the head of the pancreas [14]. Most causes of

death after PPPD are vascular disease with diabetes mellitus. The major difference between PPPD and DPPHR is preservation of the duodenum and thereby physiologic food transit. The removal of the duodenum cuts off neuronal and hormonal feedback mechanisms between the pancreas and the duodenum, which are important for regulation of exocrine and endocrine pancreatic secretion [15]. The importance of duodenal preservation in pancreatic surgery is underscored by the fact that pancreatic enzyme secretion and endocrine function is reduced following the PPPD in comparison with normal subjects, but not after the DPPHR. The DPPHR preserves the stomach and pylorus and spares the complete duodenum and the extrahepatic bile duct, which are important for hormonal control of exocrine and endocrine pancreatic function.

The DPPHR should be favored over the PPPD in benign or low-grade malignant tumors of the head of the pancreas, if there is no compromise with oncologic radicality.

References

1. Beger HG, Krautzberger W, Bittner R, Buchler M, Limmer J. Duodenum-preserving resection of the head of the pancreas in patients with severe chronic pancreatitis. Surgery. 1985;97:467–73.
2. Imaizumi T, Hanyu F, Suzuki M, Nakasako T, Harada N. Clinical experience with duodenum-preserving total resection of the head of the pancreas. J Hepatobiliary Pancreat Surg. 1995;2:38–44.
3. Takada T, Yasuda H, Uchiyama K, Hasegawa H. Duodenum-preserving pancreaticoduodenostomy. A new technique for complete excision of the head of the pancreas with preservation of biliary and alimentary integrity. Hepatogastroenterology. 1993;40:356–9.
4. Beger HG, Gansauge F, Siech M, Schwarz M, Poch B. Duodenum-preserving total pancreatic head resection for cystic neoplastic lesions in the head of the pancreas. J Hepatobiliary Pancreat Surg. 2008;15:149–56.
5. Buchler MW, Friess H, Muller MW, Wheatley AM, Beger HG. Randomized trial of duodenum preserving pancreatic head resection versus pylorus preserving pancreatic whipple in chronic pancreatitis. Am J Surg. 1995;169:65–70.
6. Miyakawa S, Hayakawa M, Horiguchi A, Mizuno K, Ishihara S, Niwamoto N, et al. Estimation of fat absorption with the ^{13}C-trioctanoin breath test after pancreatoduodenectomy or pancreatic head resection. World J Surg. 1996;20:1024–9.
7. Kato K. A fundamental study of pancreatography (in Japanese). Jpn J Gastroenterol. 1972;69:503–23.
8. Kim SW, Kim KH, Jang JY, Park S, Park YH. Paractical guidelines for the preservation of the pancreaticoduodenal arteries during duodenum-preserving resection of the head of the pancreas. Hepatogastroenterology. 2001;48:264–9.
9. Miyakawa S, Horiguchi A, Mizuno K, Ishihara S, Niwamoto N, Miura K. Preservation of arterial arcades during duodenum-preserving total pancreatic head resection for intraductal papillary tumor. Hepatogastroenterology. 2003;50:993–7.
10. Takada T, Yasuda H, Uchiyama K, Hasegawa H, Iwagaki T, Yamakawa Y. Complete duodenum-preserving resection of the head of the pancreas with preservation of the biliary tract. J Hepatobiliary Pancreat Surg. 1995;2:38–44.
11. Kato K, Nakazawa S. A basic study in the visualization of the pancreatic and biliary ducts. Stomach Intest. 1973;8:335–43.
12. Miyakawa S, Horiguchi A, Ishihara S, Ito M, Nagata H, Shimizu T. Duodenum preserving pancreatic head resection. Operation. 2005;59:1945–9.
13. Traverso LW, Longmire WP. Preservation of the pylorus in pancreaticoduodenectomy. Surg Gynecol Obstet. 1978;146:959–62.
14. Yasuda H, Takada T, Toyota N, Amano H, Yoshida M, Takada Y, et al. Limited pancreatectomy: significance of postoperative maintenance of pancreatic exocrine function. J Hepatobiliary Pancreat Surg. 2000;7:466–72.
15. Ito K. Duodenum preservation in pancreatic head resection to maintain pancreatic exocrine function (determined by pancreatic function diagnostant test and cholecystokinin secretion). J Hepatobiliary Pancreat Surg. 2005;12:123–8.