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The Impact of Stump Closure Techniques on Pancreatic Fistula Stratified by the Thickness of the Pancreas in Distal Pancreatectomy

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Keywords
Pancreatic fistula · Distal pancreatectomy · Thickness · Clamp-crushing method

Abstract
Background: The purpose of this retrospective study was to evaluate the impact of stump closure techniques on pancreatic fistula (PF) focusing on pancreatic thickness after distal pancreatectomy (DP). ***Methods:*** A total of 213 patients who underwent DP between 2007 and 2017 were retrospectively reviewed. The risk factors of PF were investigated. ***Results:*** In all patients, age ≥65 years (odds ratio [OR]: 3.60, $p = 0.012$), operation time ≥300 min (OR: 3.05, $p = 0.013$) and thickness of transected pancreas (OR: 1.37, $p < 0.001$) were identified as independent risk factors for clinically relevant PF. A receiver operating curve analysis revealed the optimum cutoff values of thickness to be 14 mm with stapler closure and 17 mm with the clamp-crushing method. There were no significant differences regarding PF between the stapler closure and clamp-crushing methods in the thin (<14 mm) and very thick pancreas (≥17 mm) groups ($p = 0.822$, $p = 0.072$). In contrast, stapler closure was the only independent risk factor for developing PF in the moderately thick (≥14, <17 mm) pancreas group (OR: 6.75 and $p = 0.004$, respectively). ***Conclusion:*** The clamp-crushing method was superior to stapler closure for pancreatic transection, especially in patients with moderately thick pancreas.

Background

Postoperative pancreatic fistula (PF) is a major cause of morbidity after distal pancreatectomy (DP), occurring in 15–40% of patients, despite improvements in surgical techniques and perioperative patient care [1–3]. Various surgical techniques for division and closure of the pancreatic remnant have been proposed previously in an effort to reduce the incidence of PF, such as hand-sewn closure [1, 4, 5], stapler use with or without reinforcement [6, 7], energy devices [8, 9] and the use of patches [10, 11]. However, the optimum procedure has not been established.

The stapler method, which closes the pancreatic stump concurrently with division, is widely applied by surgeons due to its simplicity of use. Although the clamp-crushing method (transecting the pancreatic parenchyma with Pean crushing and ligating small vessels and the main and branched pancreatic ducts) had previously been applied for pancreas division in our institution, stapler closure

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has been used instead since 2011. However, the incidence of PF with the use of stapling devices remains high.

Previous studies have reported that a thicker pancreas is a risk factor for developing PF after DP when using a stapler [12–16]. One possible weak point of stapler closure may be difficulty adjusting the compression strength according to the texture or thickness of the pancreas. Kleeff et al. [1] mentioned that the pancreatic parenchyma could be crushed by mechanical stapling, and subsequent injury of small pancreatic ducts could cause PF.

It is true that a thick pancreas easily develops PF; however, the mechanism underlying the development of PF and the relationship between PF and thickness of the pancreas may differ between the stapler and hand-sewn closure techniques.

Therefore, the purpose of the present study was to evaluate the impact of the stump closure method on the occurrence of PF with stratification of patients according to the thickness of the transected pancreas.

Methods

Patients

Between January 2007 and December 2017, 226 patients underwent DP at Shizuoka Cancer Center. One patient was excluded from the study due to a lack of clinical data. In the early period, the clamp-crushing method was performed. However, our routine procedure gradually shifted to one of stapler closure starting in April 2011, and stapler closure has been routinely used since September 2013. Twelve patients in whom other methods (cautery in 9 patients and energy devices in three) were used for pancreas transection were also excluded. The remaining 213 patients were retrospectively reviewed.

Surgical Techniques and Postoperative Management

Open DP with D2 lymph node dissection was performed in patients with malignant diseases. In patients who were diagnosed preoperatively with benign diseases, lymph node dissection was omitted. In the clamp-crushing method, the pancreatic parenchyma was transected by clamp-crushing with Pean, and small vessels and branched pancreatic ducts exposed on the cut surface of the pancreas were ligated and divided. The main pancreatic duct was also ligated. The cut margin of the remnant pancreas was left open without sutures or adding any agent. In the stapler closure technique, the pancreas was divided using stapling devices. The closure jaw was clamped slowly, taking a few minutes at a fixed speed. The following stapler devices were used: Endo GIA (Covidien Medtronic, Plymouth, MN, USA), Echelon Flex (Ethicon Endosurgery, Cincinnati, OH, USA), TA stapler (Covidien Medtronic), and TLH60 (Ethicon Endosurgery). The stapling devices and cartridges for the stapler were left to the surgeon's preference. The cut line of the pancreas was detailed in the operative records. Two closed suction drains were placed adjacent to the pancreatic stump and in the left subphrenic space.

Amylase value of the drainage fluid was measured on postoperative days 1 and 3. The drainage tubes were to be removed on postoperative day 4 when the amylase level of the drainage fluid was less than 3 times the upper limit of the institutional normal serum amylase value, the appearance of the drainage fluid was clear, and the patient's condition was good. The drain was usually exchanged when drain placement had been continued for more than 7 days. Postoperative PF was diagnosed and classified based on the definition of the International Study Group of Pancreatic Surgery [17].

Resection Site of the Pancreas

The resection line of the pancreas was estimated using preoperative computed tomography based on the descriptions in the operative records. Thickness of the pancreatic resection line was measured on axial view using a 2-mm slice contrast-enhanced computed tomography scan (see online suppl. material 1; see www.karger.com/doi/10.1159/000505061 for all online suppl. material). The thickest value of the pancreatic resection line in each slice was used for analysis in the present study.

Statistical Analyses

Results are expressed as median (range) for continuous data. Continuous data were compared using the Mann-Whitney *U* test or dichotomized according to a receiver operating characteristic (ROC) analysis. Categorical data were compared using Pearson's χ^2 test or Fisher's exact probability test where appropriate. A p value <0.05 was considered statistically significant. Variables with $p < 0.05$ in the univariate analysis were entered into a multivariate logistic regression analysis to identify independent factors. Statistical analyses were performed using the SPSS software program for Windows, version 21.0 (SPSS, Chicago, IL, USA).

Results

A total of 213 patients (107 men and 106 women) with a median age of 67 (23–85) years underwent DP. The pathological diagnosis was pancreatic cancer in 121 patients, intraductal papillary mucinous neoplasm in 28, neuroendocrine tumor in 15, cystic neoplasms in 22, metastatic pancreatic tumor in 11, solid pseudopapillary neoplasm in 8 and others in 8. The clamp-crushing method was used in 86 patients, and stapler closure was performed in 127 (Endo GIA in 84, Echelon Flex in 34, TA stapler in 8, and TLH60 in 1). Regional lymph node dissection was performed in 176 patients. The median operation time was 234 (100–766) min and blood loss was 363 (0–2,716) mL. The postoperative complications are summarized in suppl. material 2. The overall incidence of any PF was 152 patients; biochemical leakage was noted in 61 patients, grade B PF in 89 patients, and grade C PF in 2 patients. Clinically relevant PF (grade B or C) occurred in 91 patients (42.7%). Postoperative complications of Clavien-Dindo grade IIIa or higher occurred in 145 patients

Table 1. Risk factors for the development of pancreatic fistula in all patients

Factor	Pancreatic fistula		Univariate *p* value	Multivariate	
	absent	present		odds ratio	*p* value
Age					
<65 years	52 (67)	26 (33)	**0.044**	1.00	**0.012**
≥65 years	70 (52)	65 (48)		3.60 (1.33–9.72)	
Gender					
Female	69 (65)	37 (35)	**0.027**	1.00	0.637
Male	53 (50)	54 (50)		1.23 (0.52–2.92)	
BMI					
<25	106 (87)	69 (76)	**0.037**	1.00	0.253
≥25	16 (13)	22 (24)		1.89 (0.64–5.62)	
Disease					
PC	67 (55)	54 (45)	0.577		
Others	55 (60)	37 (40)			
Pancreatic texture					
Soft	118 (58)	85 (42)	0.331		
Hard	4 (40)	6 (60)			
Transection site					
Neck	111 (91)	75 (82)	0.094		
Body/tail	11 (9)	16 (17)			
Approach					
Laparoscopic	12 (50)	12 (50)	0.513		
Open	110 (58)	79 (42)			
Splenectomy					
No	2 (33)	4 (67)	0.405		
Yes	120 (58)	87 (42)			
Stump closure					
Clamp-crushing	55 (64)	31 (36)	0.121		
Stapler	67 (53)	60 (47)			
Cartridge size					
<2 mm	59 (59)	41 (41)	0.010	1.00	0.182
≥2 mm	8 (31)	18 (69)		2.11 (0.70–6.34)	
Op. time					
<300 min	96 (63)	56 (37)	**0.009**	1.00	**0.013**
≥300 min	26 (43)	35 (57)		3.05 (1.28–8.35)	
Blood loss					
<500 mL	88 (61)	56 (39)	0.107		
≥500 mL	34 (49)	35 (51)			
Thickness of pancreas, mm	12 (5–24)	15 (8–31)	**<0.001**	1.37 (1.20–1.57)	**<0.001**
MPD diameter, mm	1.7 (0.6–8.1)	1.8 (0.8–4.8)	0.127		

Categorical data are expressed as *n* (%). Number data are expressed as median (range). Bold was used to show significant difference ($p < 0.05$). BMI, body mass index; PC, pancreatic cancer; Op. time, operation time; MPD, main pancreatic duct.

(68.1%). There were no in-hospital deaths during the study period. The median postoperative hospital stay was 20 days.

Univariate and multivariate analyses were performed to identify risk factors for clinically relevant PF in all patients (Table 1). The median thickness of the transected pancreas was 15 (8–31) mm in patients with PF and 12 (5–24) mm in those without PF. There were no significant differences in the incidence of PF between stapler closure and the clamp-crushing method. In the multivariate analysis, age ≥65 years (odds ratio [OR]: 3.60, 95% confidence interval [CI]: 1.33–9.72, $p = 0.012$), operation time ≥300

Table 2. Univariate and multivariate analyses for postoperative pancreatic fistula in the thin (<14 mm) pancreas group

Factor	Patients, *n*	Patients with pancreatic fistula, *n*	Univariate *p* value	Multivariate	
				odds ratio	*p* value
Age					
<65 years	38	6 (16)	0.075		
≥65 years	75	24 (32)			
Gender					
Female	64	16 (25)	0.674		
Male	49	14 (29)			
BMI					
<25	97	24 (25)	0.284		
≥25	16	6 (38)			
Disease					
PC	70	20 (29)	0.662		
Others	43	10 (23)			
Pancreatic texture					
Soft	110	28 (25)	0.172		
Hard	3	2 (67)			
Transection site					
Neck	107	28 (26)	0.699		
Body/tail	6	2 (33)			
Approach					
Laparoscopic	9	3 (33)	0.697		
Open	104	27 (26)			
Splenectomy					
No	3	2 (67)	0.172		
Yes	110	28 (25)			
Stump closure					
Clamp-crushing	76	21 (28)	0.822		
Stapler	37	9 (24)			
Cartridge size					
<2 mm	66	17 (26)	0.348		
≥2 mm	10	4 (40)			
Op. time					
<300 min	31	14 (45)	**0.009**	1.00	**0.007**
≥300 min	82	16 (20)		3.40 (1.39–8.30)	
Blood loss					
<500 mL	79	18 (23)	0.173		
≥500 mL	34	12 (35)			
MPD diameter					
<2 mm	73	16 (22)	0.132		
≥2 mm	40	14 (35)			

Categorical data are expressed as *n* (%). Bold was used to show significant difference ($p < 0.05$). BMI, body mass index; PC, pancreatic cancer; Op. time, operation time; MPD, main pancreatic duct.

min (OR: 3.05, 95% CI: 1.28–8.35, $p = 0.013$) and thickness of the transected pancreas (OR: 1.37, 95% CI: 1.20–1.57, $p < 0.001$) were identified as independent risk factors for clinically relevant PF.

A receiver operating characteristic curve analysis revealed the optimum cut-off values for developing PF after DP to be 14 mm in patients undergoing stapler closure and 17 mm in patients undergoing the clamp-crushing method. The area under the curve of the cut-off level was 0.778 (95% CI: 0.698–0.859) with stapler closure and 0.691 (95% CI: 0.577–0.805) with clamp-crushing. Thereafter, we divided patients into 3 groups: those with

Table 3. Univariate and multivariate analyses for postoperative pancreatic fistula in patients with pancreas thickness ≥14 but <17 mm

Factor	Patients, *n*	Patients with pancreatic fistula, *n*	Univariate *p* value	Multivariate	
				odds ratio	*p* value
Age, years					
<65 years	17	7 (41)	0.542		
≥65 years	29	16 (55)			
Gender					
Female	21	8 (38)	0.236		
Male	25	15 (60)			
BMI					
<25	36	17 (47)	0.474		
≥25	10	6 (60)			
Disease					
PC	23	12 (52)	1.000		
Others	23	11 (48)			
Pancreatic texture					
Soft	43	22 (51)	1.000		
Hard	3	1 (33)			
Transection site					
Neck	38	19 (50)	1.000		
Body/tail	8	4 (50)			
Approach					
Laparoscopic	5	2 (40)	1.000		
Open	41	21 (51)			
Splenectomy					
No	2	1 (50)	1.000		
Yes	44	22 (50)			
Stump closure					
Clamp-crushing	20	5 (25)	**0.006**	1.00	**0.004**
Stapler	26	18 (69)		6.75 (1.82–25.00)	
Cartridge size					
<2 mm	19	12 (63)	0.356		
≥2 mm	6	5 (83)			
Op. time					
<300 min	29	13 (45)	0.542		
≥300 min	17	10 (59)			
Blood loss					
<500 mL	28	12 (43)	0.365		
≥500 mL	18	11 (61)			
MPD diameter					
<2 mm	23	12 (52)	0.768		
≥2 mm	23	11 (48)			

Categorical data are expressed as *n* (%). Bold was used to show significant difference ($p < 0.05$). BMI, body mass index; PC, pancreatic cancer; Op. time, operation time; MPD, main pancreatic duct.

a pancreas thickness of <14 mm (thin pancreas group, $n = 113$), those with a pancreas thickness of 14 to <17 mm (moderately thick pancreas group, $n = 46$) and those with a pancreas thickness of ≥17 mm (very thick pancreas group, $n = 54$). Clinically relevant PF occurred in 30/113 [26.5%] patients in the thin pancreas group, in 23/46 (50%) patients in the moderately thick pancreas group, and in 38/54 [70.3%] patients in the very thick pancreas group.

In the thin pancreas group, univariate and multivariate analyses revealed that an operation time ≥300 min was an independent risk factor for developing PF (Table 2). The

Table 4. Univariate and multivariate analyses for postoperative pancreatic fistula in patients with pancreas thickness ≥17 mm

Factor	Patients, *n*	Patients with pancreatic fistula, *n*	Univariate *p* value	Multivariate	
				odds ratio	*p* value
Age					
<65 years	23	13 (57)	0.074		
≥65 years	31	25 (81)			
Gender					
Female	21	13 (62)	0.363		
Male	33	25 (76)			
BMI					
<25	42	28 (67)	0.264		
≥25	12	10 (83)			
Disease					
PC	28	22 (79)	0.236		
Others	26	16 (62)			
Pancreatic texture					
Soft	50	35 (70)	1.000		
Hard	4	3 (75)			
Transection site					
Neck	41	28 (68)	0.553		
Body/tail	13	10 (76)			
Approach					
Laparoscopic	10	7 (70)	1.000		
Open	44	31 (70)			
Splenectomy					
No	1	1 (100)	1.000		
Yes	53	37 (70)			
Stump closure					
Clamp-crushing	29	17 (59)	0.072		
Stapler	25	21 (84)			
Cartridge size					
<2 mm	15	12 (80)	0.504		
≥2 mm	10	9 (90)			
Op. time					
<300 min	41	27 (66)	0.301		
≥300 min	13	11 (85)			
Blood loss					
<500 mL	37	26 (70)	1.000		
≥500 mL	17	12 (71)			
MPD diameter					
<2 mm	38	26 (68)	0.629		
≥2 mm	16	12 (75)			

Categorical data are expressed as *n* (%). BMI, body mass index; PC, pancreatic cancer; Op. time, operation time; MPD, main pancreatic duct.

incidence of PF was comparable between stapler closure and the clamp-crushing method in the thin pancreas group.

In the moderately thick pancreas group, the incidence of PF was significantly higher in patients who underwent stapler closure than in those who underwent clamp-crushing (69 vs. 25%, $p = 0.006$) (Table 3). A multivariate analysis revealed that stapler closure was the only independent risk factor for developing PF after DP in the moderately thick pancreas group (OR: 6.75, $p = 0.004$).

In the very thick pancreas group, the occurrence of PF was higher with stapler closure than with clamp-crushing, but this trend did not reach statistical significance

($p = 0.072$; Table 4). No variables were significantly associated with PF development in the very thick pancreatic group.

Discussion

The present study showed that thickness of the transected pancreas significantly affected the development of PF after DP. The clamp-crushing method was advantageous, especially in patients with a moderately thick pancreas, compared to stapler closure, although differences in the incidence of PF between the two techniques were small in patients with a thin or very thick pancreas.

The present study demonstrated that thickness of the pancreas was an important factor that should be considered when dividing the pancreas in DP. Several studies have reported that thickness of the pancreatic remnant is a risk factor for PF after DP with stapler closure [12–16]. Kawai et al. [14] reported that stapler closure for a thick pancreas (>12 mm) was associated with a significantly increased occurrence of PF compared with hand-sewn sutures or bipolar scissor techniques (86.7 vs. 38.5%, respectively). In contrast, the incidence of PF was comparable among these techniques in a thin (<12 mm) pancreas. Results in the present study were consistent with these previous findings in terms of stump closure for a thin pancreas. However, the clamp-crushing method showed a significant reduction in the rate of PF compared to stapler closure in a moderately thick pancreas, as the cut-off value of pancreatic thickness for PF differed between the clamp-crushing method and stapler closure. Of further note, there was no statistically significant difference in the rate of PF between the 2 techniques in the very thick pancreas group. These findings suggest that the clamp-crushing method may be beneficial compared to other techniques, especially for patients with a moderately thick pancreas.

One major cause of PF following DP is considered to be leakage of pancreatic fluid from the main and peripheral pancreatic ducts on the cut surface of the pancreatic remnant. Although a stapler is able to close both the main and peripheral pancreatic ducts simultaneously by compressing the stump, compressing a thick pancreas with a stapler can injure the pancreatic parenchyma and tiny branches of the pancreatic duct. In addition, attempts to staple a thick pancreas without tearing can lead to incomplete closure of small ducts. In contrast, crushing the pancreatic parenchyma using Pean and ligating the fibrous bundles, including the peripheral pancreatic ducts, is a reasonable method for managing a thick pancreas [18]. Therefore, the clamp-crushing method should be applied in patients with a moderately thick pancreas, whereas stapler closure may be reasonable in those with a thin pancreas, due to its convenience and technical simplicity and the comparable PF rates between the 2 groups. Further improvements are needed in patients with a very thick pancreas, who show a markedly high rate of PF than those with a thinner pancreas. Coverage of the pancreatic stump – e.g., using a falciform ligament patch, seromuscular patch, or fibrin glue – has been proposed in several studies [19, 20]. The combination of the clamp-crushing method and coverage of the pancreatic remnant may be effective for managing patients with a thicker pancreas.

Several limitations associated with the present study warrant mention. First, this was a retrospective, single-institutional study that had potential bias in the selection of patients. Second, the rate of PF incidence (overall: 69.8%, clinically relevant PF: 41.8%) in this study is higher than that reported previously. This discrepancy might be due to differences in the patient characteristics. The present study included more patients with a soft pancreas, which is reported to be a risk factor of PF [21]. One possible explanation may be that pancreatic texture was judged based on the findings of the pancreas at the level of the transection line. The texture of the pancreas proximal to the tumor is generally soft. Alternatively, this outcome may be because there were no patients with chronic pancreatitis in the present study. Thus, most of our patients had a soft pancreas in this study. Furthermore, our cautious drain management after DP may have increased the rate of grade B PF. Drains were left if the amylase value in the drainage fluid was over 375 IU/L (3 times the upper limit of the institutional normal range of serum amylase) at POD 3, regardless of infection. Drainage was continued until the drainage fluid had dried up or the drain amylase value had decreased to <375 IU/L without infection. The mortality rate for our series was 0, which seems to provide clinical justification of our perioperative management approach. Third, there were some biases in the selection of the stump closure method during the transitional period. However, there were no significant difference in the incidence of PF among surgeons (data not shown). Fourth, we retrospectively examined the transection line using the operation record; however, there might have been some discrepancy between the estimated transection line on CT and the actual transection line.

In conclusion, we should take into account the thickness of the transected pancreas in DP, and it is important

to consider the clamp-crushing method, especially in patients with a moderately thick pancreas. Further studies are needed to identify the appropriate method for closure according to the characteristics of the pancreas, including thickness.

Statement of Ethics

This study was approved by the Institutional Review Board of Shizuoka Cancer Center (Approval No. 30-J70-30-1). Informed consent was obtained from all patients.

Disclosure Statement

The authors have no conflicts of interest to disclose.

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Author Contributions

N.W.: conception, design of the study, and analysis and interpretation of data. N.W. and Y.Y.: drafting and revision of the article. All authors: final approval of the version to be published.

References

1 Kleeff J, Diener MK, Z'Graggen K, Hinz U, Wagner M, Bachmann J, et al. Distal pancreatectomy: risk factors for surgical failure in 302 consecutive cases. Ann Surg. 2007;245:573–82.
2 Elliott IA, Dann AM, Ghukasyan R, Damato L, Girgis MD, King JC, et al. Pasireotide does not prevent postoperative pancreatic fistula: a prospective study. Oxford: HPB; 2018.
3 Ban D, Shimada K, Konishi M, Saiura A, Hashimoto M, Uesaka K. Stapler and nonstapler closure of the pancreatic remnant after distal pancreatectomy: multicenter retrospective analysis of 388 patients. World J Surg. 2012;36:1866–73.
4 Bilimoria MM, Cormier JN, Mun Y, Lee JE, Evans DB, Pisters PW. Pancreatic leak after left pancreatectomy is reduced following main pancreatic duct ligation. Br J Surg. 2003;90:190–6.
5 Fahy BN, Frey CF, Ho HS, Beckett L, Bold RJ. Morbidity, mortality, and technical factors of distal pancreatectomy. Am J Surg. 2002;183:237–41.
6 Kajiyama Y, Tsurumaru M, Udagawa H, Tsutsumi K, Kinoshita Y, Akiyama H. Quick and simple distal pancreatectomy using the GIA stapler: report of 35 cases. Br J Surg. 1996;83:1711.
7 Okano K, Kakinoki K, Yachida S, Izuishi K, Wakabayashi H, Suzuki Y. A simple and safe pancreas transection using a stapling device for a distal pancreatectomy. J Hepato-Biliary-Pancreatic Sci. 2008;15:353–8.
8 Blansfield JA, Rapp MM, Chokshi RJ, Woll NL, Hunsinger MA, Sheldon DG, et al. Novel method of stump closure for distal pancreatectomy with a 75% reduction in pancreatic fistula rate. J Gastrointest Surg. 2012;16:524–8.
9 Shubert CR, Ferrone CR, Fernandez-Del Castillo C, Kendrick ML, Farnell MB, Smoot RL, et al. A multicenter randomized controlled trial comparing pancreatic leaks after TissueLink versus SEAMGUARD after distal pancreatectomy (PLATS) NCT01051856. J Surg Res. 2016;206:32–40.
10 Carter TI, Fong ZV, Hyslop T, Lavu H, Tan WP, Hardacre J, et al. A dual-institution randomized controlled trial of remnant closure after distal pancreatectomy: does the addition of a falciform patch and fibrin glue improve outcomes? J Gastrointest Surg. 2013;17:102–9.
11 Hassenpflug M, Hinz U, Strobel O, Volpert J, Knebel P, Diener MK, et al. Teres ligament patch reduces relevant morbidity after distal pancreatectomy (the DISCOVER randomized controlled trial). Ann Surg. 2016;264:723–30.
12 Chang Y, Kang J, Jang J-Y, Jung W, Kang M, Lee K, et al. Prediction of pancreatic fistula after distal pancreatectomy based on cross-sectional images. World J Surg. 2017;41:1610–7.
13 Sugimoto M, Gotohda N, Kato Y, Takahashi S, Kinoshita T, Shibasaki H, et al. Risk factor analysis and prevention of postoperative pancreatic fistula after distal pancreatectomy with stapler use. J Hepato-Biliary-Pancreatic Sci. 2013;20:538–44.
14 Kawai M, Tani M, Okada K-i, Hirono S, Miyazawa M, Shimizu A, et al. Stump closure of a thick pancreas using stapler closure increases pancreatic fistula after distal pancreatectomy. Am J Surg. 2013;206:352–9.
15 Eguchi H, Nagano H, Tanemura M, Takeda Y, Marubashi S, Kobayashi S, et al. A thick pancreas is a risk factor for pancreatic fistula after a distal pancreatectomy: selection of the closure technique according to the thickness. Dig Surg. 2011;28:50–6.
16 Okano K, Oshima M, Kakinoki K, Yamamoto N, Akamoto S, Yachida S, et al. Pancreatic thickness as a predictive factor for postoperative pancreatic fistula after distal pancreatectomy using an endopath stapler. Surg Today. 2013;43:141–7.
17 Bassi C, Marchegiani G, Dervenis C, Sarr M, Abu Hilal M, Adham M, et al. The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 years after. Surgery. 2017;161:584–91.
18 Koga R, Yamamoto J, Saiura A, Natori T, Katori M, Kokudo N, et al. Clamp-crushing pancreas transection in pancreatoduodenectomy. Hepato-Gastroenterology. 2009;56:89–93.
19 Hassenpflug M, Hartwig W, Strobel O, Hinz U, Hackert T, Fritz S, et al. Decrease in clinically relevant pancreatic fistula by coverage of the pancreatic remnant after distal pancreatectomy. Surgery. 2012;152:S164–171.
20 Suzuki Y, Kuroda Y, Morita A, Fujino Y, Tanioka Y, Kawamura T, et al. Fibrin glue sealing for the prevention of pancreatic fistulas following distal pancreatectomy. Arch Surg. 1995;130:952–5.
21 Ridolfini MP, Alfieri S, Gourgiotis S, Di Miceli D, Rotondi F, Quero G, et al. Risk factors associated with pancreatic fistula after distal pancreatectomy, which technique of pancreatic stump closure is more beneficial? World J Gastroenterol. 2007;13:5096–100.