J Hepatobiliary Pancreat Surg (2004) 11:25–33
DOI 10.1007/s00534-003-0863-6

Journal of HBP Surgery

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Original articles

Current pancreatogastrointestinal anastomotic methods: results of a Japanese survey of 3109 patients

Manabu Watanabe[1], Sadahito Usui[1], Hirohisa Kajiwara[1], Mitsuhiko Nakamura[1], Yoshinobu Sumiyama[1], Tadahiro Takada[2], and Takukazu Nagakawa[3]

[1] Third Department of Surgery, Toho University School of Medicine, 2-17-6 Ohashi, Meguro-ku, Tokyo 153-8515, Japan
[2] Department of Surgery, Teikyo University School of Medicine, Tokyo, Japan
[3] Department of Health Sciences School of Medicine, Kanazawa University, Kanazawa, Japan

Abstract
Background. Pancreatogastrointestinal anastomosis is the most important anastomotic method of reconstructing the digestive tract following pancreaticoduodenectomy.
Methods. We therefore conducted a survey on pancreatogastrointestinal anastomosis at the 28th Japan Pancreatic Surgery Club in 2001.
Results. Results revealed that of the methods of pancreatogastrointestinal anastomosis, pancreatojejunostomy (82.9%) was overwhelmingly more popular than pancreatogastrostomy (17.1%). Amastomotic leakage occurred in 12.8% of cases, and 13.0% of these patients died. The incidence of anastomotic leakage was 11.0% with pancreatogastrostomy, and 13.3% with pancreatojejunostomy. There was no significant difference in the development of anastomotic leakage among the anastomotic organ used with the pancreas, the pancreas resection method, and the pancreatic juice drainage method. Investigation of intra-abdominal hemorrhage and abscess, which are serious complications that result from anastomotic leakage, revealed that intra-abdominal hemorrhage occurred in 1.1% of all cases, and intra-abdominal abscess was seen in 3.3% of all cases. However, there were no significant differences between pancreatogastrostomy and pancreatojejunostomy with respect to incidence rates of intra-abdominal hemorrhage and abscess or mortality.
Conclusion. The method of pancreatogastrointestinal anastomosis should be chosen according to each individual case.

Key words Pancreaticoduodenectomy · Pancreatojejunostomy · Pancreatogastrostomy · Anastomotic leakage

Offprint requests to: M. Watanabe
Received: September 24, 2002 / Accepted: March 22, 2003

Introduction

Pancreatogastrointestinal anastomosis is the most important type of digestive tract reconstruction following pancreaticoduodenectomy.[1] When anastomotic leakage occurs, postoperative treatment becomes difficult, and the outcome can even at times fatal. Various surgical techniques are performed for pancreatogastrointestinal reconstruction following pancreatectomy, but these are still being debated, and a consensus has yet to be achieved on which method is best.

We therefore conducted, at the 28th Japan Pancreatic Surgery Club (JPSC) meeting in 2001, a questionnaire survey about reconstruction methods following pancreaticoduodenectomy and pylorus-preserving pancreaticoduodenectomy performed within the past 5 years in members' institutions. The survey focused on pancreatogastrointestinal anastomosis.

In this article we present the results of the survey, and discuss the current situation regarding pancreatogastrointestinal anastomotic methods and associated problems.

Survey subjects and methods

We received responses from 83 institutional members of the JPSC. There were a total of 3109 cases, of which 1384 involved pancreaticoduodenectomy and 1672 involved pylorus-preserving pancreaticoduodenectomy.

Statistical analysis was performed with the Mann-Whitney test or Fisher's exact test. A P value <0.05 was considered significant.

The Mann-Whitney test was used to assess the significance of the differences in operative time and blood loss volume. Fisher's exact test was used to assess the significance of the incidence rate of anastomotic leakage for various methods of surgery.

Results

Sex and age distribution

Patients comprised 1902 males and 1207 females. Ages ranged from 17 to 90, and the mean age was 63.6 ± 10.5 (mean ± standard deviation) years.

Disease distribution

Cancer of the pancreas head was most common (1173 cases), followed by bile duct cancer (648 cases), papilla vater carcinoma (594 cases), chronic pancreatitis (128 cases), gallbladder cancer (95 cases), duodenal carcinoma (87 cases), stomach cancer (48 cases), and intraductal papillary-mucinous tumor (IPMT) (43 cases).

Reconstruction methods (Table 1)

Method PD-IIA was used in 1509 cases, followed by method IIIA (447 cases), method IV (371 cases), and method IIB (284 cases). Method C was used in 398 cases (Fig. 1).

Pancreas resection methods and stump management

Of the resected pancreases, 1744 were normal and 1204 showed severe fibrosis. The diameter of the pancreatic duct was less than 4 mm in 1861 cases and greater than 4 mm in 1163 cases. The pancreas was resected using a scalpel in 2085 cases, electric cautery in 609 cases, laparoscopic coagulating shears (LCS) in 220 cases, and an ultrasonic dissector in 52 cases. In most cases (2608 cases), the pancreatic cut end margin was managed with only hemostasis, but fish-mouth suturing was used in 307 cases, and mattress suturing in 102 cases. Fibrin paste was used at the anastomotic site in 1416 cases, which represented 45.5% of the total.

Pancreatogastrointestinal anastomosis and pancreatic juice drainage

Pancreatojejunostomy was performed in 2483 cases, and pancreatogastrostomy in 511 cases. With pancreatojejunostomy, mucosa-to-mucosa anastomosis was performed in 1502 cases, the pancreatic duct dunking method was used in 796 cases, and the cut-end-margin dunking method was used in 185 case. With pancreatogastrostomy, the dunking method was used in 405 cases, and mucosa-to-mucosa anastomosis was performed in 106 cases (Fig. 2). Of the types of pancreatic juice drainage used in pancreatogastrointestinal anastomosis, there were 1774 cases of complete external drainage, 882 cases of incomplete external drainage, 266 cases where the short inner lost-tube method was used, and 141 cases were performed without a drainage stent (Fig. 3). A polyvinylchloride tube with knot was used for pancreatic duct stenting in 2747 cases. Additionally, there were 72 cases where an ATOM multiple purpose tube (Atom Medical, Tokyo, Japan) and 56 cases where

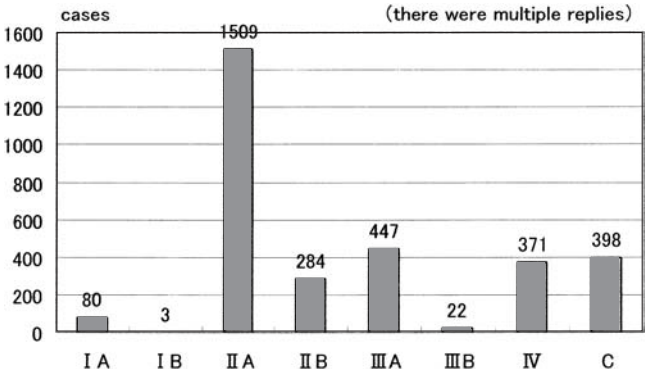

Fig. 1. Reconstruction methods (see Table 1 for type definitions)

Table 1. Reconstructive surgical techniques after pancreaticoduodenectomy (PD)[2]

Techique	Definition
Type of anastomosis	
PD-I	Bile duct, pancreas, and stomach, in that order
PD-II	Pancreas, bile duct, and stomach, in that order
PD-III	Stomach, pancreas, and bile duct, in that order
PD-IV	Other
Pancreatogastrointestinal anastomatic methods	
A	Pancreatojejunostomy (mucosa-to-mucosa anastomosis)
B	Pancreatojejunostomy (dunking method)
C	Pancreatogastrostomy

Reconstructive surgical techniques after pancreaticoduodenectomy were classified in order adorally from the jejunum for anastomosis between the pancreas, bileduct, and stomach and the jejunum

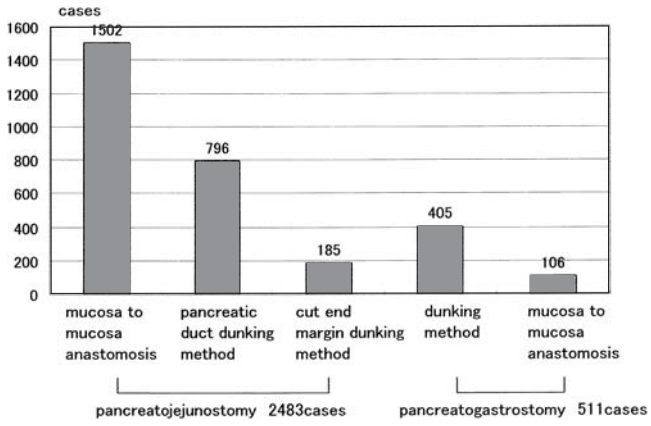

Fig. 2. Pancreatogastrointestinal anastomosis methods

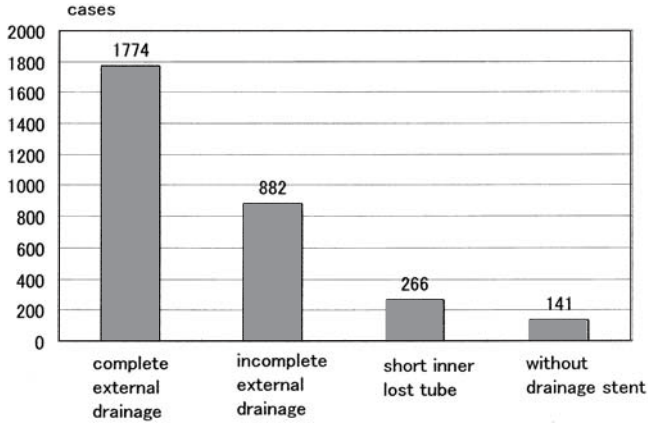

Fig. 3. Pancreatic juice drainage methods

an RTBD tube (Retrograde transhepatic biliary drainage tube) was used for pancreatic duct stenting. The pancreatic duct stent was extracted from the body via the bowel in 1527 cases, via the liver in 620 cases, and via the stomach in 520 cases. They were removed from 1 to 525 days after surgery, and the average duration of placement was 31.1 ± 16.8 days. Postoperative pancreatic duct patency was checked in 674 patients, which represented 21.7% of the total. The testing was conducted from 1 to 365 days after surgery, averaging 71.1 ± 55.5 days. Of the main test methods, computed tomography (CT) was used in 180 (26.7%) pancreatojejunostomy cases and 99 (14.7%) pancreatogastrostomy cases. Magnetic resonance cholangiopancreatography (MRCP) was used in 198 (29.4%) pancreatojejunostomy cases and 48 (7.1%) pancreatogastrostomy cases. A pancreatic juice secretion test was conducted in 149 (22.1%) pancreatojejunostomy cases and 42 (6.2%) pancreatogastrostomy cases. The cases with pancreatic duct patency confirmed by using an endoscope (45 cases; 6.7%) or endoscopic ultrasonography (EUS) (25 cases; 3.7%) were more conspicuous

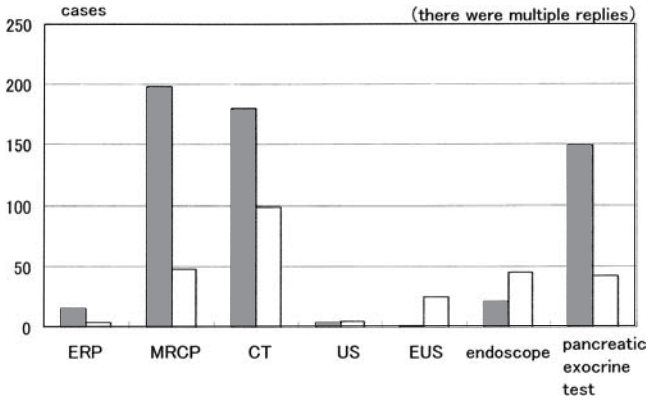

Fig. 4. Methods of checking pancreatic duct patency. *Black bars*, pancreatojejunostomy; *white bars*, pancreatogastrostomy; *ERP*, endoscopic retrograde pancreatography; *MRCP*, magnetic resonance cholangiopancreatography; *CT*, computed tomography; *US*, ultrasonography; *EUS*, endoscopic ultrasonography

among pancreatogastrostomy cases than among pancreatojejunostomy cases (Fig. 4).

Definition of pancreatogastrointestinal anastomotic leakage

Concurrently with the questionnaire survey, we also asked for the definition of pancreatogastrointestinal anastomotic leakage used at each institution, and received replies from 72 institutions. The diagnosis of pancreatogastrointestinal anastomotic leakage was made on the basis of amylase value during drainage at 49 institutions. There were 29 institutions that required the standard amylase value to be 1000 to 5000 IU/l, 17 required it to be 5000 to 10 000 IU/l, and 19 required it to be at least 10 000 IU/l in order to diagnose anastomotic leakage. Aside from the amylase value during drainage, 40 institutions diagnosed pancreatogastrointestinal anastomotic leakage according to the state of the drained fluid, 10 institutions according to pancreatographic findings, and 5 on the basis of a reduction in the drained amount of pancreatic juice.

Incidence, treatment, and outcome of pancreatogastrointestinal anastomotic leakage

There were 399 cases of pancreatogastrointestinal anastomotic leakage, which was 12.8% of the total cases of pancreatogastrointestinal anastomosis. For the treatments of anastomotic leakage, an operative procedure was performed in a small number of cases (26 cases; 6.5%). The main treatments were intermittent irrigation (129 cases), continuous aspiration (98 cases), and continuous irrigation (76 cases). Sixty-six patients were given somatostatin analog agents (Fig. 5). As for the types of operative procedure, there were seven cases of

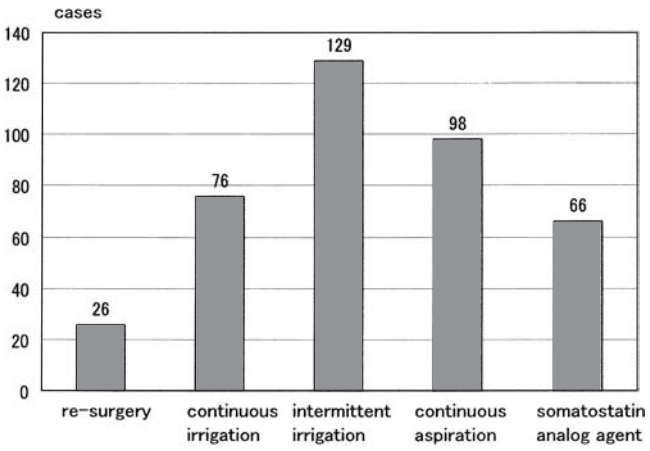

Fig. 5. Measures against anastomotic leakage

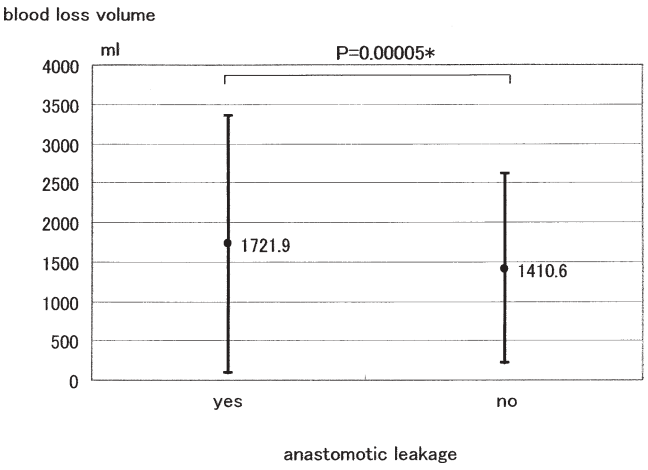

Fig. 6. Blood loss volume and anastomotic leakage

laparotomic drainage, five of hemostasis, four of complete resection of the residual pancreas, three of pancreatojejunostomy, two of pancreatic external fistula surgery, and one of pancreatic resection. The main liquid used for irrigation was physiologic saline only in 166 cases, physiologic saline plus antibacterial agents in 15 cases, and physiologic saline plus proteinase inhibitors in 12 cases. Acid water was also used in 26 cases. The dose of somatostatin agents ranged from 50 to 2000 μg/day (mean 223.6 ± 262.0 μg/day) and they were administered for a period of 1 to 70 days (mean 14.2 ± 12.7 days).

Secondary complications following anastomotic leakage included 102 cases (25.6%) of intra-abdominal abscess and 35 cases (8.8%) of intra-abdominal hemorrhage. Fifty-two people (13.0%) died.

Investigation of pancreatogastrointestinal anastomotic leakage

We investigated the following factors in cases of pancreatogastrointestinal anastomotic leakage: surgical technique, blood loss volume, operative time, pancreatic duct diameter, state of the pancreas, pancreas excision method, pancreatic stump treatment method, and pancreatic juice drainage method. Anastomotic leakage occured in 12.6% (174/1384) of patients who underwent pancreaticoduodenectomy and in 13.0% (218/1672) of patients who underwent pylorus-preserving pancreaticoduodenectomy. There was no significant difference in the occurrence of anastomotic leakage between these groups ($P = 0.744$).

The blood loss volume was 1721.9 ± 1637.6 ml in the cases with confirmed anastomotic leakage, and more than 1410.6 ± 1194.4 ml in cases without anastomotic leakage ($P = 0.00005$) (Fig. 6). The operative time was also longer in the cases with confirmed anastomotic

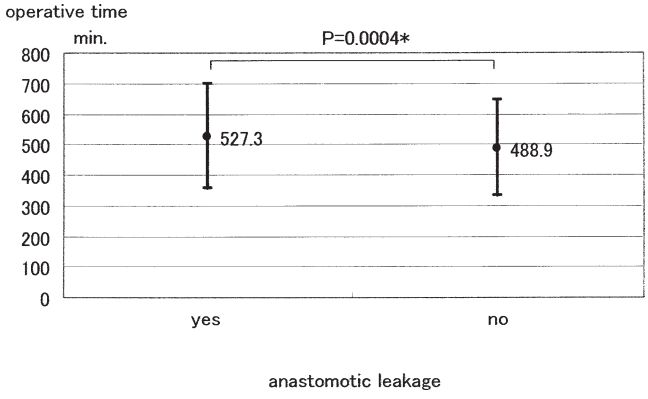

Fig. 7. Operative time and anastomotic leakage

leakage (527.3 ± 169.1 min) than in the cases without anastomotic leakage (488.9 ± 155.3 min) ($P = 0.0004$) (Fig. 7). Both blood loss volume and operative time were significantly related to anastomotic leakage. Anastomotic leakage was observed more frequently in patients whose pancreatic duct was less than 4 mm (16.6%) in diameter and normal without fibrosis (16.1%), compared with those with ducts wider than 4 mm (7.1%) and fibrotic (8.2%). These differences were also significant ($P = 0.001$ for both).

With pancreatic resection, the incidence rate of anastomotic leakage when the scalpel method was used was low at 12.2%, but no differences were seen among the electric cautery, ultrasonic dissector, and LCS methods ($P = 0.303$) (Fig. 8). Regarding the pancreatic stump treatment, the incidence of anastomotic leakage was 19.6% among patients that underwent mattress suturing, which seemed to be higher than that of those who underwent hemostasis only or fish-mouth suturing, although the differences were not significant ($P = 0.119$) (Fig. 9). Examination of the anastomotic leakage rate

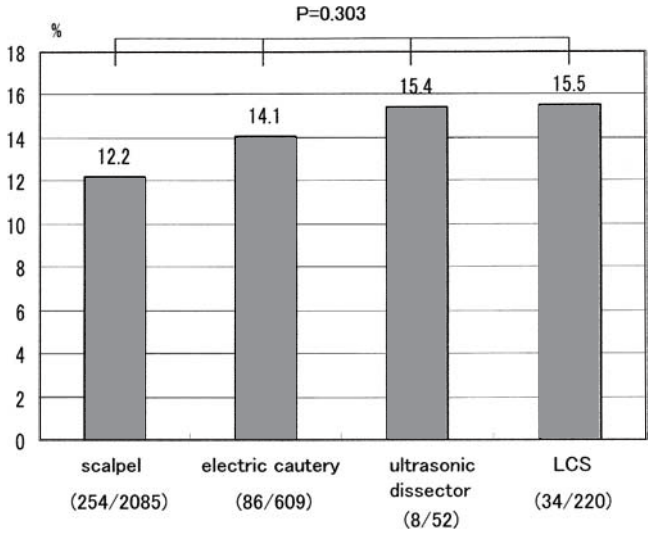

Fig. 8. Incidence rate of anastomotic leakage by pancreatic resection methods. *LCS*, laparoscopic coagulating shears

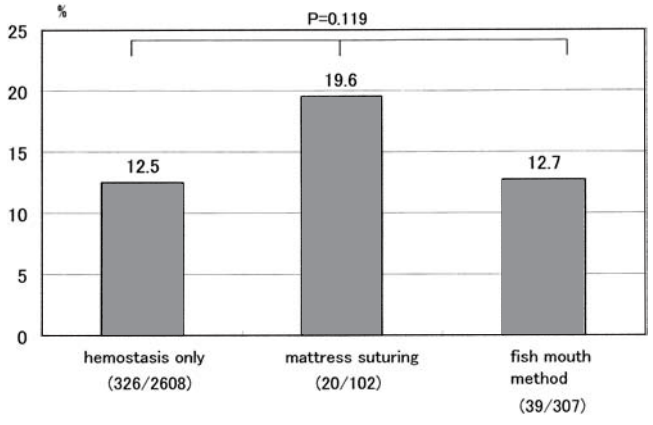

Fig. 9. Incidence rate of anastomotic leakage by management of resected pancreatic stump

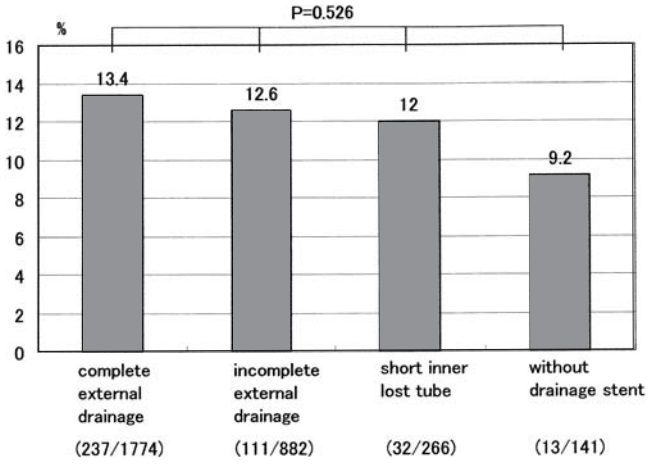

Fig. 10. Incidence rate of anastomotic leakage by pancreatic juice drainage method

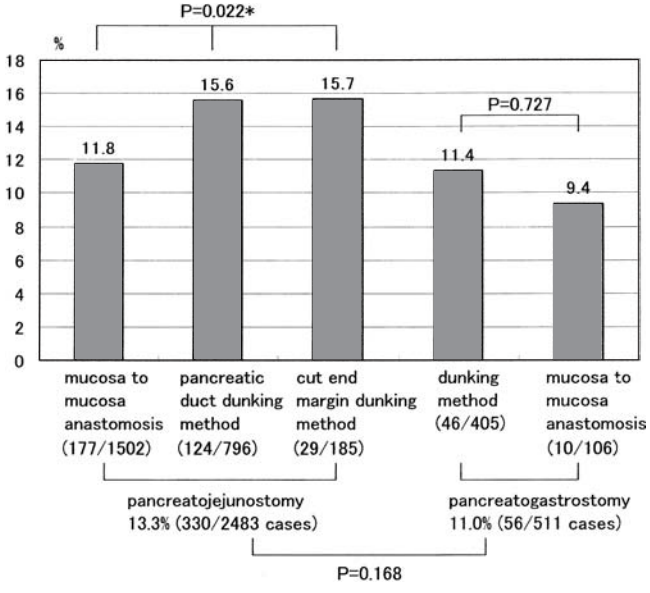

Fig. 11. Incidence rate of anastomotic leakage by various anastomotic methods

by the different pancreatic juice drainage methods showed a low rate of leakage in cases where a stent tube was used (9.2%); however, no differences were seen in the rates of leakage among the pancreatic juice complete external drainage, incomplete external drainage, and short inner lost-tube methods ($P = 0.526$) (Fig. 10).

Comparison of anastomotic leakage between pancreatogastrostomy and pancreatojejunostomy

We compared the rates of anastomotic leakage between pancreatogastrostomy and pancreatojejunostomy (Fig. 11). The overall rate of anastomotic leakage in cases of pancreatogastrostomy was 11.0%; on the other hand, that in cases of pancreatojejunostomy was 13.3%. This difference was not significant ($P = 0.168$). In cases of pancreatogastrostomy, the incidence of anastomotic leakage was 11.4% with the dunking method and 9.4% with mucosa-to-mucosa anastomosis. The difference was not significant ($P = 0.727$). On the other hand, in cases of pancreatojejunostomy, the incidence was 11.8% with mucosa-to-mucosa anastomosis, 15.6% with the pancreatic duct dunking method, and 15.7% with the cut-end-margin dunking method. These differences were significant ($P = 0.022$).

We next evaluated the incidence rates of intra-abdominal hemorrhage (Fig. 12) and intra-abdominal abscess (Fig. 13) as secondary complications of anastomotic leakage.

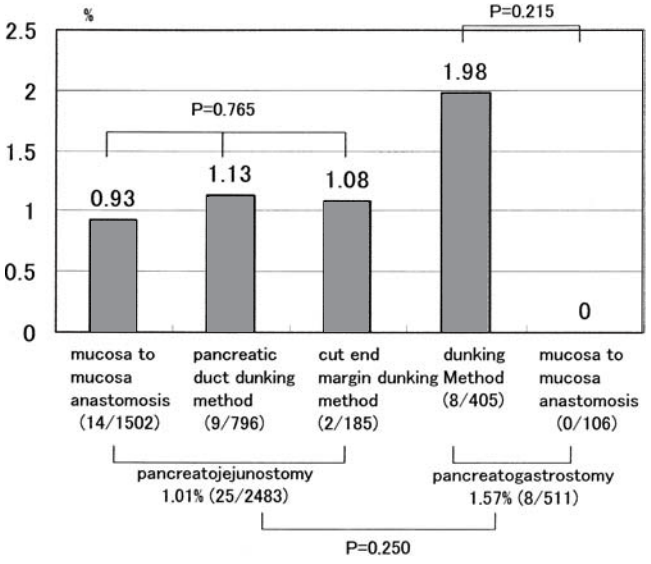

Fig. 12. Incidence rate of intra-abdominal hemorrhage by various anastomotic methods

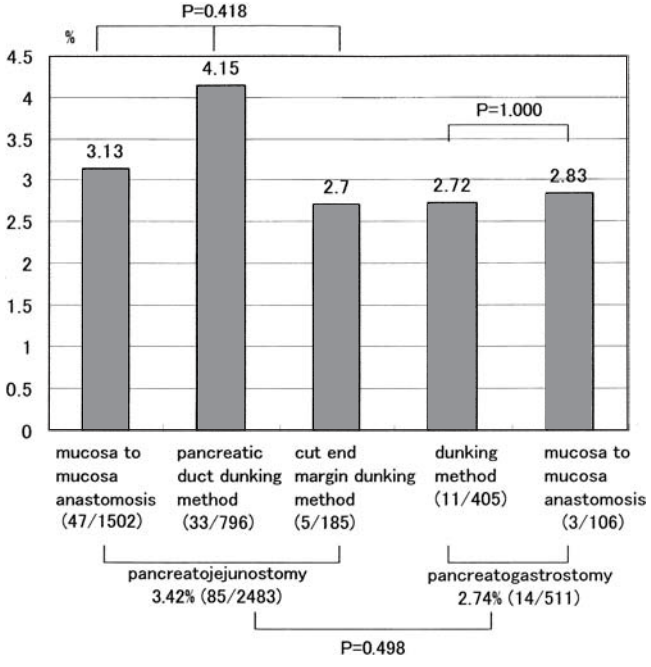

Fig. 13. Incidence rate of intra-abdominal abscess by various anastomotic methods

The overall incidence rates of intra-abdominal hemorrhage were 1.57% in cases of pancreatogastrostomy and 1.01% in cases of pancreatojejunostomy. This difference was not significant ($P = 0.250$). In cases of pancreatogastrostomy, the incidence of intra-abdominal hemorrhage was 1.98% with the dunking method; however, hemorrhage, was not observed for mucosa-to-mucosa anastomosis cases, although the difference between them was not significant ($P = 0.215$). In cases of pancreatojejunostomy, the incidence of intra-abdominal hemorrhage was 0.93% with mucosa-to-mucosa anastomosis, 1.13% with the pancreatic duct dunking method, and 1.08% with the cut-end-margin dunking method. These differences were not significant ($P = 0.765$).

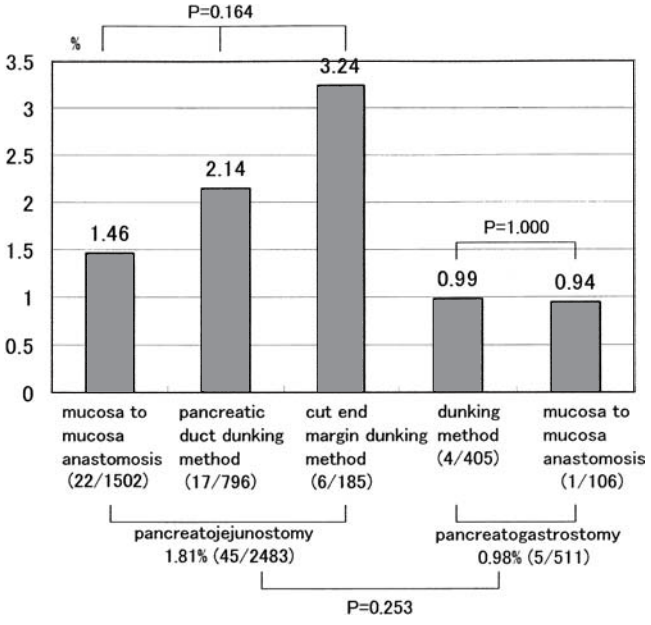

Fig. 14. Mortality rate due to anastomotic leakage (by various anastomotic methods)

The overall incidence of intra-abdominal abscess was 3.42% for pancreatojejunostomy and 2.74% for pancreatogastrostomy. This difference was not significant ($P = 0.498$). By surgical technique for pancreatojejunostomy cases, the rates were 4.15% for the pancreatic duct dunking method, 3.13% for mucosa-to-mucosa anastomosis, and 2.7% for the cut-end-margin dunking method. These differences were not significant ($P = 0.418$). For pancreatogastrostomy cases, the rates were 2.72% for the dunking method and 2.83% for mucosa-to-mucosa anastomosis, but the difference between them was not significant ($P = 1.000$).

The mortality rates among patients with anastomotic leakage complications are shown in Fig. 14. The overall mortality rates were 1.81% among pancreatojejunostomy patients and 0.98% among pancreatogastrostomy patients. This difference not significant ($P = 0.253$). Among pancreatojejunostomy patients, the highest mortality rate was when the cut-end-margin dunking method was used (3.24%), followed by the pancreatic duct dunking method (2.14%), and mucosa-to-mucosa anastomosis (1.46%), although the differences were not significant ($P = 0.164$). Among pancreatogastrostomy patients, the mortality rates were 0.99% with the dunk-

ing method and 0.94% with mucosa-to-mucosa anastomosis. The difference between them was not significant ($P = 1.000$).

Discussion

Pancreatogastrointestinal anastomosis in cases of pancreaticoduodenectomy and pylorus-preserving pancreaticoduodenectomy is the most important method of reconstructing the gastrointestinal tract, and for this reason there are various surgical techniques used at each institution for this procedure. However, when anastomotic leakage occurs, there is a high risk of intra-abdominal hemorrhage caused by active pancreatic juice.[3] Furthermore, bacterial infection and intra-abdominal abscess can be extremely severe and fatal complications. We therefore compiled the results of a questionnaire conducted at the 28th Japan Pancreatic Surgery Club on the state of pancreatogastrointestinal anastomotic methods. We received replies on 3109 cases, evaluated the responses, and compared them with those of previous surveys.

First, examination of pancreatic resection and pancreatic stump treatments prior to anastomosis revealed that the most common methods were pancreatic resection with a scalpel and hemostasis only to prevent ischemia and crush injury. This result was similar to that reported by the 24th Japan Pancreatic Surgery Club survey.[4] Conventionally, the ultrasonic dissector and LCS are rarely used, but the present results revealed that these were used in 8.7% of cases. We also previously used a scalpel, but recently we have been using an ultrasonic dissector and conducting resections by secure ligation and detachment up to the exposure of the branched pancreatic duct and microvessels. Regarding pancreatic juice drainage, complete external drainage via the bowel is still common, and this finding was also similar to that of the 24th survey. Clinical studies and experimental data show that the patency of pancreatogastrointestinal anastomosis can be clearly improved by using a stent.[5,6] We perform pancreatic juice incomplete drainage by the short inner lost-tube method. Tube placement maintains patency of the pancreatic duct and avoids complications, and it also helps shorten the hospital stay.

In terms of the methods of pancreatogastrointestinal anastomotic reconstruction, PDIIA (Table 1) was the overwhelmingly predominant method (48.5%; 1509 cases). In the 1992 18th Japan Pancreatic Surgery Club survey,[7] the PDIIA method accounted for 35.3% of the total, and the PDIIB method virtually the same (33.5%). This change suggests that the preferred method of anastomosis has switched from the dunking method to mucosa-to-mucosa anastomosis. Examination of the 2994 cases for which replies were received showed that pancreatojejunostomy was the predominant method (82.9%; 2483 cases). The 24th survey showed that use of pancreatogastrostomy had been increasing at 36.1%, but the present survey showed a decrease of 17.1% (511 cases).

We next studied anastomotic leakage at the pancreatogastrointestinal anastomosis, which is one of the most serious complications in pancreaticoduodenectomy. The overall incidence of anastomotic leakage was 12.8% (399 cases). Postoperative complications of pancreaticoduodenectomy relate to increased bleeding and the prolongation of operative time.[8] According to the present results, the blood loss volume and operative time significantly affected postoperative complications. It is also known that the factor most related to the incidence of anastomotic leakage is the state of the residual pancreas.[3,9–11] The present results showed no fibrosis of the residual pancreas, and a high rate of anastomotic leakage in so-called normal pancreases that maintained pancreatic exocrine function. In cases of pancreatic ducts without dilation, we thought that the pancreatic duct wall was thin and brittle, and the incidence of anastomotic leakage was high. Examination of pancreatic juice drainage showed that pancreatic duct tubing was not necessary for avoiding anastomotic leakage.

We then compared the cases of anastomotic leakage at the pancreatogastrointestinal anastomotic site between pancreatogastrostomy and pancreatojejunostomy. Previous surveys found no differences in the incidence of anastomotic leakage between pancreatogastrostomy and pancreatojejunostomy.[9,12,13] Our results also showed no significant difference between the two groups: the anastomotic leakage rate for pancreatogastrostomy was 11.0% and the rate for pancreatojejunostomy was 13.3%. In terms of anastomotic methods, rates of leakage were slightly higher with the cut-end-margin dunking method (15.7%) and pancreatic duct dunking method (15.6%). The incidence of anastomotic leakage with these methods reported by the 24th Japan Pancreatic Surgery Club survey was 8.8% and 8.7%, respectively, slightly higher than those for other anastomotic methods. The overall anastomotic leakage incidence (8.6%) in that survey was slightly lower than that in the current survey, but we attribute this to a difference in the definition of anastomotic leakage. In the present survey, 29% of institutions responded that anastomotic leakage was diagnosed on the basis of an amylase value during drainage of at least 10 000 IU/l, whereas the 24th Japan Pancreatic Surgery Club survey reported that 66.7% of institutions responded thus. There is no agreed-upon definition of anastomotic leakage, and the differing survey results shows a clear difference in its definition.[14] A study of the

severe secondary complications of intra-abdominal hemorrhage and abscess showed that 1.1% of all cases and 8.8% of anastomotic leakage cases developed intra-abdominal hemorrhage. Intra-abdominal hemorrhage was seen in 1.01% of all cases of pancreatojejunostomy, and in 7.58% of pancreatojejunostomy with anastomotic leakage. As for pancreatogastrostomy cases, no cases of intra-abdominal hemorrhage were reported for mucosa-to-mucosa anastomosis, the rate of occurrence was 1.57% for the dunking method, but 14.29% of all cases of anastomotic leakage. With the dunking method, pancreatic juice from the pancreatic duct or pancreatic stump is completely drained into the stomach, but if the anastomosis ruptures, the contents of the pancreatic duct, including the pancreatic juice, leak into the peritoneal cavity and a serious condition results.

The incidence of intra-abdominal abscess was 3.3% overall and 25.6% among cases with anastomotic leakage. Intra-abdominal abscess was seen in 3.42% of all pancreatojejunostomy cases and in 25.8% of those with anastomotic leakage. The rate was 2.74% in all cases of pancreatogastrostomy and 25.0% in those with anastomotic leakage. The mortality rate among all patients with anastomotic leakage was 13.0% (52 cases), which is very similar to the result of 14.0% reported by the 24th Japan Pancreatic Surgery Club survey. According to anastomotic method, the mortality rates were 1.81% among all pancreatojejunostomy patients, and 13.64% among those with anastomotic leakage. In all pancreatogastrostomy patients, the mortality rate was 0.98%, and 8.93% among those with anastomotic leakage. Thus, there were no significant differences between pancreatogastrostomy and pancreatojejunostomy.

The results of this questionnaire show that pancreatojejunostomy, and more specifically mucosa-to-mucosa anastomosis, is still a common method of pancreatogastrointestinal anastomosis. In pancreatojejunal mucosa-to-mucosa anastomosis, if the anastomosis is performed well the wound will heal well and patency of the pancreatic duct will also be good, but pancreatic duct-wall injury or rupture during the surgical operation also tends to cause anastomotic leakage. Also, after pancreatojejunostomy causes anastomotic leakage and the activated pancreatic juice leaks, the risk to the patient becomes serious, so more careful anastomotic management and suitable measures at the time of anastomotic leakage are vital. It has been reported that pancreatogastrostomy is highly safe, and there are a growing number of institutions performing this procedure. However, in the present survey, few institutions were conducting pancreatogastrostomy, and compared with pancreatojejunostomy, it cannot be described as significantly safer in terms of preventing anastomotic leakage. With pancreatogastrostomy, aside from anastomotic leakage, delayed gastric emptying caused by fixation at the posterior wall of the stomach or late pancreatic duct occlusion during mucous membrane suturing is a concern. However, the advantages of pancreatogastrostomy are that it enables direct viewing of the anastomotic site postoperatively using an endoscope, and in many cases, postoperative pancreatic duct patency can be confirmed. Examination of postoperative pancreatic duct patency by various other methods is also possible.[15]

We conducted a study on pancreatogastrostomy and pancreatojejunostomy focusing on anastomotic leakage, but the relative merits of the two methods were not elucidated. The key factors for a successful outcome of pancreaticoduodenectomy are subtle technique and an experienced surgeon and staff.[16] This survey by the Japan Pancreatic Surgery Club should be continued, and further studies on safe and reliable pancreatogastrointestinal anastomotic methods are also needed.

Conclusion

We conducted a questionnaire survey on pancreatogastrointestinal anastomosis at the 28th Japan Pancreatic Surgery Club. We received responses from 83 institutions on 3109 cases and collated and analyzed the results. Pancreatogastrointestinal anastomotic leakage still occurs in 12.8% of cases, and 13.0% of these cases have poor outcome. The questionnaire survey results show no significant difference in the development of anastomotic leakage among the anastomotic organ used with the pancreas, the pancreas resection method, and the pancreatic juice drainage method. Every effort should be made to reduce anastomotic leakage. Also, the choice of method for pancreatogastrointestinal anastomosis should be made according to each individual case.

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