

An easier method for performing a pancreaticojejunostomy for the soft pancreas using a fast-absorbable suture

Kenichi Hakamada, Shunji Narumi, Yoshikazu Toyoki, Masaki Nara, Kenosuke Ishido, Takuya Miura, Norihito Kubo, Mutsuo Sasaki

Kenichi Hakamada, Shunji Narumi, Yoshikazu Toyoki, Masaki Nara, Kenosuke Ishido, Takuya Miura, Norihito Kubo, Mutsuo Sasaki, Gastroenterological Surgery, Hirosaki University Graduate School of Medicine, 5 Zaifu-cho, Hirosaki 036-8562, Japan

Author contributions: Hakamada K designed research; Hakamada K, Narumi S, Toyoki Y, Nara M, Ishido K, Miura T, Kubo N and Sasaki M performed research; Hakamada K, Narumi S, Toyoki Y, analyzed data; and Hakamada K wrote the paper.

Correspondence to: Kenichi Hakamada, MD, Department of Gastroenterological Surgery, Hirosaki University Graduate School of Medicine, 5 Zaifu-cho, Hirosaki 036-8562, Japan. hakamada@cc.hirosaki-u.ac.jp

Telephone: +81-172-395079 Fax: +81-172-395080

Received: November 7, 2007 Revised: December 18, 2007

Abstract

AIM: To clarify the usefulness of a new method for performing a pancreaticojejunostomy by using a fast-absorbable suture material irradiated polyglactin 910, and a temporary stent tube for a narrow pancreatic duct with a soft pancreatic texture.

METHODS: Among 63 consecutive patients with soft pancreas undergoing a pancreaticoduodenectomy from 2003 to 2006, 35 patients were treated with a new reconstructive method. Briefly, after the pancreatic transaction, a stent tube was inserted into the lumen of the pancreatic duct and ligated with it by a fast-absorbable suture. Another tip of the stent tube was introduced into the intestinal lumen at the jejunal limb, where a purse-string suture was made by another fast-absorbable suture to roughly fix the tube. The pancreaticojejunostomy was completed by ligating two fast-absorbable sutures to approximate the ductal end and the jejunal mucosa, and by adding a rough anastomosis between the pancreatic parenchyma and the seromuscular layer of the jejunum. The initial surgical results with this method were retrospectively compared with those of the 28 patients treated with conventional duct-to-mucosa anastomosis.

RESULTS: The incidences of postoperative morbidity including pancreatic fistula were comparable between the two groups (new; 3%-17% *vs* conventional; 7%-14% according to the definitions). There was no mortality and re-admission. Late complications were also rarely seen.

CONCLUSION: A pancreaticojejunostomy using

an irradiated polyglactin 910 suture material and a temporary stent is easy to perform and is feasible even in cases with a narrow pancreatic duct and a normal soft pancreas.

© 2008 WJG. All rights reserved.

Key words: Pancreaticojejunostomy; Duct-to-mucosa contact method; Fast-absorbable suture; Irradiated polyglactin 910; Pancreatic fistula

Peer reviewer: Hiroshi Yoshida, MD, First Department of Surgery, Nippon Medical School, 1-1-5 Sendagi, Bunkyo-ku, Tokyo 113-8603, Japan

Hakamada K, Narumi S, Toyoki Y, Nara M, Ishido K, Miura T, Kubo N, Sasaki M. An easier method for performing a pancreaticojejunostomy for the soft pancreas using a fast-absorbable suture. *World J Gastroenterol* 2008; 14(7): 1091-1096 Available from: URL: <http://www.wjgnet.com/1007-9327/14/1091.asp> DOI: <http://dx.doi.org/10.3748/wjg.14.1091>

INTRODUCTION

Leakage of the pancreaticoenterostomy remains a major cause of postoperative morbidity and mortality after pancreaticoduodenectomy^[1-7]. Many factors have been identified that are associated with an increased incidence of this complication. Among them, a small pancreatic duct size with a soft pancreas creates one of the technical hurdles to the completion of the anastomosis, and is known to be a risk factor for major leakage^[3,8-13]. Several methods have been advocated to reduce the occurrence of leakage^[5,14-21], but the best technique is still a subject of debate^[22-29].

We established a new anastomotic technique for pancreaticojejunostomy by using a fast-absorbable suture material, irradiated polyglactin 910, and a temporary stent tube.

MATERIALS AND METHODS

One hundred and one consecutive patients underwent an elective pancreaticoduodenectomy for hepato-biliary and pancreatic disease between February 2003 and January 2007 at the Hirosaki University Hospital. Among them, 63 patients, in whom the pancreas was macroscopically normal and soft in texture, and in whom a pathological examination of the pancreatic cut end confirmed the absence of fibrosis or pancreatitis, were included in

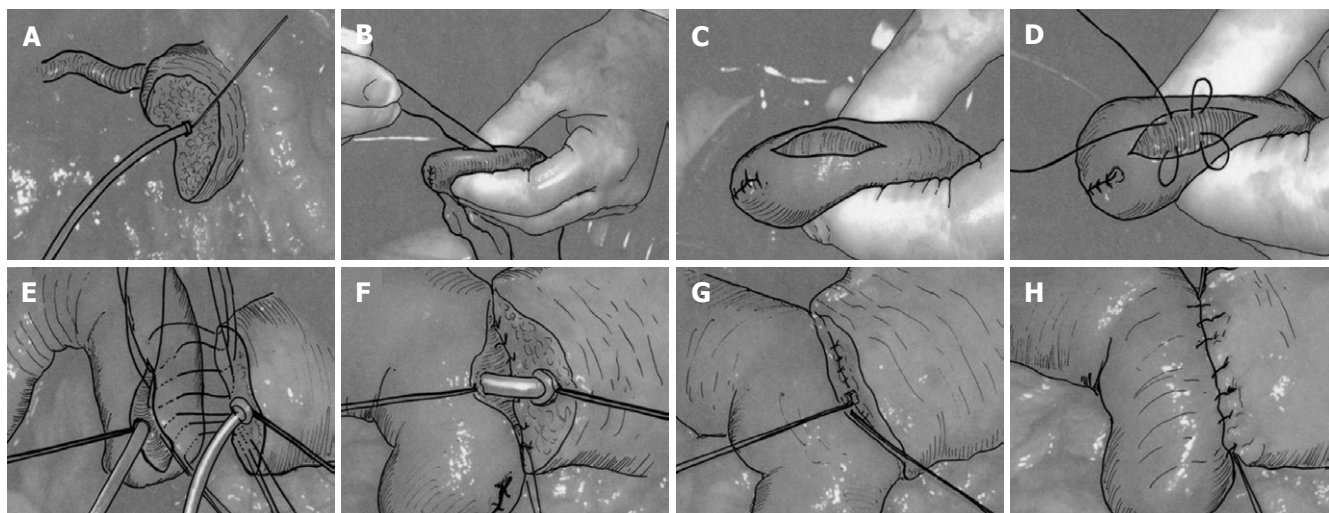


Figure 1 New Duct-to-mucosa contact method. **A:** The stent tube was ligated with the pancreatic duct by an irradiated polyglactin 910 suture; **B, C, D:** The seromuscular layer of the jejunal wall was cut. The submucosa was exposed and a purse-string suture using an irradiated polyglactin 910 suture was performed at the center, where another tip of the stent tube was introduced and ligated by this suture material; **E, F, G:** After the posterior side of the pancreatic parenchyma was anastomosed to the seromuscular layer of the jejunal wall, two stay sutures of the stent tube were ligated to approximate the pancreatic ductal cut end and the jejunal mucosa; **H:** The pancreaticojejunostomy was completed by adding an anterior suture to the pancreatic parenchyma and the jejunal wall.

this study. The reconstruction of the pancreatic stump after the pancreaticoduodenectomy was performed by a pancreaticojejunostomy in two fashions, the conventional duct-to-mucosa anastomosis, or a new duct-to-mucosa contact method. Five surgeons performed either of the anastomotic techniques, as was their preference, however, one of the authors, KH, supervised all operations and the procedures were strictly standardized in the institute.

The postoperative management was prescribed according to the clinical pathway. The amylase level in the peripancreatic external drain was measured on postoperative d 1, 3 and 6. In this study, a pancreatic fistula was defined by four internationally well-documented criteria, which are described as follows: (1) drainage of more than 50 mL per day of fluid with an amylase content above three times the serum amylase activity on and after postoperative d 10 as described by Yeo *et al*^[30] (Definition A); (2) drainage of more than 50 mL per day of fluid with an amylase content above three times the serum amylase activity on and after postoperative d 7 as described by Park *et al*^[31] (Definition B); (3) drainage of more than 10 mL per day of fluid with an amylase content above three times the serum amylase activity on and after postoperative d 4 as described by Buchler *et al*^[32] and Pederzoli *et al*^[33] (Definition C); (4) drainage of any measurable volume of fluid with an amylase content greater than three times the normal serum value on or after postoperative d 3 according to the International Study Group of Pancreatic Fistula (ISGPF) classification scheme^[34,35]. According to the ISGPF definition, outcomes were divided into four grades: (1) no fistula; (2) Grade A: biochemical fistula without clinical sequelae; (3) Grade B: fistula that shows clinical symptoms or requires any therapeutic intervention; (4) Grade C: fistula with severe clinical sequelae. The occurrence of Grade B or C fistulas is included in the postoperative morbidity. A delayed gastric emptying is defined as the need for nasogastric drainage for more than 10 d^[2,7,12], or as the delay of the resumption of a regular diet beyond 14 d

postoperatively^[36]. Computed tomography (CT), either a helical CT or a multidirector row CT, was performed serially before discharge and on the third and sixth postoperative month to rule out cancer recurrence. Based on these findings, the diameter of the main pancreatic duct ventral to the base of the superior mesenteric artery was measured by an enhanced computed tomogram. A progression of pancreatic ductal dilatation was defined by the diameter on the sixth month CT being 130% or greater than that before the hospital discharge. The glucose tolerance was evaluated serially by blood hemoglobin A_{1c} or a 75-g oral glucose tolerance test at the same intervals as the CT scans. Diabetes mellitus was defined as a fasting glucose level greater than 1.26 g/L or a two-hour glucose level greater than 2 g/L.

The data were collected prospectively for all patients and included the preoperative historical information and laboratory data, the details of the operative procedure, the pathology, and the clinical information regarding the postoperative course, postoperative morbidity and mortality, and the late complications occurring at least 6 mo postoperatively.

The statistical analyses were performed using the SPSS 11.0 statistical software. The comparisons between the two groups were carried out by Chi-square test for the categorical data and Student's *t*-test for the continuous data. The continuous variables were reported as the mean \pm SD. *P* values less than 0.05 were thought to be significantly different.

Surgical procedures

New Duct-to-mucosa contact method: The pancreatic transection was performed with an electrocautery or a scalpel. A stent tube (5, 6, or 7.5 Fr, Sumitomo Bakelite, Tokyo, Japan) with a notch near the tip was inserted into the lumen of the main pancreatic duct. The stent tube was ligated with the pancreatic duct near the cut end by a 4-0 fast-absorbable synthetic suture, irradiated polyglactin 910 (vicryl RAPIDETM, Ethicon, Somerville, N.J.) (Figure 1 A),

Table 1 Preoperative and operative data

	New method <i>n</i> (%)	Conventional method <i>n</i> (%)	<i>P</i>
Patient number	35	28	
Male/female	20/15	11/17	0.77
Age (yr)	64.1 ± 9.2	68.0 ± 8.6	0.09
Preoperative biliary drainage	28 (80)	19 (68)	0.27
Diabetes mellitus	8 (23)	13 (46)	0.05
Weight loss > 10%	4 (11)	4 (14)	0.74
Operative indications			< 0.01
Biliary adenocarcinoma ¹	28 (80)	10 (36)	
Ampullary adenocarcinoma	2 (6)	2 (7)	
Duodenal adenocarcinoma	1 (3)	1 (4)	
Pancreatic adenocarcinoma	0	12 (43)	
Other pancreatic neoplasm ²	4 (11)	3 (11)	
Type of resection			0.44
Classical Whipple	6 (17)	7 (25)	
Pylorus-preserving	29 (83)	21 (75)	
Pancreaticojejunostomy	35 (100)	28 (100)	-
Diameter of pancreatic duct (mm)	2.4 ± 0.5	4.2 ± 1.9	< 0.01
Operative time (min)	392 ± 72	418 ± 110	0.24
Time after resection (min)	187 ± 56	181 ± 66	0.74
Blood loss (g)	1074 ± 490	1112 ± 607	0.78
Patients transfused	5 (14)	5 (18)	0.7

¹Carcinomas of the bile duct and the gallbladder; ²Non-invasive intraductal papillary-mucinous neoplasm, islet cell tumor, and lymphangiohemangioma of the pancreatic head.

The notch functions to prevent the tube from dislodging. The jejunal limb was moved to the pancreatic cut end by a retro-mesenteric route. The seromuscular layer of the jejunum was cut at the anti-mesenteric side, and the serosal side of the mucosa was exposed by the same width as the pancreatic cut surface (Figure 1B and C). A purse-string suture was made by using a 4-0 irradiated polyglactin 910 at the center of the mucosa, where another tip of the stent tube was introduced into the intestinal lumen, and ligated by this fast-absorbable suture (Figure 1D). After the posterior side of the pancreatic parenchyma was anastomosed to the seromuscular layer of the jejunal wall by using 4-0 polydioxanone suture, a long-lasting absorbable synthetic suture (PDS-IITM, Ethicon) (Figure 1E and F), two stay sutures of irradiated polyglactin 910 were ligated together to approximate the ductal cut end and the jejunal mucosa (Figure 1G). No other suture was added to the duct-to-mucosa contact. Next, the anterior side of the pancreatic parenchyma was anastomosed to the seromuscular layer of the anterior wall of the jejunum by polydioxanone sutures (Figure 1H). The other tip of the tube was introduced extracorporeally through the transhepatic or transintestinal route. The pancreatic juice flowed through the lumen of the stent tube and then drained externally. The whole anastomotic procedure usually required 10 to 15 min at maximum.

After confirmation of a stable anastomosis by the tube pancreatography on postoperative d 14, the tube could be pulled out without any resistance.

Conventional Duct-to-mucosa anastomosis

After the posterior side of the pancreatic parenchyma was anastomosed to the wall of the seromuscular layer

of the jejunum by using 4-0 polydioxanone sutures, the pancreatic ductal end was anastomosed to the small hole at the antimesenteric side of the jejunal limb by using 5-0 polydioxanone sutures in an interrupted fashion. Then the anterior side of the pancreatic parenchyma was anastomosed to the wall of the seromuscular layer of the jejunum by using 5-0 polydioxanone sutures. No stent tube was used.

RESULTS

The new duct-to-mucosa contact method was applied to 35 patients, while the conventional duct-to-mucosa anastomosis was performed in 28 patients (Table 1). The male-to-female ratio was the same between the two groups; however the duct-to-mucosa contact method was applied to older patients. There were no differences in the presence of jaundice, diabetes mellitus, or malnutritional status, which was defined as a 10% or greater weight loss.

The operative indications were different between the two groups. The duct-to-mucosa contact method was applied more frequently to biliary cancer, while the conventional duct-to-mucosa anastomosis was preferred in pancreatic cancer. The diameters of the pancreatic duct at the cut surface were significantly smaller in the duct-to-mucosa contact method group (2.4 ± 0.5 vs 4.2 ± 1.9 mm, $P < 0.01$). The total operative time, as well as the time after resection, was the same between the two groups. The amount of blood loss and the number of patients transfused were comparable in both groups.

Postoperative complications occurred equally to both groups (Table 2). Pancreatic fistula was noted in 3% of the patients in the duct-to-mucosa contact method group and in 7% in the duct-to-mucosa anastomosis group ($P = 0.43$) according to Definition A. By the more strict definitions of Definition B and C, pancreatic fistula was found in 8% and 17% by the new method, while in 8% and 11% by the conventional method, respectively ($P = 0.77$ and $P = 0.47$). Fistulas of any grade (Grade A-C) by the ISGPF definition occurred in the same degree. Moreover, the incidences of Grade B or C fistulas, which were categorized into clinically relevant fistulas, were also comparable between the two groups (17% vs 14%, $P = 0.76$). Intestinal bleeding from the ruptured pseudoaneurysm of the common hepatic artery, which occurred in a patient treated with duct-to-mucosa anastomosis on postoperative d 21, was successfully treated with radiological intervention using a self-expandable metallic stent. Other abdominal and non-abdominal complications, both infectious and non-infectious, were comparable between the two groups. No operative mortality was found in this series. The length of hospital stay and the re-admission rate were equal in both groups.

A late pancreatic ductal dilatation, as determined by a comparison with the ductal diameter before discharge, was noted in one patient in each group. An exacerbation of diabetes mellitus was rarely found in either group, and the recovery of body weight was comparable between the two groups.

DISCUSSION

Pancreatic fistula is the major cause of postoperative

Table 2 Postoperative course, complications and late outcome

	New method	Conventional method	P
	n (%)	n (%)	
Morbidity ¹	16 (46)	11 (39)	0.61
Abdominal complications	15 (43)	10 (36)	0.56
Pancreatic fistula			
Definition A (Yeo <i>et al</i>)	1 (3)	2 (7)	0.43
Definition B (Park <i>et al</i>)	3 (8)	3 (8)	0.77
Definition C (Buchler <i>et al</i>)	6 (17)	3 (11)	0.47
Grade B or C by ISGPF definition	6 (17)	4 (14)	0.76
ISGPF definition			
No fistula	20 (57)	21 (75)	0.23
Grade A	9 (26)	3 (11)	
Grade B	6 (17)	3 (11)	
Grade C	0	1 (4)	
Biliary leakage	0	0	-
Intraabdominal abscess	2 (6)	4 (14)	0.25
Intraabdominal bleeding	0	0	-
Intestinal bleeding	0	1 (4)	0.26
Delayed gastric emptying	2 (6)	0	0.20
Liver abscess	0	1 (4)	0.26
Wound infection	2 (6)	0	0.20
Other complications	1 (3)	2 (7)	0.43
Pneumonia	0	1 (4)	0.26
Pulmonary embolism	0	1 (4)	0.26
Catheter fever	1 (3)	0	0.37
Re-operation	0	0	-
In-hospital mortality	0	0	-
Hospital stay (d)	29.5 ± 10.9	28.0 ± 12.2	0.60
Re-admission within 30 d	1 (3)	1 (4)	0.87
Late complications ²			
Progression of ductal dilatation	1 (3)	1 (4)	0.87
Exacerbation of diabetes	1 (3)	1 (4)	0.87
Body weight gain (%) ³	100.3 ± 4.6	101.3 ± 9.0	0.65

¹Total patients with one or more complications; ²Comparison before hospital discharge and on the sixth month; ³Percent body weight gain at 6th month in comparison to that at the time of discharge.

morbidity and mortality after pancreaticoduodenectomy. The incidence is estimated to be 5% to 30%^[1,5,7,34,35], which varies according to the definition^[34,35]. Many risk factors for pancreatic fistula have been disclosed, among which the most significant factors are thought to be a soft pancreatic texture, a narrow pancreatic duct, and a high output of pancreatic juice^[3,8-13].

Pancreaticocenterostomy is the most physiologic method to deal with the remnant pancreatic stump, because the continuity of the pancreatic exocrine and intestinal functions can be restored^[37-39]. Indeed, a pancreaticocenterostomy, either *via* a pancreatico-jejunostomy or a pancreaticogastrostomy, is easy to perform in cases of a dilated pancreatic duct with a firm texture of the pancreatic parenchyma, but in cases with a normal pancreas, it is quite hard to anastomose a narrow pancreatic duct and a fragile parenchyma to the jejunal or gastric wall^[11,13,40]. To overcome the technical difficulties of performing a pancreaticocenterostomy of a soft pancreas, we have developed a new anastomotic technique of a "duct-to-mucosa contact method" by using a fast absorbable suture material and a temporary stent tube.

In this method, the pancreatic ductal end is approximated to the serosal side of the jejunal mucosa by ligating two stay sutures of the temporary stent tube. This method can be applied easily to a narrow pancreatic

duct if the stent tube can be inserted into it. In our series, the mean diameter of the pancreatic duct in the duct-to-mucosa contact method group was significantly smaller than that in the conventional duct-to-mucosa anastomosis group. The surgeons tended to choose this method for the narrow duct because it was a very simple procedure and they did not need to hold a fine needle or use a surgical microscope^[21].

The priority of this method is the use of an irradiated polyglactin 910 suture. This synthetic absorbable suture material has an initial strength comparable to that of nylon but it loses its tensile strength rapidly, being 50% at 5 d and almost none at 14 d, according to the commercial information^[41]. An added advantage of this material is the very mild inflammatory reaction of the surrounding tissues^[42,43]. These characteristics favor its use in the field of oral surgery^[44,45] as well as in pediatric^[42], gynecological^[46,47], and plastic surgery^[48,49].

In this duct-to-mucosa contact method, the irradiated polyglactin 910 suture was used to secure the complete external drainage of the pancreatic juice and to approximate the pancreatic duct and the mucosa for about a week. The anastomosis of the pancreatic parenchyma and the intestinal seromuscular wall was secured by the more long-lasting absorbable synthetic sutures comprised of polydioxanone^[50]. In most cases, the color of the drained pancreatic juice changes from transparent to bile-staining by POD 14, when the irradiated polyglactin 910 has already been degraded and the stent can be removed without any resistance. These phenomena suggested to us that the exposure of the pancreatic juice to the anastomotic site could be avoided for about 2 wk postoperatively.

It has been suggested that the rate of formation of a pancreatic fistula varies according to the definition. Bassi *et al*^[34] summarized the current pancreatic fistula concept by analyzing 26 definitions described in the past 10 year, and applied four definitions to a group of 242 patients undergoing a pancreaticojejunostomy after a pancreatic resection. They found the incidence of pancreatic fistula to range from 9.9% to 28.5% according to the different definitions applied. Pratt *et al*^[35] also reported incidences of pancreatic fistula between 9.1% and 19.3% by applying different definitions to 176 patients undergoing a pancreaticoduodenectomy. As a result, it is quite important to use a universally accepted definition of pancreatic fistula to compare the different aspects of the new surgical method with the conventional one. In this study, we applied three well-documented definitions as described by Yeo *et al* (1995)^[7], Park (1998)^[31], and Buchler (1992)^[32] and Pederzoli (1994)^[33] to help compare our results with those of previous reports. We examined a high risk group of pancreatic fistula in which the pancreatic texture was soft and the pathology confirmed the absence of fibrosis and pancreatitis change. Nevertheless, the incidences were comparable to the overall incidences of the previous reports using these definitions^[1,3,6,7,12,13,22,29], or were even lower than those in cases restricted to the soft pancreas^[9,10]. In a current objective definition by the ISGPF classification scheme, Pratt *et al*^[35] reported an overall incidence of 11.9% in Grade B fistula and 3.4% in

Grade C fistula, which were comparable with our results of 14.4% in Grade B fistula and 1.6% in Grade C fistula. A subgroup analysis of the incidences of pancreatic fistula limited to the soft pancreas in each Grade according to the ISGPF definition has not yet been reported to date.

Consequently, the total incidence of the postoperative infectious and non-infectious complications was not different from that with conventional duct-to-mucosa anastomosis. The late status of the anastomotic site also seemed to be stable according to the serial measurements of the pancreatic ductal diameter as determined by CT scans. Good recovery of the nutritional status and avoiding worsening of the diabetic symptoms seemed to be primarily due to the uniform preoperative backgrounds of the normally functioning pancreas in this series, but these results may indirectly favor the use of this new method.

The primary aim of this study was to introduce a new method of performing a pancreaticojejunostomy, because this method is quite easy to perform even in a difficult anastomosis of a narrow duct of a normal soft pancreas. Indeed any conclusion for the surgical method needs to await randomization or a good cohort study, but our preliminary results were comparable with those previously reported from mass volume centers. These facts seem to justify the carrying out of a randomized prospective study to compare this new method with appropriate controls.

COMMENTS

Background

A narrow pancreatic duct with a soft pancreatic texture creates a high risk for the development of a pancreatic fistula after pancreaticoduodenectomy. Several methods have been advocated to reduce the occurrence of leakage, but the best technique is still a subject of debate.

Research frontiers

The authors developed a new method for performing a pancreaticojejunostomy with a fast-absorbable suture material, irradiated polyglactin 910, and a temporary stent tube.

Innovation and breakthrough

This easy-to-perform method was feasible in cases with narrow pancreatic duct and a soft pancreas. Both early and late surgical results were comparable to or better than the methods ever reported.

Applications

This method is expected to give a new idea of overcoming the difficulties of pancreaticoenterostomy for a soft pancreatic texture with a narrow pancreatic duct.

Peer review

In this study, 35 consecutive patients with a soft pancreas undergoing a pancreaticoduodenectomy from 2003 to 2006 were treated by a new reconstructive method. This work adds significant information for future development of pancreaticojejunostomy therapy.

REFERENCES

- Aranha GV, Aaron JM, Shoup M, Pickleman J. Current management of pancreatic fistula after pancreaticoduodenectomy. *Surgery* 2006; **140**: 561-568; discussion 568-569
- Bassi C, Falconi M, Salvia R, Mascetta G, Molinari E, Pederzoli P. Management of complications after pancreaticoduodenectomy in a high volume centre: results on 150 consecutive patients. *Dig Surg* 2001; **18**: 453-457; discussion 458
- DeOliveira ML, Winter JM, Schafer M, Cunningham SC, Cameron JL, Yeo CJ, Clavien PA. Assessment of complications after pancreatic surgery: A novel grading system applied to 633 patients undergoing pancreaticoduodenectomy. *Ann Surg* 2006; **244**: 931-937; discussion 937-939
- Goonetilleke KS, Siriwardena AK. Nationwide questionnaire survey of the contemporary surgical management of pancreatic cancer in the United Kingdom & Ireland. *Int J Surg* 2007; **5**: 147-151
- Lygidakis NJ, Jain S, Sacchi M, Vrachnos P. Reappraisal of a method of reconstruction after pancreatoduodenectomy. *Hepatogastroenterology* 2005; **52**: 1077-1082
- Schmidt CM, Powell ES, Yiannoutsos CT, Howard TJ, Wiebke EA, Wiesenauer CA, Baumgardner JA, Cummings OW, Jacobson LE, Broadie TA, Canal DF, Goulet RJ Jr, Curie EA, Cardenes H, Watkins JM, Loehrer PJ, Lillemoe KD, Madura JA. Pancreaticoduodenectomy: a 20-year experience in 516 patients. *Arch Surg* 2004; **139**: 718-725; discussion 725-727
- Yeo CJ, Cameron JL, Sohn TA, Lillemoe KD, Pitt HA, Talamini MA, Hruban RH, Ord SE, Sauter PK, Coleman J, Zahurak ML, Grochow LB, Abrams RA. Six hundred fifty consecutive pancreaticoduodenectomies in the 1990s: pathology, complications, and outcomes. *Ann Surg* 1997; **226**: 248-257; discussion 257-260
- Cheng Q, Zhang B, Zhang Y, Jiang X, Zhang B, Yi B, Luo X, Wu M. Predictive factors for complications after pancreaticoduodenectomy. *J Surg Res* 2007; **139**: 22-29
- Lin JW, Cameron JL, Yeo CJ, Riall TS, Lillemoe KD. Risk factors and outcomes in postpancreaticoduodenectomy pancreaticocutaneous fistula. *J Gastrointest Surg* 2004; **8**: 951-959
- Marcus SG, Cohen H, Ranson JH. Optimal management of the pancreatic remnant after pancreaticoduodenectomy. *Ann Surg* 1995; **221**: 635-645; discussion 645-648
- Muscari F, Suc B, Kirzin S, Hay JM, Fourtanier G, Fingerhut A, Sastre B, Chipponi J, Fagniez PL, Radovanovic A. Risk factors for mortality and intra-abdominal complications after pancreatoduodenectomy: multivariate analysis in 300 patients. *Surgery* 2006; **139**: 591-598
- van Berge Henegouwen MI, De Wit LT, Van Gulik TM, Obertop H, Gouma DJ. Incidence, risk factors, and treatment of pancreatic leakage after pancreaticoduodenectomy: drainage versus resection of the pancreatic remnant. *J Am Coll Surg* 1997; **185**: 18-24
- Yang YM, Tian XD, Zhuang Y, Wang WM, Wan YL, Huang YT. Risk factors of pancreatic leakage after pancreaticoduodenectomy. *World J Gastroenterol* 2005; **11**: 2456-2461
- Bassi C, Butturini G, Salvia R, Crippa S, Falconi M, Pederzoli P. Open pancreaticogastrostomy after pancreaticoduodenectomy: a pilot study. *J Gastrointest Surg* 2006; **10**: 1072-1080
- Kakita A, Yoshida M, Takahashi T. History of pancreaticojejunostomy in pancreaticoduodenectomy: development of a more reliable anastomosis technique. *J Hepatobiliary Pancreat Surg* 2001; **8**: 230-237
- Labas P, Ohradka B, Cambal M, Fillo J. Pancreatic duct occlusion with acrylic glue after pancreas resection. *Przegl Lek* 2003; **60**: 789-791
- Payne RF, Pain JA. Duct-to-mucosa pancreaticogastrostomy is a safe anastomosis following pancreaticoduodenectomy. *Br J Surg* 2006; **93**: 73-77
- Peng SY, Wang JW, Lau WY, Cai XJ, Mou YP, Liu YB, Li JT. Conventional versus binding pancreaticojejunostomy after pancreaticoduodenectomy: a prospective randomized trial. *Ann Surg* 2007; **245**: 692-698
- Tanaka T, Matsugu Y, Fukuda Y. Use of ultrasonically activated shears improves the safety of pancreaticojejunostomy after pancreaticoduodenectomy. *Arch Surg* 2002; **137**: 1258-1261
- Tani M, Onishi H, Kinoshita H, Kawai M, Ueno M, Hama T, Uchiyama K, Yamaue H. The evaluation of duct-to-mucosal pancreaticojejunostomy in pancreaticoduodenectomy. *World J Surg* 2005; **29**: 76-79
- Wada K, Traverso LW. Pancreatic anastomotic leak after the Whipple procedure is reduced using the surgical microscope.

- Surgery* 2006; **139**: 735-742
- 22 **Duffas JP**, Suc B, Msika S, Fourtanier G, Muscari F, Hay JM, Fingerhut A, Millat B, Radovanowic A, Fagniez PL. A controlled randomized multicenter trial of pancreatogastrostomy or pancreatojejunostomy after pancreatoduodenectomy. *Am J Surg* 2005; **189**: 720-729
 - 23 **Kaido T**. Recent randomized controlled trials in pancreaticoduodenectomy. *Pancreas* 2006; **33**: 228-232
 - 24 **Li-Ling J**, Irving M. Somatostatin and octreotide in the prevention of postoperative pancreatic complications and the treatment of enterocutaneous pancreatic fistulas: a systematic review of randomized controlled trials. *Br J Surg* 2001; **88**: 190-199
 - 25 **Lillemoe KD**, Cameron JL, Kim MP, Campbell KA, Sauter PK, Coleman JA, Yeo CJ. Does fibrin glue sealant decrease the rate of pancreatic fistula after pancreaticoduodenectomy? Results of a prospective randomized trial. *J Gastrointest Surg* 2004; **8**: 766-772; discussion 772-774
 - 26 **Shrikhande SV**, Qureshi SS, Rajneesh N, Shukla PJ. Pancreatic anastomoses after pancreaticoduodenectomy: do we need further studies? *World J Surg* 2005; **29**: 1642-1649
 - 27 **Suc B**, Msika S, Fingerhut A, Fourtanier G, Hay JM, Holmieres F, Sastre B, Fagniez PL. Temporary fibrin glue occlusion of the main pancreatic duct in the prevention of intra-abdominal complications after pancreatic resection: prospective randomized trial. *Ann Surg* 2003; **237**: 57-65
 - 28 **Wente MN**, Shrikhande SV, Muller MW, Diener MK, Seiler CM, Friess H, Buchler MW. Pancreaticojejunostomy versus pancreaticogastrostomy: systematic review and meta-analysis. *Am J Surg* 2007; **193**: 171-183
 - 29 **Winter JM**, Cameron JL, Campbell KA, Chang DC, Riall TS, Schulick RD, Choti MA, Coleman J, Hodgin MB, Sauter PK, Sonnenday CJ, Wolfgang CL, Marohn MR, Yeo CJ. Does pancreatic duct stenting decrease the rate of pancreatic fistula following pancreaticoduodenectomy? Results of a prospective randomized trial. *J Gastrointest Surg* 2006; **10**: 1280-1290; discussion 1290
 - 30 **Yeo CJ**, Cameron JL, Maher MM, Sauter PK, Zahurak ML, Talamini MA, Lillemoe KD, Pitt HA. A prospective randomized trial of pancreaticogastrostomy versus pancreaticojejunostomy after pancreaticoduodenectomy. *Ann Surg* 1995; **222**: 580-588; discussion 588-592
 - 31 **Park BJ**, Alexander HR, Libutti SK, Huang J, Royalty D, Skarulis MC, Jensen RT, Gorden P, Doppman JL, Shawker TH, Fraker DL, Norton JA, Bartlett DL. Operative management of islet-cell tumors arising in the head of the pancreas. *Surgery* 1998; **124**: 1056-1061; discussion 1061-1062
 - 32 **Buchler M**, Friess H, Klempa I, Hermanek P, Sulkowski U, Becker H, Schafmayer A, Baca I, Lorenz D, Meister R. Role of octreotide in the prevention of postoperative complications following pancreatic resection. *Am J Surg* 1992; **163**: 125-130; discussion 130-131
 - 33 **Pederzoli P**, Bassi C, Falconi M, Camboni MG. Efficacy of octreotide in the prevention of complications of elective pancreatic surgery. Italian Study Group. *Br J Surg* 1994; **81**: 265-269
 - 34 **Bassi C**, Dervenis C, Butturini G, Fingerhut A, Yeo C, Izbicki J, Neoptolemos J, Sarr M, Traverso W, Buchler M. Postoperative pancreatic fistula: an international study group (ISGPF) definition. *Surgery* 2005; **138**: 8-13
 - 35 **Pratt WB**, Maithel SK, Vanounou T, Huang ZS, Callery MP, Vollmer CM Jr. Clinical and economic validation of the International Study Group of Pancreatic Fistula (ISGPF) classification scheme. *Ann Surg* 2007; **245**: 443-451
 - 36 **Riediger H**, Makowiec F, Schareck WD, Hopt UT, Adam U. Delayed gastric emptying after pylorus-preserving pancreatoduodenectomy is strongly related to other postoperative complications. *J Gastrointest Surg* 2003; **7**: 758-765
 - 37 **Bartoli FG**, Arnone GB, Ravera G, Bachi V. Pancreatic fistula and relative mortality in malignant disease after pancreaticoduodenectomy. Review and statistical meta-analysis regarding 15 years of literature. *Anticancer Res* 1991; **11**: 1831-1848
 - 38 **Felekouras E**, Kyriakopoulos A, Griniatsos J, Papalambros E, Bramis J, Bastounis E. Pancreaticojejunostomy versus alternative treatment of the pancreatic stump after pancreaticoduodenectomy: a comparative analysis of early postoperative outcome. *Int Surg* 2004; **89**: 221-226
 - 39 **Popiela T**, Kedra B, Sierzega M, Gurda A. Risk factors of pancreatic fistula following pancreaticoduodenectomy for periampullary cancer. *Hepatogastroenterology* 2004; **51**: 1484-1488
 - 40 **Ohwada S**, Tanahashi Y, Ogawa T, Kawate S, Hamada K, Tago KI, Yamada T, Morishita Y. In situ vs ex situ pancreatic duct stents of duct-to-mucosa pancreaticojejunostomy after pancreaticoduodenectomy with billroth I-type reconstruction. *Arch Surg* 2002; **137**: 1289-1293
 - 41 http://www.ethicon.novartis.us/brands/en/vicryl_rapide.shtml
 - 42 **Duprez K**, Bilweis J, Duprez A, Merle M. Experimental and clinical study of fast absorption cutaneous suture material. *Ann Chir Main* 1988; **7**: 91-96
 - 43 **Tandon SC**, Kelly J, Turtle M, Irwin ST. Irradiated polyglactin 910: a new synthetic absorbable suture. *J R Coll Surg Edinb* 1995; **40**: 185-187
 - 44 **Aderriotis D**, Sandor GK. Outcomes of irradiated polyglactin 910 Vicryl Rapide fast-absorbing suture in oral and scalp wounds. *J Can Dent Assoc* 1999; **65**: 345-347
 - 45 **McCaul LK**, Bagg J, Jenkins WM. Rate of loss of irradiated polyglactin 910 (Vicryl Rapide) from the mouth: a prospective study. *Br J Oral Maxillofac Surg* 2000; **38**: 328-330
 - 46 **Greenberg JA**, Lieberman E, Cohen AP, Ecker JL. Randomized comparison of chromic versus fast-absorbing polyglactin 910 for postpartum perineal repair. *Obstet Gynecol* 2004; **103**: 1308-1313
 - 47 **Kettle C**, Hills RK, Jones P, Darby L, Gray R, Johanson R. Continuous versus interrupted perineal repair with standard or rapidly absorbed sutures after spontaneous vaginal birth: a randomised controlled trial. *Lancet* 2002; **359**: 2217-2223
 - 48 **Brackeen AR**, Wells MJ, Freed JM. Irradiated polyglactin 910 (Vicryl Rapide) for placement of full-thickness skin grafts. *Dermatol Surg* 2005; **31**: 1707-1709
 - 49 **Parell GJ**, Becker GD. Comparison of absorbable with nonabsorbable sutures in closure of facial skin wounds. *Arch Facial Plast Surg* 2003; **5**: 488-490
 - 50 **Muftuoglu MA**, Ozkan E, Saglam A. Effect of human pancreatic juice and bile on the tensile strength of suture materials. *Am J Surg* 2004; **188**: 200-203

S- Editor Yang RH L- Editor Alpini GD E- Editor Yin DH