In search of the best reconstructive technique after pancreaticoduodenectomy: pancreaticojejunostomy versus pancreaticogastrostomy

Jan Grendar, MD
Jean-François Ouellet, MD
Francis R. Sutherland, MD
Oliver F. Bathe, MD, MSc
Chad G. Ball, MD, MSc
Elijah Dixon, MD, MSc

Accepted for publication
Oct. 15, 2014

Early-released on Apr. 1, 2015; subject to
revision

Correspondence to:

E. Dixon
Division of General Surgery
Faculty of Medicine, University of
Calgary
EG — 26, Foothills Medical Centre
1403 — 29 Street NW
Calgary AB T2N 2T9
elijah.dixon@albertahealthservices.ca

DOI: 10.1503/cjs.010014

Background: It has been suggested that pancreaticogastrostomy (PG) is a safer reconstruction than pancreaticojejunostomy (PJ), resulting in lower morbidity, including lower pancreatic leak rates and decreased postoperative mortality. We compared PJ and PG after pancreaticoduodenectomy (PD).

Methods: A randomized clinical trial was designed. It was stopped with 50% accrual. Patients underwent either PG or PJ reconstruction. The primary outcome was the pancreatic fistula rate, and the secondary outcomes were overall morbidity and mortality. We used the Student *t*, Mann–Whitney *U* and χ^2 tests for intention to treat analysis. The effect of randomization, American Society of Anesthesiologists score, soft pancreatic texture and use of pancreatic stent on overall complications and fistula rates was calculated using logistic regression.

Results: Our trial included 98 patients. The rate of pancreatic fistula formation was 18% in the PJ and 25% in the PG groups ($p = 0.40$). Postoperative complications occurred in 48% of patients in the PJ and 58% in the PG groups ($p = 0.31$). There were no significant predictors of overall complications in the multivariate analysis. Only soft pancreatic gland predicted the occurrence of pancreatic fistula (odds ratio 5.89, $p = 0.003$).

Conclusion: There was no difference in the rates of pancreatic leak/fistula, overall complications or mortality between patients undergoing PG and those undergoing PJ after PD.

Contexte : Selon certains, la pancréatogastrostomie (PG) est une technique de reconstruction plus sécuritaire que la pancréatojéjunostomie (PJ) et entraîne une morbidité moindre, y compris un taux moins élevé de fuites pancréatiques et une mortalité postopératoire diminuée. Nous avons comparé la PJ et la PG post-pancréatoduodénectomie.

Méthodes : Un essai clinique randomisé a été conçu et cessé à l'atteinte d'un taux de participation de 50 %. Les patients ont subi une reconstruction par PG ou par PJ. Le paramètre principal était le taux de fistules pancréatiques et les paramètres secondaires étaient la morbidité et la mortalité globales. Nous avons utilisé les tests *t* de Student, *U* de Mann–Whitney et du χ^2 carré pour l'analyse en intention de traiter. Nous avons calculé l'effet de la randomisation, du score de l'American Society of Anesthesiologists, de la consistance molle du pancréas et du recours à l'endoprothèse pancréatique sur les complications globales et les taux de fistules à l'aide d'une analyse de régression logistique.

Résultats : Notre essai a regroupé 98 patients. Le taux de fistules pancréatiques a été de 18 % dans le groupe soumis à la PJ et de 25 % dans le groupe soumis à la PG ($p = 0,40$). Des complications postopératoires sont survenues chez 48 % des patients du groupe soumis à la PJ et chez 58 % du groupe soumis à la PG ($p = 0,31$). Aucun prédicteur significatif des complications globales n'est ressorti à l'analyse multivariée. Seule la consistance molle du pancréas a permis de prédire la survenue d'une fistule pancréatique (rapport des cotes 5,89, $p = 0,003$).

Conclusion : Nous n'avons noté aucune différence quant aux taux de fuites ou de fistules pancréatiques, de complications globales ou de mortalité entre les patients soumis à la PG et à la PJ post-pancréatoduodénectomie.

The first pancreatic resections were performed more than 100 years ago.^{1,2} More specifically, 1-stage pancreaticoduodenectomies (PD) have been performed since the 1930s.¹ But it wasn't until the early 1990s when a drop in mortality below 5% was reported in high-volume expert centres.^{3,4} Despite this, the procedure is still associated with substantial morbidity, owing mostly to problems related to the anastomosis between the pancreas and the gastrointestinal tract. Uncontrolled leak at this site is associated with substantial complications that can start a downward spiral of sepsis, multiorgan failure and even death. Consequently, multiple strategies have been implemented and researched in order to decrease this leak rate.⁵ These include different suturing techniques; options for external and internal drainage; topical sealants; and pharmacologic prophylaxis, including octreotide.^{6,7} Another factor evaluated is the luminal organ to which the pancreas is anastomosed. The 2 main options are pancreaticojejunostomy (PJ) and pancreaticogastrostomy (PG).

Previously, mostly because of an absence of data resulting from prospective randomized trials, the choice of reconstructive technique was largely institution-specific. This is supported by a survey distributed among members of the Canadian Hepato-Pancreatico-Biliary Society that showed that 100% of the 20 high-volume pancreas surgeons across the country were using strictly PJ anastomosis (unpublished data, 2004). In contrast, some centres, particularly in Europe, preferred the option of PG anastomosis.

The theoretical advantages of PG reconstruction include the convenient location of the well-vascularized stomach; the lack of activation of pancreatic proenzymes theoretically decreasing morbidity, even in the case of a leak; and the option of relatively safe and easy drainage and control of the area with a nasogastric (NG) tube.

During the course of the present study, a number of other similar trials were published.⁸⁻¹⁵ Some of these comparisons have been summarized in recent systematic reviews and meta-analyses.¹⁶⁻²⁰ Observational studies suggested that PG is a safer reconstruction than PJ, resulting in lower morbidity, including lower pancreatic leak rates and decreased postoperative mortality.²¹⁻²⁸

METHODS

Study design

This study was designed as a single-centre randomized controlled trial consisting of standard pretreatment assessment and a randomized treatment with either PG or PJ reconstruction after a standard PD. The 2 arms received identical postoperative therapy. Neither participants, nor the health care providers were blinded to group assignment. The primary outcome was the rate of pancreatic anastomotic leak/fistula, and the secondary outcomes were overall morbidity and mortality and length of stay in hospital. The trial pro-

ocol was publicly accessible at ClinicalTrials.gov with the identifier number NCT00841607. The study was conducted from August 2006 to May 2012. Pancreatic leak/fistula was defined as either radiologically proven anastomotic leak or continued drainage (via drain, enterocutaneous fistula or wound) of lipase-rich fluid on postoperative day 10. The severity was then reclassified using the International Study Group of Pancreatic Fistula classification.²⁹ Postoperative morbidity was classified using the Clavien-Dindo system.³⁰

Randomization was performed in the operating room at the beginning of the case using sealed randomization envelopes that were computer generated. Four hepato-pancreaticobiliary (HPB) surgeons performed the procedures.

Patients

Participation in the study was offered to adult patients (≥ 18 yr) with pancreatic or periampullary neoplasms in whom preoperative imaging and clinical status suggested resectable disease and in whom PD was planned. All participants provided informed consent.

Patients younger than 18 years; adults unable to provide consent; patients with gastric involvement, metastatic disease or local unresectability; pregnant or nursing women; patients enrolled in other studies; and patients receiving radiation or chemotherapy during the perioperative time period were excluded (patients in our institution who have resectable disease undergo resection without neoadjuvant therapy). Patients were able to withdraw their consent at any time before the surgery for any reason. The University of Calgary institutional review board approved our study protocol.

Intervention

As mentioned earlier, PJ reconstruction was the preferred method of all pancreatic surgeons in major centres across Canada, including all 4 HPB surgeons in Calgary who were involved in the present study. The surgeons adopted the technique for PG described by Bassi and colleagues.³¹ In order to familiarize themselves with PG, the 4 surgeons learned the procedure by watching a step-by-step instructional video from Dr. Bassi and subsequently performed 5 procedures together as a group before starting the trial.

A standard laparotomy was performed and resectability was assessed. The texture of the pancreatic gland was assessed throughout the procedure by the staff surgeon. The texture was then recorded at the end of the case using a 5-point scale (i.e., very soft, soft, average, hard, very hard). Similarly, the size of the pancreatic duct was recorded (in millimetres). After breaking the seal on the randomization envelope, in case of resectable tumours the procedure continued with a standard resection:

either traditional PD (3 surgeons) or pylorus-preserving PD (1 surgeon). After that, reconstruction was performed using standard techniques with the only variation being the method of pancreatic anastomosis: either a PJ or a PG was performed.

For PJ, a 2-layer end-to-side anastomosis (with a separate duct-to-mucosa layer) was performed using an internal pancreatic duct stent in most cases. Surgeons were permitted slight technical differences in the techniques they developed throughout their careers; details regarding these differences were recorded. For PG, the pancreatic remnant was mobilized for at least 2 cm and then brought through a posterior gastrotomy and anastomosed in 2 layers to the posterior wall of the stomach (outer layer of pancreas to seromuscular of the stomach and inner layer of pancreas to full thickness gastric wall). In PG reconstruction, an internal pancreatic duct stent is not used because the pancreas protrudes into the lumen of the stomach and there is no anastomosis of the duct. Use of a stent was considered only in case of a substantial kink of the usually soft gland as a result of this anastomosis.

Postoperative care was provided using a standardized order set to achieve homogeneity regardless of the arm in which the patient was randomly assigned. Individualization in terms of timing of removal of NG tubes and drains, use of octreotide or blood transfusions and progression of care was then based on regular assessment by the team. We analyzed the lipase level in fluid from external drains on postoperative day 3. The drains were removed if the fluid was not lipase-rich. In case of lipase-rich contents, the fluid was retested on postoperative day 10.

Sample size calculation

We performed a 2-sample power calculation with equal variances and normal distribution based on a primary outcome of a pancreatic fistula rate of $15\% \pm 10\%$, as suggested in previous trials and reviews.^{11,16} We used a significance threshold of $p < 0.05$ and a power of 0.9 to detect a clinically meaningful decrease in fistula rate by 5%. This calculation indicated that 85 patients were needed in each study arm for a total of 170 patients.

Early study termination

During the course of the trial, 2 of the participating surgeons lost clinical equipoise owing to personal experience with the 2 reconstruction techniques and to emerging results from other centres. The surgeons believed that continuing to offer PJ reconstruction to patients with very soft pancreases was not in the patients' best interest, and the surgeons refused to follow the arm to which the patients were randomly assigned. As a result, 4 patients crossed over from the PJ to the PG arm, and the study was prematurely stopped with only 98 patients enrolled.

Statistical methods

We performed an intention to treat analysis. We compared continuous variables using the Student *t* test and categorical variables using the χ^2 test. Nonparametric data were compared using the Mann–Whitney *U* test. These analyses compared preoperative patient characteristics, intraoperative events and postoperative outcomes with a main focus on overall postoperative complications and overall pancreatic fistula rates.

It is well documented that pancreatic texture significantly influences rates of pancreatic fistulas and postoperative complications.¹⁶ We can also expect that higher American Society of Anesthesiologists (ASA) scores on preoperative assessment should predict postoperative complications. Based on face validity we performed age- and sex-adjusted logistic regression to identify the influence of these factors (ASA score, pancreatic texture, randomization to PJ reconstruction) on overall postoperative complications and overall pancreatic fistula rates. We dichotomized the pancreatic gland texture into soft (texture ratings 1 and 2) versus nonsoft (ratings 3–5) for these calculations. Both pancreatic gland texture and pancreatic duct size were previously validated predictors of pancreatic leak.³² Because both factors assess a characteristic of the pancreatic gland, we selected only pancreatic gland texture for our calculation.

During the initial design of the study, the use of pancreatic duct stent was considered a characteristic of the reconstruction. A stent was being used in the PJ anastomosis where duct-to-mucosa is one of the layers. In the PG reconstruction a stent was not going to be used because the anastomosis does not involve suturing the pancreatic duct. It is an anastomosis between the pancreatic capsule and the wall of the stomach. Owing to premature termination of the trial and variability in the use of a pancreatic duct stent in the PG group, this variable became a potentially important confounder and was therefore included as a fourth variable in the multivariate analysis.

We considered results to be significant at $p < 0.05$, and we used STATA software version 12 (StataCorp) for all calculations. Results are reported as means $\pm$ standard deviations or as numbers with percentages, as appropriate.

RESULTS

Patient characteristics

As mentioned earlier, our trial was stopped before full recruitment was achieved. We initially recruited 162 patients, but 61 were excluded because they were found to have unresectable disease during the procedure and 3 more withdrew consent. Our study population included 98 patients, of whom 48 were randomly assigned to PG and 50 were assigned to PJ reconstruction. Seven patients initially assigned to PG actually underwent PJ reconstruction:

4 whose glands were too stiff to mobilize sufficiently, 2 who had major artery anatomic variations preventing mobilization and 1 who had previous gastric surgery that had not been documented before the procedure. Similarly, 4 patients initially assigned to PJ underwent PG reconstruction owing to surgeon preference, as described in the Methods section. This crossover was due to loss of equipoise and resulted in us stopping the trial. As a result, 45 patients underwent PG and 53 underwent PJ reconstruction (Fig. 1).

The median age of the study population was 66 ± 12 years. The most common symptom was jaundice ($n = 68$, 69%), followed by pain and weight loss ($n = 53$, 54%).

Intention to treat analysis

Comparison of patient characteristics between the PG and PJ groups (Table 1) did not reveal any significant differences in age; sex; presenting symptoms; or comorbidity burden, quantified using a Charlson score, Charlson-Age comorbidity index and preoperative ASA score. The only significant difference was in the rate of preoperative biopsies (27 [57%] patients in the PG group v. 17 [34%] in the PJ group, $p = 0.020$), but there was no difference in frequency of overall preoperative biliary instrumentation.

Multiple intraoperative characteristics were also compared (Table 1). There was no difference in duration of surgery, estimated blood loss, intraoperative complications, postoperative use of octreotide, need for blood transfusions or use of postoperative perianasto-

mot external drains between the groups (80.85% in the PG group v. 91.67% in PJ group, $p = 0.13$). The difference in pancreatic gland texture and percentage of soft pancreatic glands between the groups (52% v. 39%) was not significant. There were significant differences between PG and PJ reconstructions in terms of the length of mobilization of the pancreas (31 ± 15 mm in the PG group v. 18 ± 10 mm in the PJ group, $t_{87} = 4.55$, $p < 0.001$) and the frequency in which a stent was left in the pancreatic duct (10 [22%] in the PG group v. 39 [83%] in the PJ group, $\chi^2_1 = 34.97$, $p < 0.001$). The length of mobilization is considered a part of the particular reconstruction characteristic rather than an additional factor and therefore will always show a significant difference when comparing the 2 recon-

Table 1. Preoperative patient characteristics and procedural comparison

Characteristic	Group, no (%) or mean $\pm$ SD*		p value
	PG, $n = 48$	PJ, $n = 50$	
Age, yr	63.6 ± 13.1	68.1 ± 10.7	0.07
Female sex	28 (58.33)	21 (42)	0.11
Biliary instrumentation	33 (70.21)	36 (72)	0.85
Preoperative biopsy	27 (57.45)	17 (34)	0.020
Charlson score, median (IQR)	2 (2, 3)	2 (2, 3)	0.31
Charlson-Age index, median (IQR)	4 (3–5)	5 (4–6)	0.10
ASA score			0.07
1	16 (33.33)	8 (16)	
2	29 (60.42)	34 (68)	
3	3 (6.25)	8 (16)	
Weight loss	27 (56.25)	26 (52)	0.67
Jaundice at presentation	29 (60.42)	39 (78)	0.06
Pain at presentation	27 (56.25)	26 (52)	0.67
Duration of surgery, min	349 ± 70	356 ± 65	0.64
Estimated blood loss, mL	490 ± 305	410 ± 250	0.12
Gland mobilization, mm	31.17 ± 15.41	18.35 ± 10.53	< 0.001
Stent left in pancreatic duct	10 (21.74)	39 (82.98)	< 0.001
Intraoperative complications	1 (2.13)	4 (8.16)	0.18
Pancreatic duct size, mm	3.8 ± 2.4	4.3 ± 2.6	0.26
Pancreatic gland texture			0.42
Very soft	14 (29.17)	12 (26.09)	
Soft	11 (22.92)	6 (13.04)	
Average	14 (29.17)	12 (26.09)	
Hard	8 (16.67)	13 (28.26)	
Very hard	1 (2.08)	3 (6.52)	
Soft pancreatic gland (texture 1 or 2)	25 (52.08)	18 (39.13)	0.21
External drain	38 (80.85)	44 (91.67)	0.13
Epidural anesthesia	47 (97.92)	48 (96)	0.58
Octreotide postoperatively	42 (89.36)	39 (78)	0.13
Blood transfusion	5 (10.87)	13 (26)	0.06

ASA = American Society of Anesthesiologists; IQR = interquartile range; PG = pancreaticogastrostomy; PJ = pancreaticojejunostomy; SD = standard deviation.
*Unless otherwise indicated.

Fig. 1. Flow of patients through the trial. PG = pancreaticogastrostomy; PJ = pancreaticojejunostomy.

struction techniques. The pancreatic duct was identified during all procedures. The use of the stent was added in the multivariate analysis.

There was no difference in surgeon distribution between the groups ($\chi^2_3 = 7.02$, $p = 0.07$). Owing to the relatively small number of cases, we did not consider using operating surgeon as a variable, and we did not perform any comparisons among surgeons.

Our comparison of postoperative outcomes (Table 2) revealed no significant difference in length of stay in hospital, overall postoperative complications, overall pancreatic fistula rates or grades of pancreatic fistulas.

Age- and sex-adjusted logistic regression analyses were conducted for overall postoperative complications and overall fistula rates (Table 3). None of the factors were found to be predictive of overall postoperative complications. Most importantly, there was no difference between PJ and PG (odds ratio [OR] 1.00). In the model predict-

ing postoperative pancreatic fistula, only soft pancreatic gland was associated with significantly greater risk (OR 5.89, $p = 0.003$). Randomization to reconstruction was not significant (OR 0.57, $p = 0.46$).

DISCUSSION

As in the literature from other parts of the world, our study did not identify any significant difference in overall morbidity or mortality between PJ and PG reconstruction. Unlike several other centres that did identify statistically lower rates of postoperative leaks with PG reconstruction, we did not obtain such a result. We found that pancreatic gland texture and patient characteristics, such as age and sex, had greater influence on outcomes than the surgical technique used for reconstruction.

When mortality is already low, it is difficult to identify new surgical techniques that would substantially decrease these rates. Therefore, length of stay in hospital becomes an important characteristic of patient outcomes. We found no significant difference in length of stay between the groups. As PG was a new technique for the surgeons involved in the present study, it is possible that later NG tube removal and slower progress in postoperative advancement in the PG group early in the study may have affected length of stay. That could also explain the relatively large standard deviation in the PG group. Their length of stay may seem excessive for surgeons practising in the United States, but this is standard length of stay in the Canadian system.

Limitations

A major limitation of this study was the crossover between the PG and PJ groups. This is partly caused by the need for much more gland mobilization for PG reconstruction. Certain patients will therefore not be suitable candidates for this type of anastomosis, particularly patients with very firm pancreatic glands and those with anatomic variations preventing safe mobilization. Surgeon preference was another reason for crossover to the PG group; furthermore, initial preference for the PJ anastomosis and initial relative unfamiliarity with PG anastomosis and learning curve could have influenced rates of overall postoperative complications, especially severe postoperative complications, in the early stages of the study. Owing to the relatively small number of patients in each arm, we did not compare early and late complications. Consequently, a learning curve phenomenon cannot be ruled out. Also, the potential problem with a single-centre study is external validity. Finally, in terms of methods and statistical analyses, we were not able to consider the present study a randomized clinical trial owing to the crossover and premature termination of the trial.

Table 2. Postoperative outcomes

Outcome	Group, no (%) or mean $\pm$ SD		<i>p</i> value
	PG, <i>n</i> = 48	PJ, <i>n</i> = 50	
Length of stay	17.4 $\pm$ 11.6	14.0 $\pm$ 5.4	0.25
Postoperative complications	29 (60.42)	24 (48)	0.31
Pancreatic fistula	12 (25)	9 (18)	0.40
Pancreatic fistula grade			
No fistula	36 (75)	41 (82)	0.40
A	4 (8.33)	3 (6)	0.65
B	6 (12.5)	5 (10)	0.70
C	2 (4.17)	1 (2)	0.53
Mortality	2 (4.17)	1 (2)	0.53

PG = pancreaticogastrostomy; PJ = pancreaticojejunostomy; SD = standard deviation.

Table 3. Multivariate analyses

Category	OR (95% CI)	<i>p</i> value
Postoperative complications		
Age > 70 yr	0.84 (0.32–2.19)	0.72
Female sex	0.50 (0.20–1.26)	0.14
ASA 2	1.31 (0.44–3.89)	0.63
ASA 3	5.51 (0.79–38.37)	0.09
Soft pancreatic gland	2.55 (0.98–6.65)	0.06
Randomization to PJ	1.00 (0.31–3.25)	> 0.99
Use of pancreatic stent	0.39 (0.11–1.37)	0.14
Pancreatic fistula		
Age > 70 yr	0.90 (0.27–2.94)	0.86
Female sex	0.34 (0.11–1.05)	0.06
ASA 2	2.09 (0.49–9.00)	0.32
ASA 3	3.51 (0.43–28.41)	0.24
Soft pancreatic gland	5.89 (1.70–20.39)	0.005
Randomization to PJ	0.57 (0.13–2.51)	0.46
Use of pancreatic stent	1.28 (0.26–6.30)	0.76

ASA = American Society of Anesthesiologists; CI = confidence interval; OR = odds ratio; PJ = pancreaticojejunostomy.

CONCLUSION

Within the limitations of this study, we did not identify any difference in overall rates of pancreatic fistulas/leaks between PJ and PG reconstruction when comparing all patients undergoing a Whipple procedure. As predicted, we found that a soft pancreatic gland was associated with higher rates of all postoperative pancreatic fistulas/leaks. None of the factors we studied predicted overall postoperative complications.

Funding: This trial received funding from the MSI Foundation, Canadian Association of General Surgeons, and the University of Calgary Department of Surgery

Affiliations: From the Division of General Surgery, University of Calgary, Calgary, Alta. (Grendar, Sutherland, Bathe, Ball, Dixon); and the CHU de Québec, Pavillon Hôpital de l'Enfant-Jésus, Québec, Que. (Ouellet).

Competing interests: None declared.

Contributors: O. Bathe, C. Ball and E. Dixon designed the study. J. Grendar, J.-F. Ouellet, C. Ball and E. Dixon acquired the data, which J. Grendar, F. Sutherland, C. Ball and E. Dixon analyzed. J. Grendar, O. Bathe, C. Ball and E. Dixon wrote the article, which all authors reviewed and approved for publication.

References

- Whipple AO, Parsons WB, Mullins CR. Treatment of carcinoma of the ampulla of Vater. *Ann Surg* 1935;102:763-79.
- Schnelldorfer T, Adams DB, Warshaw AL, et al. Forgotten pioneers of pancreatic surgery: beyond the favorite few. *Ann Surg* 2008;247:191-202.
- Cameron JL, Riall TS, Coleman J, et al. One thousand consecutive pancreaticoduodenectomies. *Ann Surg* 2006;244:10-5.
- Lieberman MD, Kilburn H, Lindsey M, et al. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection for malignancy. *Ann Surg* 1995;222:638-45.
- Lai EC, Lau SH, Lau WY. Measures to prevent pancreatic fistula after pancreaticoduodenectomy: a comprehensive review. *Arch Surg* 2009;144:1074-80.
- D'souza MA, Shrikhande SV. Pancreatic resectional surgery: an evidence-based perspective. *J Cancer Res Ther* 2008;4:77-83.
- Ball CG, Howard TJ. Does the type of pancreaticojejunostomy after Whipple alter the leak rate? *Adv Surg* 2010;44:131-48.
- Bassi C, Falconi M, Molinari E, et al. Reconstruction by pancreaticojejunostomy versus pancreaticogastrostomy following pancreatotomy: results of a comparative study. *Ann Surg* 2005;242:767-773.
- Duffas JP, Suc B, Msika S, et al. A controlled randomized multicenter trial of pancreatogastrostomy or pancreaticojejunostomy after pancreatoduodenectomy. *Am J Surg* 2005;189:720-9.
- Fernández-Cruz L, Cosa R, Blanco L, et al. Pancreatogastrostomy with gastric partition after pylorus-preserving pancreatoduodenectomy versus conventional pancreaticojejunostomy: a prospective randomized study. *Ann Surg* 2008;248:930-8.
- Yeo CJ, Cameron JL, Maher MM, et al. A prospective randomized trial of pancreaticogastrostomy versus pancreaticojejunostomy after pancreaticoduodenectomy. *Ann Surg* 1995;222:580-592.
- Figueras J, Sabater L, Planellas P, et al. Randomized clinical trial of pancreaticogastrostomy versus pancreaticojejunostomy on the rate and severity of pancreatic fistula after pancreaticoduodenectomy. *Br J Surg* 2013;100:1597-605.
- Topal B, Fieuws S, Aerts R, et al. Pancreaticojejunostomy versus pancreaticogastrostomy reconstruction after pancreaticoduodenectomy for pancreatic or periampullary tumours: a multicentre randomised trial. *Lancet Oncol* 2013;14:655-62.
- Wellner UF, Sick O, Olschewski M, et al. Randomized controlled single-center trial comparing pancreatogastrostomy versus pancreaticojejunostomy after partial pancreatoduodenectomy. *J Gastrointest Surg* 2012;16:1686-95.
- El Nakeeb A, Hamdy E, Sultan AM, et al. Isolated Roux loop pancreaticojejunostomy versus pancreaticogastrostomy after pancreaticoduodenectomy: a prospective randomized study. *HPB (Oxford)* 2014;16:713-22.
- McKay A, Mackenzie S, Sutherland FR, et al. Meta-analysis of pancreaticojejunostomy versus pancreaticogastrostomy reconstruction after pancreaticoduodenectomy. *Br J Surg* 2006;93:929-36.
- Dixon E, Fingerhut A, Bassi C, et al. Meta-analysis of pancreaticojejunostomy versus pancreaticogastrostomy reconstruction after pancreaticoduodenectomy: authors' comment (*Br J Surg* 2006; 93: 929-936). *Br J Surg* 2006;93:1435.
- Shen Y, Jin W. Reconstruction by pancreaticogastrostomy versus pancreaticojejunostomy following pancreaticoduodenectomy: a meta-analysis of randomized controlled trials. *Gastroenterology research & practice* 2012;2012:627095.
- Ma JP, Peng L, Qin T, et al. Meta-analysis of pancreaticoduodenectomy prospective controlled trials: pancreaticogastrostomy versus pancreaticojejunostomy reconstruction. *Chin Med J* 2012;125:3891-7.
- Wente MN, Shrikhande SV, Muller MW, et al. Pancreaticojejunostomy versus pancreaticogastrostomy: systematic review and meta-analysis. *Am J Surg* 2007;193:171-83.
- Adloff M, Schloegel M, Ollier JC, et al. Pancreaticojejunostomy or pancreatogastrostomy after cephalic pancreatoduodenectomy. *Chirurgie* 1992;118:63-70.
- Andivot T, Cardoso J, Dousset B, et al. Complications of two types of pancreatic anastomosis after pancreaticoduodenectomy. *Ann Chir* 1996;50:431-7.
- Aranha GV, Hodul P, Golts E, et al. A comparison of pancreaticogastrostomy and pancreaticojejunostomy following pancreaticoduodenectomy. *J Gastrointest Surg* 2003;7:672-82.
- Kim SW, Youk EG, Park YH. Comparison of pancreatogastrostomy and pancreaticojejunostomy after pancreatoduodenectomy performed by one surgeon. *World J Surg* 1997;21:640-3.
- Mason GR, Freeark RJ. Current experience with pancreatogastrostomy. *Am J Surg* 1995;169:217-9.
- Miyagawa S, Makuuchi M, Lygidakis NJ, et al. A retrospective comparative study of reconstructive methods following pancreaticoduodenectomy-pancreaticojejunostomy vs. pancreaticogastrostomy. *Hepatogastroenterology* 1992;39:381-4.
- Oussoultzoglou E, Bachellier P, Bigourdan JM, et al. Pancreaticogastrostomy decreased relaparotomy caused by pancreatic fistula after pancreaticoduodenectomy compared with pancreaticojejunostomy. *Arch Surg* 2004;139:327-35.
- Schlitt HJ, Schmidt U, Simunec D, et al. Morbidity and mortality associated with pancreatogastrostomy and pancreaticojejunostomy following partial pancreatoduodenectomy. *Br J Surg* 2002;89:1245-51.
- Bassi C, Dervenis C, Butturini G, et al. Postoperative pancreatic fistula: an international study group (ISGPF) definition. *Surgery* 2005;138:8-13.
- Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205-13.
- Bassi C, Butturini G, Salvia R, et al. Open pancreaticogastrostomy after pancreaticoduodenectomy: a pilot study. *J Gastrointest Surg* 2006;10:1072-80.
- Callery MP, Pratt WB, Kent TS, et al. A prospectively validated clinical risk score accurately predicts pancreatic fistula after pancreatoduodenectomy. *J Am Coll Surg* 2013;216:1-14.