Pancreaticojejunostomy has classically been the prototype of pancreatic reconstruction after pancreaticoduodenectomy including antrectomy for periampullary lesions. In recent years, there is a trend toward preserving the pylorus because pylorus-preserving pancreaticoduodenectomy (PPPD) is claimed to be less time-consuming and technically easier to perform, as well as to avoid the sequelae of Chinese Medical Journal (Taipei) 2002;65:254-259

Original

Non-stented Pancreaticogastrostomy after Pylorus-preserving Pancreaticoduodenectomy

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Key Words
amylase; gastric pH; pancreaticoduodenectomy; pancreaticogastrostomy; periampullary; pylorus-preserving

Background. We hypothesized that neutralization of the gastric acidity by alkaline pancreatic secretion via a non-stented pancreaticogastrostomy after pylorus-preserving pancreaticoduodenectomy (non-stented PPPD-PG) might provide protection against marginal or stress ulcer. Surgical risk of non-stented pancreaticogastrostomy was also assessed to clarify the importance of stenting in pancreatic anastomosis.

Methods. From January 1997 to December 2000, 54 patients with resectable periampullary lesions were included for non-stented PPPD-PG. Gastric pH and amylase levels were measured on the postoperative day 7. Surgical risks including pancreatic leak age, morbidity and mortality were also assessed.

Results. Patients undergoing the non-stented PPPD-PG presented significantly higher gastric levels of pH and amylase than healthy patients as controls (median pH 5.0 vs 2.8, p = 0.007; and median amylase 7,660 vs 21 IU/L, p = 0.031). Among the patients undergoing the non-stented PPPD-PG, low gastric pH and amylase levels were associated with high gastric drainage group ≥ 600 c.c./day. However, only 1 of the 18 patients with low gastric amylase level (high gastric drainage group) developed significant steatorrhea and needed replacement of concentrated pancreatic enzymes. There were 18 (33.3%) complications and 1 (1.8%) mortality. The cause of death was cardiac arrhythmia, not related to operation. Gastric atonia was the most common complication (18.5%), followed by wound infection, intraabdominal abscess, and intraabdominal bleeding in 2 patients (5.6%) in divided ay. No pancreatic leak nor ulcer-related complication occurred after non-stented PPPD-PG.

Conclusions. Experience of no pancreatic leak in our 54 non-stented PPPD-PG implies that stenting of pancreaticogastrostomy might not be crucial in prevention of pancreatic leak age and ductal occlusion. Moreover, non-stented PPPD-PG can increase gastric pH and amylase levels, which might be beneficial in protection against marginal ulceration.

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Pancreaticojejunostomy has classically been the prototype of pancreatic reconstruction after pancreaticoduodenectomy in including antrectomy for periampullary lesions. In recent years, there is a trend toward preserving the pylorus because pylorus-preserving pancreaticoduodenectomy (PPPD) is claimed to be less time-consuming and technically easier to perform, as well as to avoid the sequelae of Pancreaticojejunostomy has classically been the prototype of pancreatic reconstruction after pancreaticoduodenectomy in including antrectomy for periampullary lesions. In recent years, there is a trend toward preserving the pylorus because pylorus-preserving pancreaticoduodenectomy (PPPD) is claimed to be less time-consuming and technically easier to perform, as well as to avoid the sequelae of
gas tric re sec tion. How ever, pan cre atic leak age and post op er a tive mar ginal ul cer con tinue to be two of the major com pli ca tions as seen in clas sic pan cre atico duodenectomy when the pan cre atico jejunostomy is used fol low ing PPPD. The re ported in ci dence of pan cre atic leak age has been be 6%-24%, with an aver age of 13.6%. Pan cre atic leak age, with sub se quent se ri ous com pli ca tions of in traabdominal ab scess, bleed ing and sep sis, car ries a mor tal ity of 8%-40%, with an av er age of 12.5%. The in ci dence of mar ginal ul cer is 2%-19%. There fore, vari ous tech ni cal mod i fi ca tions for pan cre atic re con struc tion have been at tempted to min i mize leak age.

Pancreaticogastrostomy, in tro duced by Waugh and Clagett in 1946, which has re cently be gun to at tract at ten tion by its low leak age rate. Stenting of the pan cre atic anas to mo sis has been claimed to re duce pan cre atic leak age in some re ports, but there is no unan i mous rec om mend a tion to use a stent. There fore, a study of non-stented pan cre atic anas to mo sis may be help ful to clar ify the im por tance of stenting re gard ing the pan cre atic leak age.

Based on the hy poth e sis that neu tral iza tion of the gas tric acid ity by al ka line pan cre atic se cre tions via a non-stented pancreaticogastrostomy might pro vide pro tec tion against mar ginal or stress ul cer, we con tin ued our pre lim i nary study to mea sure the gas tric pH and am y lase lev els fol low ing a non-stented pancre aticogastrostomy after py lo rus-preserving pan cre aticoduodenectomy (non-stented PPPD-PG). Sur gi cal risks of this non-stented pro ce dure, in clud ing pan cre atic leak age, mor bid ity and mor tal ity, were also as sessed to clar ify the im por tance of stenting in pan cre atic anas to mo sis.

Methods

A to tal of 54 pa tients with resectable per iampullary les ions were in cluded for non-stented PPPD-PG from Jan u ary 1997 to De cem ber 2000. Ap pro pri ate in formed con sent was ob tained from each pa tient. Pancreaticoduodenectomy was per formed by py lo rus-preserving mod i fi ca tion. Be fore the pan cre aticogastrostomy, the prox i mal 3 to 4 cm of the pan cre atic rem nant was freed from the splenic vein and retroperitonium. The pan cre atic stump was an as tom osed and invagi nated into the pos te rior wall of the low body of the stomach. The pan cre aticogastrostomy was per formed then by in ter rupted two-layer su tures, with 3-0 silk for the outer layer placed be tween the pan cre atic cap su le and seromuscular layer of the pos te rior gas tric wall and 3-0 poly glactin (Vicryl; Ethicon, Inc, Somerville, NJ) for the in ner layer placed be tween the cut edge of the pan creas and the full thick ness of the pos te rior gas tric wall. No pan cre atic duct stent was used in the pro ce dure. After pan cre atic re con struc tion, an end-to-side, also non-stented, choledochojejunostomy and an end-to-side antecolic duodenojejunostomy com pleted the biliary and gastroin tes ti nal re con struc tion. No vagotomy was per formed through out. Octreotide and to tal pa ren tal nu tri tion were not given rou tinely after op er a tion.

To eval u ate how the al ka line pan cre atic se cre tion af fected the gas tric acidi ty, aliquots of the gas tric drain age from the naso-gastric tube placed dur ing op er a tion were sent for de ter mi na tion of gas tric pH and am y lase on the post op er a tive day 7. As con trols, gas tric pH and am y lase lev els were mea sured in 30 healthy per sons with out ac tive pep tic ul cer dis ease. De mo graphic data, op er a tion time, intraoperative blood loss, hos pi tal stay, post op er a tive mor bid ity and sur gi cal mor tal ity were re corded. A pan cre atic leak age was de fined as drain age of ab nor mal dirty dis charge with am y lase con cen tra tion 3 times higher than se rum am y lase level or ra dio graph i cally-proven leak age at any post op er a tive pe riod. The cause of gas tric bleed ing was eval u ated by en dos copy or an te rior gas trotomy if sur gi cal in ter ven tion was needed to check bleed ers. Gas tric atonia was de fined as in ab il ity to re sume oral in take af ter the post op er a tive day 10. Sur gi cal mor tal ity was de fined as any death oc cur ring during hos pi tal iza tion or within 30 days after op er a tion.

Sta tis ti cal anal y sis was car ried out by us ing the SPSS 10.0 soft ware (SPSS Inc. Chi cago, Il li nois). Data are pre sented as mean ± stan dard de vi a tion. Stu dent’s t-test was used to com pare two means. Cat e gor i cal vari ables were com pared by χ² test or Fisher’s ex-
act test. A $p$ value less than 0.05 was considered to be statistically significant.

**Results**

There were 39 males and 15 females. Median age of patients was 69 years, with the mean of 66.5 ± 11.1 years and the range from 38 years to 89 years. The periampullary lesions included 25 (46%) pancreatic head cancers, 15 (28%) ampullary cancers, 3 (6%) distal common bile duct cancers, 1 (2%) duodenal cancer, 6 (11%) chronic pancreatitis and 7 (7%) other lesions. Median operation time was 6 hours, with the mean of 6.3 ± 1.8 hours and the range of 3-12 hours. Median operation blood loss was 675 c.c., with the mean of 850 ± 733 c.c. and the range of 150-4,500 c.c.. Median postoperative hospital stay was 22.0 days, with the mean of 25 ± 12.3 days and the range of 8-57 days.

The gastric pH level for the non-stented PPPD-PG group was significantly higher than that of the healthy controls (median pH 5.0 vs 2.8, $p = 0.007$). The comparison for gastric amylase level between these two groups was also similar to that seen in pH, with median amylase of 7,660 IU/L in the non-stented PPPD-PG group and 21 IU/L in the healthy controls, $p = 0.031$ (Table 1). Based on the amount of gastric drainage measured on the postoperative day 7, 18 patients (33.3%) with high gastric drainage ($\geq$ 600 c.c./day) presented significantly lower gastric pH level (median = 2.5, ranging from 2.0 to 3.9), as compared with that (median = 6.3, ranging from 4.1 to 8.2) in the low gastric drainage group ($< 600$ c.c./day) group (n = 36), $p < 0.001$ (Table 2). Simiarly, patients with high gastric drainage also presented statistically lower gas-

### Table 1. Gastric pH and amylase values following non-stented pancreaticogastrostomy

<table>
<thead>
<tr>
<th></th>
<th>Non-stented PPPD-PG (n = 25)</th>
<th>Healthy control (n = 30)</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gastric pH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>5.0</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>4.9 ± 1.9</td>
<td>3.6 ± 2.4</td>
<td>0.031</td>
</tr>
<tr>
<td>Range</td>
<td>2.0 - 8.2</td>
<td>0.8 - 7.4</td>
<td></td>
</tr>
<tr>
<td><strong>Gastric amylase, IU/L</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>7660</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>24,980 ± 32,754</td>
<td>10,124 ± 23,489</td>
<td>0.007</td>
</tr>
<tr>
<td>Range</td>
<td>13 - 161,000</td>
<td>7 - 98,075</td>
<td></td>
</tr>
</tbody>
</table>

Non-stented PPPD-PG = pylorus-preserving pancreaticoduodenectomy reconstructed by non-stented pancreaticogastrostomy.

### Table 2. Relationship between gastric pH, amylase values and drainage amount following non-stented pancreaticogastrostomy

<table>
<thead>
<tr>
<th></th>
<th>Low gastric drainage, $&lt; 600$ c.c./day $^a$ (n = 36)</th>
<th>High gastric drainage, $\geq 600$ c.c./day $^a$ (n = 18)</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gastric pH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>6.3</td>
<td>2.5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>6.1 ± 1.2</td>
<td>2.6 ± 0.5</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>4.1 - 8.2</td>
<td>2.0 - 3.9</td>
<td></td>
</tr>
<tr>
<td><strong>Gastric amylase, IU/L</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>31,511</td>
<td>345</td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>37,139 ± 34,177</td>
<td>663 ± 850</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Range</td>
<td>1,700 - 161,000</td>
<td>13 - 2,870</td>
<td></td>
</tr>
</tbody>
</table>

$^a$The gastric drainage amount was estimated on the postoperative day 7.
tric am y lase lev els (me dian = 345 IU/L, rang ing from 13 to 2870 IU/L) than those with low gas tric drain age (me dian = 31,511, rang ing from 1,700 to 161,000 IU/L), p < 0.001. How ever, only 1 of the 18 pa tients with low gas tric am y lase level (in high gas tric drain-age group) de vel oped sig nif i cant steatorrhea and needed re place ment of the con cen trated pan cre atic en zymes.

Com pli ca tions oc curred in 18 pa tients (33.3%). There was 1 (1.8%) mor tal ity. The cause of death was car diac ar ryth mia, which was the un der ly ing dis ease, but not re lated to op er a tion. Gas tric atonia was the most com mon com pli cation, oc cur ring in 10 (18.5%) pa tients. Wound in fec tion, intraabdominal ab scess and intraabdominal bleed ing oc curred in 3 (5.6%) pa tients in di vid u ally. No pan cre atic leak age oc curred af ter non-stented PPPD-PG, ac cording to our def i ni tion of pan cre atic leak age as drain age of ab nor mal dirty dis charge with am y lase con cen tra tion 3 times higher than se rum am y lase level or ra dio graph i cally-proven leak age at any post op er a tive pe riod. No ul cer-related com pli cation such as up per gas tro in tes ti nal bleed ing or per fo ra tion oc curred. How ever, there were 2 pa tients with bleed ing around the site of pan cre aticogastrostomy 1 day af ter op er a tion, sim ply due to re-bleeding from the gas tric and pan cre atic cut ting-edges of pancreaticogastrostomy, in stead of ul cer-related com pli cation. For tu nately, these 2 bleed ing ep isodes were de tected eas ily and early by nasogastric tube, and checked eas ily and ef fec tively by su ture-ligation through an te rior gastrotomy. They both re cov ered with out any sequela.

Discussion

Pancreaticogastrostomy has been re in tro duced and con sid ered a safe pan cre atic re con struc tion fol low ing PPPD. Re cent stud ies have shown that the pan cre atic leak age rate after pancreaticogastrostomy is < 5%, and the leak age-related mor tal ity is 0-2.1%, which are both much lower than those (13.6% leakage and 12.5% mortality) of clas si cal pancreaticojejunostomy. Re sults of this study also showed a rel a tively low sur gi cal risk with no pan cre atic leak age and no leak age-related mor tal ity. Our over all com pli ca tion rate was 33.3% and mor tal ity rate was 1.8%, with 1 death due to un der ly ing car diac ar ryth mia, but not re lated to op er a tion. There are sev eral pos si ble ad vant ages to ex plain the low leak age rate of pancreaticogastrostomy, in clud ing: 1. ex ce lent blood sup ply and thick wall of stom ach which is less likely to de vel op ischemic com pli ca tions and holds su tures better than the je ju num; 2. pro tec tion against en zy matic at tack to the anas to mo sis by in ac ti vating the pan cre atic pro teolytic en zymes in the rel a tively acid mi lieu of the stom ach and in the ab sence of enterokinase which is pres ent only in small bowel; 3. ten sion-free anas to mo sis as the pan cre as lies im me di ately ad ja cent to the pos te rior wall of the stom ach and the two or gans nat u rally ap posed; 4. ab sence of a long jejunal loop which may cause ten sion on the anas to mo sis by ac cumu la tion of pancreatico bil iary se cre tions and the weight of the loop it self as might oc cur in classic pan cre aticojejunos tomy.

Emp ir ically, some au thors in sist on stenting the pancreaticoenterostomy to pre vent leak age and oc clu sion of the pan cre atic duct. However, ex pe ri ence of no pan cre atic leak age in our 54 non-stented PPPD-PG implies that stenting of pan cre aticogastrostomy might not be cru cial in pre ven tion of pan cre atic leak age. More over, we ob served that the gas tric pH and am y lase lev els in the non-stented PPPD-PG group were both sig nif i cantly higher than those in the healthy con trol group in this study. These find ings pro vide an in di rect ev i dence of neu tral iza tion of the gas tric acid ity by al ka line pan cre atic se cre tion via a non-stented pancreaticogastrostomy. Be cause el e va tion of the gas tric pH plays a role in pre ven tion of the post op er a tive stress and mar ginal ul cer, the high gas tric pH level might con trib ute to no ul cer-related com pli cation in this study.

The gas tric se cre tion mea sured on post op er a tive day 7 was closely as so ci ated with the lev els of gas tric pH and am y lase. We ob served that one-third of the pa tients had high gas tric drain age (≥ 600 c.c./day) and also pre sented sig nif i cantly lower gas tric pH and am y lase lev els, as com pared to those in the other two-thirds with low gas tric drain age (< 600 c.c./day).
How ever, among the 18 pa tients with low gas tric am y lase lev els in high gas tric drain age group, only one significant steatorrhea needing replacement of the con cent rated pan cre atic en zymes. High gas tric se cre tions might ex er dilutional ef fect on the pan cre atic se cre tions. This dilutional ef fect may ex plain the low gas tric pH level and no de vel op ment of steatorrhea in the other 17 pa tients with low gas tric am y lase lev el in high gas tric drain age group. Un for tu nately, we did not iden tify any pos si ble cause to ex plain why these 18 pa tients pre sented hypersecretion of gastric juice. Other ob ser va tions in both hu mans and canines showed that pancreaticogastrostomy was fol lowed in 2 to 4 weeks by slough ing of the ex cess pan cre atic remnant with gas tric mu cosa grow ing to the mu cosa of the pan cre atic duct and pres er va tion of both en do crine and exocrine func tions. Takada et al. also con firmed the patency of the pan cre atic duct after pancreaticogastrostomy by endoscopic retrograde pan cre atogra phy in all the 17 pa tients ex am ined. As re ported by Icard and Dubois re ported that exocrine pan cre atic in suf fi ciency did not oc cur in long-term fol low up. There fore, the pancreaticogastrostomy with out stent might not sub stan tially in crease the risk of ductal oc clu sion.

Our suc cess ful ex pe ri ence in man age ment of bleed ing aroun d the site of pan cre atico gas trostomy fur ther dem on strates some of its ad van tages, such as early de tec tion of bleed ing from the pan cre atic remnant or the anas to mo sis by an ter ior gas troto my once bleed ing oc curs. Other ob ser va tions in both hu mans and ca nines showed that ble ad ing around the site of pancreaticogastrostomy ver sus pan cre atoduodenec tomy might not sub stan tially in crease the risk of ductal oc clu sion.

In con clu sion, ex pe ri ence of no pan cre atic leak age in our 54 non-stented PPPD-PG implies that stenting of pancreaticogastrostomy might not be cru cal in pre ven tion of pan cre atic leak age and ductal oc clu sion. More over, non-stented PPPD-PG can in crease gas tric pH and am y lase lev els, which might be ben e fi cial in pre tec tion against mar ginal ul cer ation.

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