J Gastrointest Surg (2012) 16:267–274
DOI 10.1007/s11605-011-1715-3

2011 SSAT POSTER PRESENTATION

The Influence of Staple Size on Fistula Formation Following Distal Pancreatectomy

Boris Sepesi · Jacob Moalem · Eva Galka · Peter Salzman · Luke O Schoeniger

Received: 10 June 2011 / Accepted: 21 September 2011 / Published online: 21 October 2011

Abstract
Background Pancreatic fistula continues to be a source of significant morbidity following distal pancreatic resections. The technique of pancreatic division varies widely among surgeons, and there is no evidence that identifies a single method as superior. In our practice, the technique of distal pancreatic resection has evolved from cut-and-sew to stapled technique with green and recently white cartridge. The aim of our study was to evaluate the rate of clinically significant fistulas [International Study Group on Pancreatic Fistula (ISGPF) grade B or C] following distal pancreatectomy and to identify variables associated with a low rate of fistula development.
Methods Clinical records of all patients who underwent distal pancreatic resections between February 1999 and July 2010 by a single surgeon were retrospectively reviewed focusing on the incidence and type of pancreatic fistula as defined by ISGPF. Study variables included age, gender, surgical approach, extent of resection, ASA classification, type of stapler cartridge, use of Seamguard™, and ISGPF classification. Statistical analysis was performed using Fisher's exact test, and univariate and multivariate logistic regression.
Results Sixty-four patients (median age 60, range 21–85; 54% male) underwent distal pancreatic resection (laparoscopy 50% vs. open 50%). The most common indications were pancreatic adenocarcinoma (N=15; 23%) and neuroendocrine neoplasms (N=14; 22%). Clinically significant pancreatic fistula developed in 24% (N=15). The rate of fistula with cut-and-sew technique was 36% (4/11), with stapled green cartridge 31% (9/29) and only 5% (1/21) with stapled vascular cartridge. Univariate logistic regression identified vascular cartridge size (p=0.04, OR 0.11) and open stapled technique (p=0.05, OR 0.12) as variables significantly associated with a low fistula rate. Both vascular cartridge size (p=0.05, OR 0.10) and open stapled technique (p=0.04, OR 0.08) remained significant when analyzed by multivariate logistic regression. Division of pancreatic parenchyma with vascular cartridges resulted in significantly (p=0.03, OR 9.0) lower fistula rate compared to green cartridges. The use of Seamguard™ did not affect fistula rate (16% vs. 27%; p=0.34) nor did the performance of multivisceral resection vs. distal pancreatectomy/splenectomy alone (21% vs. 23%, p=1.0).
Conclusion The optimal technique of pancreatic division has not been conclusively established. Dividing the pancreas utilizing vascular (2.5 mm) staple cartridges significantly decreased the rate of clinically significant pancreatic fistula and we have changed our practice accordingly. A prospective randomized trial is necessary to validate these results.

Presented at a poster session, Digestive Disease Week, Chicago May 7–10, 2011

B. Sepesi
Department of Surgery, University of Rochester Medical Center, Rochester, NY, USA

J. Moalem · E. Galka · L. O. Schoeniger (✉)
Division of Surgical Oncology, Department of Surgery, University of Rochester Medical Center,
601 Elmwood Avenue,
Rochester, NY 14642, USA
e-mail: Luke_Schoeniger@urmc.rochester.edu

P. Salzman
Department of Biostatistics and Computational Biology, University of Rochester,
Rochester, NY, USA

Keywords Distal pancreatectomy · Staple size · Pancreatic fistula · Seamguard™ · Surgical complications · Operative technique

Introduction

Continuously evolving advancements in peri-operative care, surgical technique, and increasing application of laparoscopic surgery and postoperative "fast track" pathways have decreased hospital length of stay for many complex intra-abdominal operations. However, for distal pancreatic resections, the postoperative outcome is determined mostly by the incidence of a clinically significant pancreatic fistula, the presence of which ultimately negates much of the benefit of less invasive surgical techniques or otherwise perfectly executed peri-operative patient care. Resultant prolongation of both inpatient and outpatient care with its associated financial burden to the patient and health care system motivates further study of this common occurrence in pancreatic surgery.

The development of a pancreatic fistula and its associated morbidity following distal pancreatectomy is a well-recognized entity occurring in approximately 30% of patients.[1] In response to marked variability of definitions related to the severity of pancreatic fistula, the International Study Group on Pancreatic Fistula (ISGPF) has developed a classification scheme to facilitate consistent reporting of this complication.[2] Over the last decade, many studies have attempted to identify both patient-related and surgical factors associated with the development of pancreatic fistula following distal pancreatectomy.[1,3,4] Most studies have focused mainly on the surgical technique of pancreatic division, which varies widely among surgeons.[3,4] A wide range of results have been reported using cut-and-sew technique[5] with[6] or without intestinal serosal patch[1], stapled technique[7] with[8] or without Seamguard™ (Gore® Inc., Flagstaff, AZ, USA), or pancreatic division utilizing biopolar electo-cautery[9] radiofrequency or thermal energy devices such as Habib™ (AngioDynamics®, Queensbury, NY, USA)[10] or LigaSure™ (Valleylab, Boulder, CO, USA)[11]. While two meta-analyses of stapled versus suture closure of the pancreatic parenchyma suggested more favorable results with stapled technique, a single superior method of pancreatic division has not been definitively established.[12,13]

In our practice, the technique of distal pancreatic resection evolved within the last decade from cut-and-sew to stapled technique initially with green (4.5 mm) and recently white vascular (2.5 mm) staple cartridge. The switch from green to white staple cartridge was reflective of our hypothesis that a tighter ductal seal would be achieved with a smaller (2.5 mm) staple height, and that this would result in decreased incidence of postoperative pancreatic fistula. The aim of our study was to evaluate the rate of clinically significant fistulas (ISGPF grade B or C) following division of the pancreatic parenchyma utilizing cut-and-sew and stapled techniques with green (4.5 mm) and white (2.5 mm) cartridges, and to identify variables associated with a low rate of fistula development.

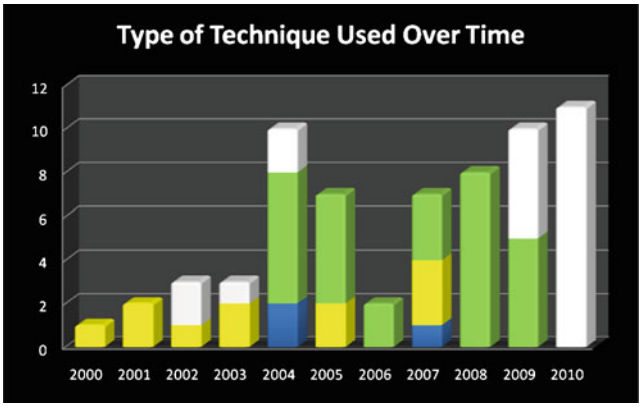
Methods

Patients

Our study population consisted of 64 unselected, consecutive patients (median age 60, range 21–85; 54% male) who underwent distal pancreatic resection for benign or malignant indications by a single surgeon (LOS) between February 1999 and July 2010. In all patients, the intent of distal pancreatic resection was the cure or palliation of pancreatic or other intra-abdominal pathology.

Operation

Operative approach and technique of pancreatic division were at the discretion of the operating surgeon. In cases where the pancreatic parenchyma was divided with a stapler, a prolonged peri-firing technique was used with slow gradual closure of the stapler, approximately over 1 min, to avoid traumatic splits of the pancreatic parenchyma.[17] Moreover, we used two sequential firing loads for parenchymal division in order to avoid forcing the stapler across the entire width of the pancreatic body. Selection of the color/size of stapler cartridge was at the discretion of the surgeon; Endo GIA™ 45 mm (Covidien® Surgical, Boulder, CO, USA) was used in 40% (N=21), Echelon Endopath™ 60 mm (Ethicon® Endosurgery) in 57% (N=30), and TA™ (Covidien® Surgical) in 3% (N=2) of cases. Initially, we and others believed that a larger stapler cartridge such as a 4.5-mm green load would be most suitable for the division of a glandular organ such as the pancreas. With time, however, we realized that the green (4.5 mm) staples may provide inadequate seal of the major and minor pancreatic ducts resulting in postoperative fistula formation. As demonstrated in Fig. 1, we made a notable change to a narrow 2.5-mm white stapler cartridge in the later part of the study period with the intent of achieving a tighter ductal seal. This paradigm shift from a green to a white stapler cartridge was made irrespective of the pancreatic texture and thickness as we believed that the complete compression of the major and minor ducts would avert fistula formation. When suture technique was applied, the pancreatic remnant was oversewn with overlapping horizontal mattress sutures of OOO Vicryl. Additionally, the pancreatic duct and the edge of the



Legend:
yellow: cut-and-sew
blue:blue cartridge
white: white cartridge
green: green cartridge

Fig. 1 Type of technique used over time (*x*-axis=years, *y*-axis=number of patients). *Yellow*—cut-and-sew, *blue*—blue cartridge, *white*—white cartridge, *green*—green cartridge

pancreas were oversewn with interrupted prolene suture.[20] A single drain was placed in all patients in the vicinity of the pancreatic stump and exteriorized through the left lateral abdominal wall. Postoperative care was directed by the operating surgeon utilizing a standardized pathway. Drain outputs were recorded continuously and amylase content measured on post operative day 3. The drain was removed when the output was less than 50 cm^3/day and its amylase level less than three times serum amylase level. Patients with clinical concern for pancreatic fistula were evaluated with computed tomography scan. Methods for the management of pancreatic fistula included *nothing per os*, parenteral nutritional support, antibiotics, subcutaneous octreotide, and, when warranted, percutaneous image-guided drainage.

Data Collection

Clinical and operative records were retrospectively reviewed focusing on the incidence and severity of pancreatic fistula as previously defined by ISGPF.[2] Pancreatic fistula was classified as either one of the four categories: no fistula, biochemical evidence of fistula as defined by surgical drain amylase level greater than three times serum level without clinical consequence (grade A), biochemical evidence of fistula requiring clinical intervention such as percutaneous drainage or total parenteral nutrition (grade B), and biochemical evidence of fistula with severe clinical sequelae necessitating intensive care unit admission or re-operation (grade C). Study variables included age, gender, surgical approach (laparoscopic or open), extent of resection (pancreas alone, pancreas and spleen, and pancreas and spleen and other visceral organs), specimen pathology, American Society of Anesthesiologist (ASA) classification, technique of pancreatic division (cut-and-sew or stapled), type of stapler cartridge (green 4.5 mm or white 2.5 mm), use of bio-absorbable staple line reinforcement Seamguard™, and ISGPF classification.

Statistical Analysis

The primary outcome measure was the rate of clinically significant (grade B and C) fistula of the entire study group and in various subgroups based on study variables. The rate of the pancreatic fistula was presented as a percentage. Categorical variables were compared using Fisher's exact test and univariate logistic regression. Multivariate logistic regression was applied to identify independent predictors of low rate of fistula development. A p value less than 0.05 was considered statistically significant. Statistical analysis was conducted using R Development Core Team program.[18] The study was approved by the University of Rochester Medical Center Research Subjects Review Board. None of the authors received financial support from any of the above manufacturers.

Results

Demographic and clinical characteristics of the patient population are summarized in Table 1. Sixty-four patients (median age 60, range 21–85; 54% male) underwent distal pancreatic resection. Laparoscopic and open approach was utilized in an equal number of patients. The median and

Table 1 Patients' demographics and clinical characteristics

Study population	*N*=64
Age (median, range)	60.5 years (21–85 years)
Gender	Male *N*=35 (54%)
Surgical approach (laparoscopy)	*N*=32 (50%)
Surgical approach (open)	*N*=32 (50%)
Length of stay (median)	7 days
ASA class 1	*N*=16 (25%)
ASA class 2	*N*=36 (56%)
ASA class 3	*N*=12 (19%)
Pancreas only	*N*=3 (5%)
Pancreas/spleen	*N*=44 (69%)
Pancreas/spleen/other organs	*N*=17 (27%)
Stapler	*N*=53 (83%)
Suture closure	*N*=11 (17%)
White 2.5-mm staple cartridge	*N*=21 (40%)
Blue 3.5-mm staple cartridge	*N*=3 (5%)
Green 4.5-mm staple cartridge	*N*=29 (55%)
Seamguard™	*N*=38 (69%)

Table 2 Final pathology of resected specimens

Adenocarcinoma	*N*=15 (23%)
Neuroendocrine tumor of pancreas	*N*=15 (23%)
Serous or mucinous neoplasm of pancreas	*N*=13 (20%)
Chronic pancreatitis	*N*=7 (10%)
Intraductal papillary mucinous neoplasm	*N*=3 (6%)
Renal cell carcinoma	*N*=6 (9%)
Gastric cancer	*N*=1 (2%)
Adrenal neoplasm	*N*=3 (6%)
Plasmacytoma	*N*=1 (2%)

mean length of stay was 7 and 9 days (range 3–70 days), respectively, and expectedly increased with the development of pancreatic fistula (no fistula median 6, mean 8 days), grade A (median 7, mean 8 days), grade B (median 8, mean 9 days), and grade C (median 10, mean 28 days). Most patients (*N*=44; 69%) underwent distal pancreatectomy with splenectomy, and spleen-preserving pancreatectomy was achieved in three patients; 17 (27%) required multi-visceral organ resection. Stapler was utilized in 53 (83%) of the cases, white 2.5-mm cartridge was used in 21 (40%) and green 4.5-mm cartridge in 29 (55%) of the patients; bio-absorbable staple line reinforcement Seamguard™ was used in 38 (69%) cases. The most common operative indications were pancreatic adenocarcinoma (*N*=15; 23%) and neuroendocrine neoplasms (*N*=14; 22%, Table 2). Overall complication rate was 52% with complications such as myocardial infarction and re-operation occurring in patients with grade B or C fistula. The rate of complications in patient without evidence of fistula was 20% (8/33) and occurred more commonly after open procedures (88%, 7/8, Table 3).

Combined fistula rate of grades A, B, and C was 39%. Clinically significant (grade B and C) pancreatic fistula developed in 15 patients (24%, Fig. 2). The rate of grade B and C fistulas was lowest when a white cartridge was used to staple the pancreas (1/21; 5%); with cut-and-sew technique it

Table 3 Overall complication rate

Type of complication	*N* (%)
Overall pancreatic leak	*N*=25 (39%)
Delirium	*N*=2 (3%)
Myocardial infarction	*N*=1 (1.5%)
Re-operation	*N*=2 (3%)
Ileus	*N*=3 (5%)
UTI	*N*=1 (1.5%)
Chylous ascites	*N*=1 (1.5%)
Pleural effusion	*N*=1 (1.5%)
Gastroparesis	*N*=2 (3%)

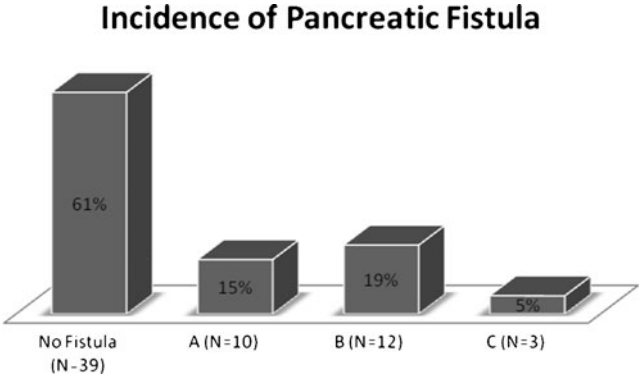


Fig. 2 Overall rate of pancreatic fistula grades A, B, and C

was 36% (4/11), and with stapled green cartridge 31% (9/29) (Fig. 3). Division of the pancreatic parenchyma with white (2.5 mm) cartridges resulted in a significantly (p=0.03, OR 9.0) lower fistula rate compared to green (4.5 mm) cartridges. The use of Seamguard™ did not affect fistula rate (Seamguard™ 16% vs. no Seamguard™ 27%; p=0.34), nor did the performance of multi-visceral resection vs. distal pancreatectomy/splenectomy alone (21% vs. 23%, p=1.0) or resection for chronic pancreatitis vs. adenocarcinoma (14% vs. 13%, p=1.0).

Univariate logistic regression identified white cartridge size (p=0.04, OR 0.11) and open stapled technique (p=0.05, OR 0.12) as the only variables significantly associated with a low rate of clinically significant (grade B and C) fistula; both variables were also significantly associated with an overall low rate of pancreatic fistula. Both white cartridge size (p=0.05, OR 0.10) and open stapled technique (p=0.04, OR 0.08) remained significant when analyzed by multivariate logistic regression for overall and clinically significant fistula formation (Tables 4, 5, and 6).

Discussion

Our primary aim was to evaluate the rate of a clinically significant (grade B and C) pancreatic fistula following distal pancreatic resection, after cut-and-sew and stapled techniques with green (4.5 mm) and white (2.5 mm)

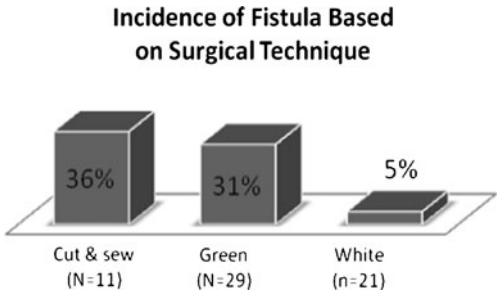


Fig. 3 Grade B and C fistula rate based on surgical technique

Table 4 Fisher's exact test (comparison of clinically significant fistula)

Variable	Fistula rate (%)	*p* value	Odds ratio
Age <60 years vs. >60 years	50% vs. 50%	1.0	
Male vs. female	31% vs. 10%	0.067	
Laparoscopic vs. open pancreatectomy	28% vs. 16%	0.364	
ASA 1 vs. ASA 2 and 3	6% vs. 27%	0.159	
Stapled vs. cut-and-sew pancreas	20% vs. 33%	0.29	
Green (4.5 mm) vs. white (2.5 mm)	31% vs. 5%	0.0313	9.0
Seamguard™ vs. no Seamguard™	16% vs. 27%	0.348	
Green+Seamguard™ vs. white+Seamguard™	29% vs. 6.5%	0.0113	6.0
Multi-visceral vs. pancreatectomy+splenectomy	21% vs. 23%	1.0	
Chronic pancreatitis vs. pancreatic carcinoma	14% vs. 13%	1.0	

cartridges, and to identify variables associated with a low rate of fistula development. Our data showed a low (5%) overall occurrence and a significantly lower incidence of pancreatic fistula following the stapled pancreatectomy with white (2.5 mm) cartridge as compared to the use of green staple load or cut-and-sew techniques. Grade B pancreatic fistula occurred only in one out of 21 patients who underwent distal pancreatectomy with white staple cartridge. That patient underwent simultaneous laparoscopic adrenalectomy and distal pancreatectomy. The patient's initial postoperative course was unremarkable; however, a short (3 days) readmission was required for nausea and emesis, which resolved with supportive measures.

Pancreatic fistula occurred in 31% of patients who underwent pancreatic division with green (4.5 mm) stapler cartridge and in 33% of patients with cut-and-sew pancreatectomy. Although the addition of the bio-absorbable staple line reinforcement (Seamguard™) resulted in an 11% decrease in the incidence of pancreatic fistula, Seamguard™ use was not significantly associated with lower fistula rate. Overall, no significant differences in the pancreatic fistula formation were noted between patients who underwent multivisceral resection versus pancreatectomy with splenectomy, in patients with class 1 ASA classification versus patients classified as class 2 and 3, or in patients with chronic pancreatitis compared with patients with pancreatic adenocarcinoma. While there was no overall difference in fistula incidence between laparoscopic and open surgical approach or stapled versus cut-and-sew technique of pancreatic closure, the use of stapled technique during an open procedure seemed to significantly lower the rate of pancreatic fistula postoperatively. It is not entirely clear why a significantly lower rate of fistula was achieved with an open stapled technique considering the same principles of parenchymal division were applied during both open and laparoscopic pancreatectomy. As demonstrated in Table 7, 21 patients underwent open stapled distal pancreatectomy and 32 patients laparoscopic distal pancreatectomy. Only three (14%) patients developed pancreatic fistula following open stapled pancreatectomy. In all three cases, green cartridge was utilized; however, only one of those three patients developed grade B fistula. Overall fistula rate after laparoscopic stapled pancreatectomy was 50%; the majority of all fistulas (61%) and clinically significant (44%) fistulas occurred following pancreatic division with green cartridge. We speculate that the direct tactile ability in positioning the stapler across the pancreas or perhaps increased intra-abdominal inflammation after an open procedure may have resulted in a lower overall rate of pancreatic fistula with open stapled technique.

Development of pancreatic fistula following surgical resection of the distal pancreas has been the Achilles heel of pancreatic surgery for many years. This complication is thought to be related to hypertension within the pancreatic duct remnant and subsequent drainage of pancreatic secretions in the path of least resistance, and occurs in 20–30% of distal pancreatic resections.[1] Despite much

Table 5 Univariate and multivariate logistic regression (no fistula and grade A vs. clinically significant grade B and C fistula)

Analysis	Univariate		Multivariate		
Variable	*p* value	Odds ratio	*p* value	Odds ratio	CI (2.5–97.5%)
White (2.5 mm) cartridge	0.045	0.111	0.051	9.75	205–1.38
Age	0.305	0.974	0.561	1.02	1.10–0.95
Male gender	0.212	2.57	0.099	0.22	1.20–0.03
Open operation (stapler used)	0.056	0.122	0.042	11.5	250–1.48
Seamguard™	0.747	0.778	0.828	0.81	4.83–0.11

Table 6 Multivariable logistic regression (no fistula vs. fistula grade A, B, and C)

Analysis	Univariate		Multivariate		
Variable	*p* value	Odds ratio	*p* value	Odds ratio	CI (2.5–97.5%)
White (2.5 mm) cartridge	0.039	0.252	0.0481	0.228	0.91–0.046
Age	0.097	0.963	0.431	0.979	1.03–0.92
Male gender	0.706	1.25	0.400	1.83	8.13–0.45
Open operation (stapler used)	0.016	0.176	0.038	0.179	0.83–0.029
Seamguard™	0.125	0.362	0.335	0.484	2.12–0.10

advancement in surgical care, the occurrence of pancreatic fistula after distal pancreatectomy has continued to vex surgeons and patients alike due to the substantial morbidity and cost related to prolonged hospital stay, readmissions, use of parenteral nutrition, antibiotics, and interventional procedures that are required to manage this complication. Despite multiple recent studies that have attempted to identify the most optimal surgical technique to decrease the rate of pancreatic fistula, there is no consensus on the optimal technique to avoid this complication. To date, nearly all studies of pancreatic fistula have focused on perfecting the closure of the pancreatic stump in a hope to achieve an unbreakable seal of the distal pancreas. Results, however, have been variable, and to our knowledge, none have focused on the impact of staple size on postoperative leak rate.

In the largest study of distal pancreatectomy patients, Ferrone et al.[1] found the fistula rate to be 29% in 462 patients. Stapler use with or without the staple line reinforcement did not significantly reduce the rate of fistula, nor did the use of falciform patch, suture closure, or targeted pancreatic duct ligation. Factors predictive of fistula formation were BMI >30 and male gender. The authors concluded that pancreatic fistula formation after distal pancreatic resection continues to be an unsolved challenge.[1] Contrary to those results, multiple smaller reports did suggest benefit of various stump closure techniques in lowering the incidence of pancreatic fistula. Harris et al. achieved 4.3% fistula rate in 69 patients by using electrocautery to transect the pancreas and suture ligation of the pancreatic stump; stapled and oversewn pancreas had fistula incidence 19.8% versus stapled stump alone 27.7%.[5] The first study to use laparoscopic radio-frequency ablation (Habib™) for pancreatic transection without additional deliberate remnant closure in 14 patients by Fronza et al. reported 14% (n=2) incidence of clinically significant fistula; one patient required re-intervention.[10] Heat energy for sealing of the pancreatic tissue delivered by the LigaSure™ device was tested in a pig model by Hartwig et al.[11] A distal pancreatectomy was performed in 22 pigs that were randomized to cut-and-sew pancreas closure and LigaSure™ sealing and cutting. Amylase was checked daily in the drain and animals were sacrificed on postoperative day 7. There was no evidence of pancreatic fistula in any animal that underwent LigaSure™ transaction of the pancreas suggesting feasibility of this technique in the division of the pancreatic parenchyma.[11] Another non-closure technique of pancreatic stump was used by Kitagawa et al. who applied saline-coupled bipolar electrocautery to the cut surface of the pancreas in 40 patients.[9] A fistula rate of 7.7% was achieved, but all patients had a decompressive pancreatic stent placed preoperatively.[9] Fischer et al. recently reported favorable results with intraoperative transampullary pancreatic duct stent placement.[14] Before suture ligating the pancreas, they advanced a pediatric feeding tube through the cut end of the distal pancreas across the ampulla into the duodenum. The authors reported significantly lower rate of fistula in a small group of patients who had stents placed compared to their historical cohort.[14] Abe et al.[19] and Reider et al.[15] independently reported on the benefits of decompressing the pancreatic duct via the ampulla of Vater in patients who underwent distal pancreatectomy. In these studies, which used either sphincterotomy, stenting, or a combination these two techniques, none of the 35 patients developed

Table 7 Fistula rate with open and laparoscopic stapled pancreatectomy with different cartridge types

Stapled technique	Open	Open stapled fistula rate (overall)	Open stapled fistula rate (grade B, C)	Laparoscopic	Laparoscopic stapled fistula rate (overall)	Laparoscopic stapled fistula rate (grade B, C)
Number of patients	*N*=21	3 (14%)	1/21 (5%)	*N*=32	16 (50%)	10 (31%)
White cartridge	9/21 (43%)	0%	0%	12/32 (38%)	4/12 (33%)	1/12 (8%)
Green cartridge	11/21 (52%)	3/11 (27%)	1/11 (9%)	18/32 (56%)	11/18 (61%)	8/18 (44%)
Blue cartridge	1/21 (5%)	0%	0%	2/32 (6%)	1/2 (50%)	1/2 (50%)

fistula.[15,19] Further controversy regarding the optimal closure of pancreatic remnant concerns the use bio-absorbable staple line reinforcement Seamguard™. While Yamamoto et al.[8] reported a 4% fistula rate using Seamguard™, Guzman et al.[16] reported a 73% rate of fistula when this bio-absorbable reinforcement was used.

The contrasting reports on the efficacy of one technique over another highlight the lack of consensus about the technique of pancreatic parenchymal division and management of the pancreatic remnant. Stapled technique showed favorable results (12% fistula in staple group N=24 vs. 27% in suture group N=11) in the study by Okano[7] who used Echelon 60 mm (Ethicon Endo-surgery; Johnson & Johnson, Cincinnati, OH, USA) to divide the pancreas. Olah et al.[6] randomized patients to stapled technique and stapling with seromuscular patch and found no additional benefit of the patch in the incidence of clinically significant fistula.[6] Nakamura et al.[17] demonstrated that stapling technique was an important factor in decreasing fistula incidence; their prolonged stapler closure technique (to avoid fracturing the pancreas) was associated with a significantly lower rate of pancreatic fistula.[17] To date, two meta-analyses compared sutured and stapled closure of the cut end of the pancreas.[12,13] Both concluded that there was no significant difference between the two techniques with respect to pancreatic fistula; however, both meta-analysis observed a trend favoring stapled closure of the pancreatic parenchyma.

Our study is limited by its retrospective nature and a small patient cohort. Our surgical approach and technique of distal pancreatectomy has evolved over the years. Initially, we used cut-and-sew technique for pancreas closure. As the stapler technology improved, we transitioned to the use of green 4.5-mm stapler load for the division of the pancreas. Larger diameter stapler load was initially thought to be less traumatic to pancreatic parenchyma; however, the stump leak rate remained high. To achieve a potentially tighter seal, we transitioned to the narrower 2.5-mm white stapler cartridge. Intraoperatively, we now pay careful attention to a very slow (approximately over 1 min) closure of the stapler device and specifically use two firing loads to completely divide the pancreatic parenchyma. Therefore, our observed low fistula rate with a white stapler cartridge may be related to our overall improvement in surgical technique. While we made no attempt to select the color/size of the stapler cartridge based on the subjective visual assessment of the thickness and texture of the pancreatic parenchyma, one could speculate that white stapler cartridge maintains tissue integrity of the "soft" pancreas better than of the fibrosed pancreas, thus decreasing the fistula rate. However, our data does not provide evidence to support this notion; rather, our findings lead us to believe that smaller size cartridge offers tighter seal of the pancreatic duct.

Conclusion

The optimal technique of pancreatic division has not been conclusively established. In our patient population, dividing the pancreas utilizing white (2.5 mm) staple cartridges was associated with a lower rate of clinically significant pancreatic fistula and we continue to favor this technique in our practice. A prospective randomized trial is necessary to validate these results.

References

1. Ferrone CR, Warshaw AL, Rattner DW, Berger D, Zheng H, Rawal B, et al. Pancreatic fistula rates after 462 distal pancreatectomies: staplers do not decrease fistula rates. J Gastrointest Surg 2008;12:1691,7; discussion 1697–8.
2. Bassi C, Dervenis C, Butturini G, Fingerhut A, Yeo C, Izbicki J, et al. Postoperative pancreatic fistula: an international study group (ISGPF) definition. Surgery 2005;138:8–13.
3. Diener MK, Knaebel HP, Witte ST, Rossion I, Kieser M, Buchler MW, et al. DISPACT trial: a randomized controlled trial to compare two different surgical techniques of DIStal PAnCreaTectomy—study rationale and design. Clin Trials 2008;5:534–45.
4. Bruns H, Rahbari NN, Loffler T, Diener MK, Seiler CM, Glanemann M, et al. Perioperative management in distal pancreatectomy: results of a survey in 23 European participating centres of the DISPACT trial and a review of literature. Trials 2009;10:58.
5. Harris LJ, Abdollahi H, Newhook T, Sauter PK, Crawford AG, Chojnacki KA, et al. Optimal technical management of stump closure following distal pancreatectomy: a retrospective review of 215 cases. J Gastrointest Surg 2010;14:998–1005.
6. Olah A, Issekutz A, Belagyi T, Hajdu N, Romics L, Jr. Randomized clinical trial of techniques for closure of the pancreatic remnant following distal pancreatectomy. Br J Surg 2009;96:602–7.
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 Hepatobiliary Pancreat Surg 2008;15:353–8.
8. Yamamoto M, Hayashi MS, Nguyen NT, Nguyen TD, McCloud S, Imagawa DK. Use of Seamguard to prevent pancreatic leak following distal pancreatectomy. Arch Surg 2009;144:894–9.
9. Kitagawa H, Ohta T, Tani T, Tajima H, Nakagawara H, Ohnishi I, et al. Nonclosure technique with saline-coupled bipolar electrocautery in management of the cut surface after distal pancreatectomy. J Hepatobiliary Pancreat Surg 2008;15:377–83.
10. Fronza JS, Bentrem DJ, Baker MS, Talamonti MS, Ujiki MB. Laparoscopic distal pancreatectomy using radiofrequency energy. Am J Surg 2010;199:401,4; discussion 404.
11. Hartwig W, Duckheim M, Strobel O, Dovzhanskiy D, Bergmann F, Hackert T, et al. LigaSure for pancreatic sealing during distal pancreatectomy. World J Surg 2010;34:1066–70.
12. Zhou W, Lv R, Wang X, Mou Y, Cai X, Herr I. Stapler vs suture closure of pancreatic remnant after distal pancreatectomy: a meta-analysis. Am J Surg 2010;200:529–36.
13. Knaebel HP, Diener MK, Wente MN, Buchler MW, Seiler CM. Systematic review and meta-analysis of technique for closure of the pancreatic remnant after distal pancreatectomy. Br J Surg 2005;92:539–46.

14. Fischer CP, Bass B, Fahy B, Aloia T. Transampullary pancreatic duct stenting decreases pancreatic fistula rate following left pancreatectomy. Hepatogastroenterology 2008;55:244–8.
15. Rieder B, Krampulz D, Adolf J, Pfeiffer A. Endoscopic pancreatic sphincterotomy and stenting for preoperative prophylaxis of pancreatic fistula after distal pancreatectomy. Gastrointest Endosc 2010;72:536–42.
16. Guzman EA, Nelson RA, Kim J, Pigazzi A, Trisal V, Paz B, et al. Increased incidence of pancreatic fistulas after the introduction of a bioabsorbable staple line reinforcement in distal pancreatic resections. Am Surg 2009;75:954–7.
17. Nakamura M, Ueda J, Kohno H, Aly MY, Takahata S, Shimizu S, et al. Prolonged peri-firing compression with a linear stapler prevents pancreatic fistula in laparoscopic distal pancreatectomy. Surg Endosc 2010.
18. R Development Core Team (2010). R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL:http://www.R-project.org/
19. Abe N, Sugiyama M, Suzuki Y, Yamaguchi T, Mori T, Atomi Y. Preoperative endoscopic pancreatic stenting: a novel prophylactic measure against pancreatic fistula after distal pancreatectomy, J Hepatobiliary Pancreat Surg. 2008;15(4):373–6. Epub 2008 Aug 1.
20. Cameron JL, Sandone C. Atlas of gastrointestinal surgery, 2nd edition, 2007 ISBN-10:1550092707