ORIGINAL ARTICLE

Operative Procedures Using a Curved Cutter Stapler for the Prevention of Pancreatic Fistula after Distal Pancreatectomy

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ABSTRACT

Aim Although numerous techniques to prevent postoperative pancreatic fistula after distal pancreatectomy have been attempted, the optimal method for pancreatic stump closure remains controversial. The aim of this retrospective cohort study was to evaluate the effectiveness of using a Curved Cutter Stapler® in the prevention of postoperative pancreatic fistula after distal pancreatectomy. **Patients and Methods** The records of a total of 35 patients (male, n=15, female, n=20) who underwent distal pancreatectomy using a Curved Cutter Stapler were reviewed. The patients were divided into two groups according to the absence or presence of postoperative pancreatic fistula. The relationship between the perioperative factors and postoperative pancreatic fistula was investigated. **Results** After PD, Grade A postoperative pancreatic fistula occurred in 4 patients (11%) and Grade B postoperative pancreatic fistula occurred in 2 patients (6%); no patients developed Grade C postoperative pancreatic fistula. There were no significant differences between the fistula and non-fistula groups with regard to the preoperative and intraoperative demographic data and relevant risk factors, including the thickness and texture of the pancreatic parenchyma. **Conclusion** Pancreatic resection using a Curved Cutter Stapler would contribute to the reduction of pancreatic fistula. The use of a Curved Cutter Stapler was thought to be favorable for the prevention of pancreatic fistula in any type of pancreas.

BACKGROUND

Postoperative pancreatic fistula (POPF) is the most common cause of morbidity and mortality after distal pancreatic resection [1]. The incidence of POPF in distal pancreatectomy (DP) remains high, ranging from 10 to 40% in recent reports [2, 3]. Different surgical groups have used various methods in their attempts to prevent pancreatic fistula after DP, including hand-sewing, compression suturing with a linear stapler, spraying of fibrin sealment, and anastomosis of the jejunum and pancreatic duct at the stump; however, there is no consensus regarding a standard surgical technique for pancreatic stump closure after DP [4].

According to a recent meta-analysis, the rate of POPF after DP in patients who received hand-sewing (28%) and those who received automated suturing (32%) did not differ to a statistically significant extent [5]. Recently, however, stapler closure has come to be commonly performed. In addition, stapler techniques can be used to close both the main pancreatic duct and the branch duct at the same time.

A laceration occurs in a straight line and fistula may develop from both ends of the pancreas even if we use a straight stapler suture device [6]. We hypothesized that this is one of the reasons why POPF cannot be completely prevented. We have therefore begun using a Curved Cutter Stapler® (Ethicon Endo-surgery, Cincinnati, OH, USA) as a pancreatic transection device. The aim of this study was to analyze POPF occurrence after closure of the pancreatic remnant after DP by using a Curved Cutter Stapler®.

PATIENTS AND METHODS

Thirty-five patients who underwent DP in Shikoku Central Hospital and Tokushima Red Cross Hospital between 2008 and 2019 were retrospectively analysed. The patients' characteristics are summarized in **Table 1**. Age, sex, BMI, history of pancreatitis, malignant disease, serum albumin level, coexist diseases such as diabetes mellitus, hypertension, ASA level, history of smoking and steroids use were evaluated as preoperative characteristics. The following operative factors were recorded: operation time, blood loss, thickness of the stump, pancreatic duct size, texture of the pancreas, and the use of green or blue cartridges, multi-organ resection and laparoscopic surgery.

All patients (male, n=17; female, n=18; age, 30-82 years) underwent stapler closure with a Curved Cutter Stapler. The Curved Cutter Stapler is a single-patient-use stapler with a curved head that cuts and staples [7]. The

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Abbreviations DP Distal Pancreatectomy; POPF Postoperative Pancreatic Fistula; ISGPF International Study Group of Pancreatic Fistula; PDS Polydioxanone Suture;
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Table 1. Demographic data and characteristics of patients with POPF and non-POPF.

	Non-Fistula group (n=29)	Fistula group (Grade A and B) (n=6)	P value
Age	69 ± 7	67 ± 8	0.49
Male/female	12/17	67 ± 8	0.15
BMI	21 ± 3	22 ± 2	0.59
Pancreatitis	3/26	1/5	0.2
Malignant/benign	23/6	3/3	0.14
Albumin level	3.5 ± 0.3	3.6 ± 0.3	0.79
Diabetes (Y/N)	5/24	1/5	0.97
ASA level (I,II / III,IV)	24/5	4/2	0.37
Smoking (Y/N)	8/21	2/4	0.78
Steroids (Y/N)	1/28	0/6	0.64

device delivers four staggered rows of titanium staples, with a knife between the second and third row of staples. The Curved Cutter Stapler is available with green and blue stapler cartridges that compress tissue to approximately 2 mm and 1.5 mm, respectively. When the handle is applied, it occludes the tissue on both sides of a 40-mm transection.

Data were collected retrospectively and the clinic-pathological features were reviewed from medical charts. All patients were divided into two groups according to the absence or presence of POPF.

Surgical Procedures and Methods

DP was performed as open surgery in 30 patients and as laparoscopic surgery in 5 patients. All pancreatic resections were performed in accordance with the standard procedure, which has been described elsewhere. Using vinyl tape, the pancreas was lifted, and reusable intestinal clips were placed horizontal to the resection line. The position of the pancreatic duct and thickness of the pancreas were measured by intraoperative US. The hardness of the pancreas was measured by ultrasonic elastography. The pancreas was compressed for 10 minutes. After pre-compression, a Curved Cutter Stapler was inserted and carefully placed over the resection line **(Figure 1)**. Firing was performed slowly so that the operator could feel the tightening one line at a time. Both jaws were closed slowly, and the pancreas was compressed on the planned transection line for 5 minutes, followed by gradual stapling for 5 min and cutting. The surgeon can select whether to use the Curved Cutter Stapler with a green or blue cartridge.

Although the green cartridge was usually used, if the thickness of the pancreas was estimated to be <12 mm, the blue cartridge would be used for transection. If the Curved Cutter Stapler could not completely cut off the pancreas the first time, a linear stapler was subsequently used to cut off the remaining pancreas. The isolation stump of the pancreas showed a fish mouth form **Figure 2**. One 5-0 PDS stitch was added at the expected site of the pancreatic duct.

Post-operative Management

In all cases, a drain was inserted into the pancreatic stump. The amylase and lipase levels of the serum and drainage fluid were monitored on postoperative days 1 and 3. Perioperative antibiotics were routinely administered three times, either intra-operatively or for one day postoperatively. Somatostatin analog was used in cases with Grade B POPF and was not used as prophylaxis against POPF. Oral intake was started if the patient showed no clinical signs of POPF. Patients with clinical signs of POPF received somatostatin analog for 7 days after surgery.

POPF was diagnosed according to the definition of the International Study Group of Pancreatic Fistula (ISGPF) [8].

Statistical analyses

Data were expressed as the mean ± standard deviation. Statistical analyses were performed using the Statistical Package for Social Science for Windows (SPSS Inc; Chicago, IL, USA). The patient characteristics and intraoperative and postoperative factors of the POPF and non-POPF groups were compared by the chi-squared test and Student's t-test. Univariate and multivariate logistic analysis were performed to identify independent predictors of POPF development. P values of <0.05 were considered to indicate statistical significance.

This study was approved by the Ethics Committee of Shikoku Central Hospital.

RESULTS

The mean age of the patients was 68 ± 8 years. Overall, pathological examinations revealed malignant disease in 26 patients (74%) and benign disease in 9 patients (26%). As additional surgical procedures, splenectomy was performed in 33 patients (94%), partial gastrectomy was performed in 2 patients (6%), liver resection (3%) was performed in one patient and adrenal gland resection was performed in one patient (3%).

Thirty-five patients who underwent DP were classified into the non-fistula or Grade A/B fistula groups. In the overall study population, Grade A POPF occurred in 4 (11%) patients and Grade B POPF occurred in 2 (6%) patients. Thus, six (17%) patients who underwent DP using a Curved Cutter Stapler developed Grade A/B POPF and 29 patients (83%) did not develop POPF. The postoperative hospital stay of the non-fistula group was significantly shorter than that of the fistula group (12.5 ± 3.5 days *vs.* 22.5 ± days, P<0.01). The closing duration for pancreatic fistula from the onset was 10 ± 7 days in cases with Grade A POPF and 16 ± 11days in cases with Grade B POPF.

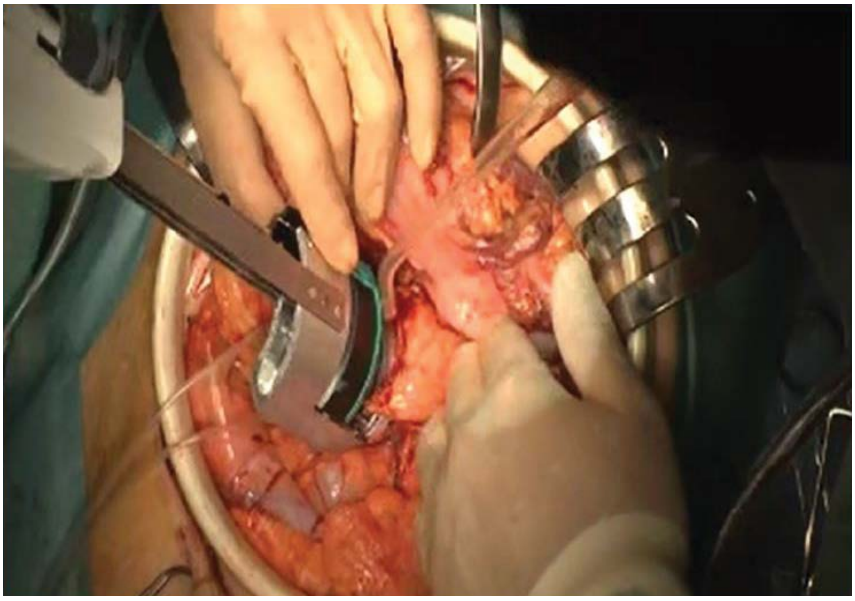

Figure 1. After pre-compression, a Curved Cutter Stapler was inserted and carefully placed over the resection line.

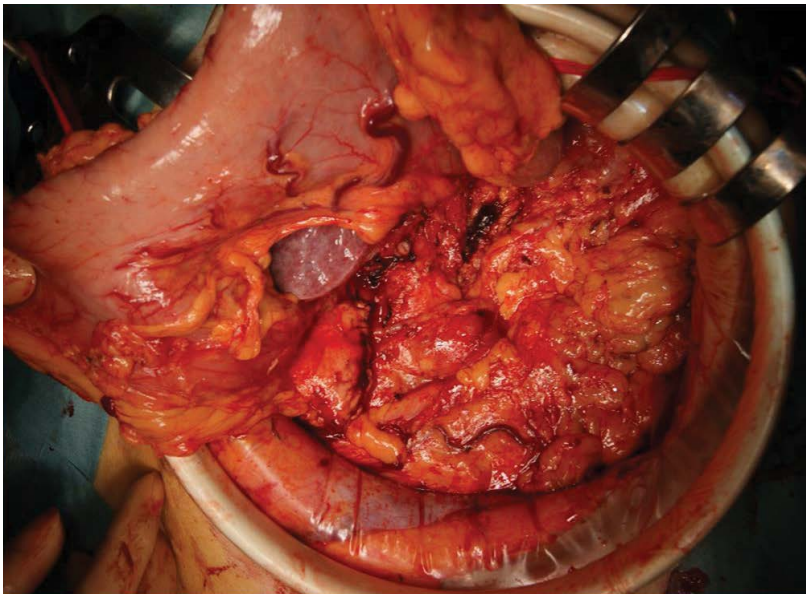

Figure 2. The isolation stump of the pancreas became the fish mouth form (Arrow). One stitch of 5-0 PDS would be added in the site expected that there is a pancreatic duct.

Table 2. Univariate analysis in determining intraoperative risk factors for patients with POPF and non-POPF.

	Non-Fistula group (n=29)	Fistula group (Grade A and B) (n=6)	P value
Mean operative time (min)	226 ± 27	240 ± 31	0.49
Mean operative blood loss (ml) 150 ± 25	150 ± 25	160 ± 45	
Blood transfusion	0/29	1/5	0.15
Additional organ resection			
Splenectomy	28	6	0.64
Others	1	0	
Pancreas tissue texture			
Soft	16	5	0.20
Hard	13	1	
Mean depth of pancreas (mm)	16 ± 4	14 ± 4	0.27
Mean diameter of duct (mm)	2.5 ± 0.7	3.1 ± 0.7	0.06
Laparoscopy/Open	4/25	1/5	0.86
Cartridges (Blue/green)	4/25	1/5	0.86

There were no significant differences in the preoperative or clinic-pathological data of the non-fistula and fistula groups **(Table 1)**. Furthermore, no intraoperative factors, such as operation time, blood loss, thickness of the stump and pancreatic duct size, texture of the pancreas, the use of green or blue cartridges, multi-organ resection or laparoscopic surgery were significantly associated with the development of fistula the univariate and multivariate analyses **(Table 2)**. The thickness of the parenchyma of the transacted portion was 16 ± 4mm in the non-fistula group and 14 ± 4 mm in the fistula group. The non-fistula group included 16 cases with a soft tissue texture and 13 with a hard tissue texture, while the fistula group included 5 cases with an in soft tissue texture and 1 case with a hard tissue texture; the difference was not statistically significant. The POPF rate was 24% (5/21) in the soft pancreas group and 7% (1/14) in the hard pancreas group; this difference was not statistically significant. Thus, the preoperative and intraoperative demographic data and relevant risk factors of the two groups did not differ to a statistically significant extent.

DISCUSSION

Our study showed that the Grade A POPF (according to the ISGPF definition) occurred in 4 patients (11%) and Grade B POPF occurred in 2 patients (6%); no patients developed Grade C POPF. Thus, relevant POPF was only detected in 2 (6%) of our patients. Although there are many methods for the prevention of POPF, no techniques are fully effective and the incidence of clinical POPF was >20% in most studies [9, 10]. The incidence of POPF in the present study was considerably low in comparison to other studies. To the best of our knowledge, this is the first report to describe the use of the Curved Cutter Stapler for pancreatic resection.

Surgeons have used various surgical techniques to prevent the occurrence of pancreatic fistula after resection of the pancreatic body and tail. In the hand-sewing method, techniques such as 1) secure tubal ligation of the pancreatic duct and 2) suture closure of the pancreatic resection stump in the shape of a fish mouth are used [11]. On the other hand, pancreatic dissection with a stapler suture device after tail resection of the pancreatic body has become easier to perform and is more commonly applied in many institutions [12, 13]. In 2005 and 2010, respectively, Knaebel et al and Zhou et al performed meta-analyses on the application of hand-sewn anastomosis and stapler suture, and reported that the use of a stapler suture device reduced the incidence of pancreatic fistula in comparison to hand-sewn anastomosis. However, in these studies, the incidence of POPF after DP did not differ to a statistically significant extent [14, 15]. In 2011, a large multicentre RCT trial (DISPACT trial) was conducted to compare the impact of automatic suture and hand-stitched methods on pancreatic fistula development after DP [5]. The incidence of pancreatic fistula was 32% (56/177 cases) in the stapler group and 28% (49/175 cases) in the hand-stitched group, which did not amount to a statistically significant difference. The study concluded that the use of a surgical stapler did not contribute to the prevention of pancreatic fistula due to the crushing and tearing of the pancreas when stapler closure was adopted. In a retrospective analysis of 284 cases of DP, Chikhladze et al reported that the technique of pancreatic stump closure after DP did not influence the incidence of POPF; however, it was associated with the pancreatic function and parenchymal texture, and that it seemed unsafe to use a stapler in cases involving a pancreas with a thick parenchyma [16, 17].

It was thought that the damage of the pancreatic membrane might have caused pancreatic fistula when a stapler was used in DP [18, 19]. Reinforcement of the pancreatic membrane at the transection line would be important for the prevention of pancreatic fistula [20, 21]. Thus, some studies using mesh reinforcement have been reported to reduce pancreatic fistula. However, a meta-analysis based on 5 retrospective and 5 prospective non-randomized studies compared reinforced staplers and bare staplers, and showed that the incidence of pancreatic fistula in the bare metal stapling group was 24% (61/249 cases), while that in the reinforced stapler group was 17% (39/234 cases) [22]. Reinforced stapler resection was not found to have a significant benefit. Further evaluation in multi-centre RCTs is necessary to clarify the utility of mesh reinforcement when it is applied in stapler closure.

The Curved Cutter Stapler has been used to perform rectal transection in the narrow pelvic cavity [7]. The reasons for using a Curved Cutter Stapler in our study were as follows: 1) pancreatic resection in a single session was possible; 2) the isolated stump has a fish mouth form; 3) there is little bleeding from the isolated stump; 4) the procedure is simple. In our study, the use of Curved Cutter Stapler was found to result in a remarkably low rate of Grade B fistula.

Kleeff et al suggested that the use of stapler may cause focal pancreatic necrosis in the surrounding stapling site; however, we hypothesized that a Curved Cutter Stapler would not cause so much damage to the stump of the pancreas because of its shape [23]. Thus, a Curved Cutter Stapler would not impair the outflow of the pancreatic juice through Wirsung's duct.

The complication rates after DP are dependent on both the surgical technique and patient factors [24]. In addition to aggressive surgery, obesity, significant comorbidities, male sex and low serum albumin levels are independent risk factors for fistula formation [25, 26, 27, 28]. Several studies have suggested that a pancreas with a soft texture is more prone to leak when a stapler is used [22, 29]. Thus, higher stapler or pancreatoenteric anastomosis might be recommended for the prevention of POPF when transecting a thick pancreas [30]. However, in the present study, the texture of the pancreatic parenchyma was not associated with the risk of POPF and the frequency of pancreatic fistula was not also related to the thickness of the pancreas when the green cartridge was use in cases involving thick pancreas.

The outcomes of pancreatic resection using a Curved Cutter Stapler are difficult to interpret due to the relatively small number of cases; however, we believe that our new method can contribute to reducing the incidence of POPF. Multi-centre prospective studies that include large groups of patients undergoing DP using the Curved Cutter Stapler are necessary to determine the best methods for the prevention of POPF.

CONCLUSION

Pancreatic resection using a Curved Cutter Stapler would contribute to reducing the incidence of pancreatic fistula and the avoidance of serious complications and would shorten hospitalization. The use of a Curved Cutter Stapler could reduce the incidence of severe and potentially fatal POPF formation. However, it is not possible to completely prevent the development of Grade A or B fistula.

Conflicts of Interest

All named authors hereby declare that they have no conflicts of interest to disclose.

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