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Retrospective Study

A Novel Invagination Procedure for Pancreaticojejunostomy Using Double purse string: A technical note

A technical note on pancreaticojejunostomy

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Abstract

BACKGROUND

Pancreatic fistula (POPF) is one of the most serious complications after pancreaticoduodenectomy (PD), and the choice of pancreaticojejunostomy is considered a key factor affecting the occurrence of postoperative pancreatic fistula. Numerous anastomotic methods and their modifications have been proposed, and there is no method that can completely avoid the occurrence of postoperative pancreatic fistula. Based on our team's experience in pancreatic surgery and review of relevant literature, we describe a novel invagination procedure for pancreaticojejunostomy using double purse string. Such an approach to the procedure has resulted in favourable outcomes.

AIM

To describe the precise procedural steps, technical details and clinical efficacy of the novel invagination procedure for pancreaticojejunostomy.

METHODS

This study adopts a single-arm retrospective cohort study methodology, encompassing a total of 65 consecutive patients who underwent PD with the novel invagination Procedure for Pancreaticojejunostomy , including the placement of a pancreatic stent, closure of the residual pancreatic end, the first layer of purse-string suturing, and eventually, the secondary layer of purse-string suturing. Baseline data included age, gender, body mass index, pancreatic texture, pancreatic duct diameter, operation time, and blood loss. Clinical outcomes encompassed operation time, blood loss, incidence of postoperative pancreatic fistula, postoperative hemorrhage, delayed gastric emptying, postoperative pulmonary infection, postoperative abdominal infection, and postoperative pulmonary infection.

RESULTS

The mean age of the patients was 59.12 (± 8.08) years. 40 males and 25 females were included, and the mean body mass index (BMI) was 21.61 kg/m² (± 2.74). A total of 41.53% of patients had a pancreatic duct diameter of 3 mm or less. The mean surgical time was 263.83 min (± 59.46), and the mean bleeding volume was 318.4 ml (± 163.50). Following the surgical intervention, merely three patients showed grade B POPF (4.62%) , while no patients showed grade C POPF. Five patients (5/65, 7.69%) were diagnosed with postoperative hemorrhage. Six patients (6/65, 9.23%) experienced delayed gastric emptying. Four patients (4/65, 6.15%) manifested postoperative pulmonary infection, while an equivalent number (4/65, 6.15%) exhibited postoperative abdominal infection. Additionally, two patients (2/65, 3.08%) presented with postoperative pulmonary infection.

CONCLUSION

The novel invagination technique for pancreatojejunostomy is straightforward, yields significant outcomes, and proves to be safe and feasible in clinical application.

Key Words: pancreatic anastomosis; pancreatojejunostomy; pancreatic fistula

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Core Tip: Xingkai Meng described a novel Invagination Procedure for Pancreaticojejunostomy which has accomplished noteworthy outcomes.

INTRODUCTION

Pancreaticoduodenectomy (PD)⁷ currently represents the treatment of choice for benign or malignant pancreatic and periampullary malignant tumours^[1]. In recent years, with continuous improvements in surgical techniques and perioperative management, the mortality rate associated with PD has been reduced to 5%, but the postoperative complication rate is still as high as 50%^[2,3]. Postoperative pancreatic fistula (POPF) is the most serious complication in patients who undergo PD, with a reported incidence of 10%–30% in the literature^[4]. Specifically, the occurrence of pancreatic fistulas contributes to prolonged hospitalization and significantly increased costs, even causing death^[5]. Multiple anastomotic techniques and their modifications have been suggested, such as pancreaticogastrostomy, duct-to-mucosa anastomosis, and invagination pancreatojejunostomy. However, none of these methods can entirely prevent the occurrence of postoperative pancreatic fistula.

The efficacy and safety of these methods have been the subjects of discussion for several decades, but the results have significantly varied across studies^[6]. A randomized clinical trial of pancreatogastrostomy (PG) vs pancreatojejunostomy (PJ) showed no difference in the rate of POPF, but there were more postoperative bleeding events with PG^[7]. The most widely used procedure in PD, duct-to-mucosa pancreatojejunostomy, poses technical challenges during PD, especially in patients with soft pancreas and nondilated main pancreatic ducts^[8]. However, in high-risk patients with a soft pancreas in a low-volume centre,⁴ invagination may reduce the

risk of clinically relevant POPF compared with duct-to-mucosa. For one reason, it is easy to mobilize and invaginate the pancreatic stump into the jejunum during invagination pancreaticojejunostomy^[9]. Furthermore, the difficulty of pancreaticojejunostomy does not depend on the main pancreatic duct diameter. Therefore, this may be an ideal technique that may be applicable for all patients^[10].

Herein, based on our team's experience in pancreatic surgery and some relevant literature, we describe a novel, convenient, and simple invagination technique, denoted as the NIP technique. In this anastomosis method, the pancreatic stump was closed with continuous sutures, and a double purse-string technique was used in pancreaticojejunostomy. To date, over 60 cases have been successfully performed utilizing this technique, yielding favourable outcomes.

MATERIALS AND METHODS

Surgical Procedures

Placement of the pancreatic stent: After carefully achieving haemostasis at a distance of 2 cm from the free end of the pancreatic duct, the main pancreatic duct was delicately incised using tissue scissors. Subsequently, a silicone tube with comparable dimensions to the residual pancreatic main duct was inserted as a supportive conduit. To facilitate pancreatic fluid drainage, the lateral wall of the supportive conduit was punctured with three to four small apertures. The pancreatic stent was fixed traverse to the abdominal and dorsal aspects of the supportive conduit using 4-0 absorbable sutures, passing through the main pancreatic duct and the surrounding pancreatic tissue to ensure secure attachment (Figure 1a).

Closure of the residual pancreatic end: The surrounding residual pancreatic tissue of the main pancreatic duct was meticulously sutured using a 4-0 Prolene thread passed through the pancreatic parenchyma, traversing the pancreatic capsule in a continuous locking pattern. This procedure effectively sealed the residual end of the pancreas. (Figures 1b).

First layer of purse-string suturing: Employing a 4-0 Prolene thread, the needle was inserted inwards from the interior of the pancreatic parenchyma. After traversing the pancreatic tissue, the needle emerged at a distance of 2 cm from the residual end of the pancreas. Using the same needle, a corresponding vertical edge of the jejunal posterior wall was punctured 2 cm from the duodenal margin, penetrating through the muscular layer of the jejunum and exiting 0.5 cm away. Maintaining a needle distance of 0.5 cm, the suture was gradually tightened, ensuring a snug fit between the residual pancreatic end and the jejunal wall. This continuous suturing technique was repeated for 6-8 stitches, completing the posterior anastomosis of the pancreatic-duodenal junction. A small incision was made in the corresponding end of the jejunum, opposite to the pancreatic stent, using an electric scalpel. The size of the incision was adjusted to allow smooth insertion of the residual pancreatic end into the jejunum. The pancreatic stent was then inserted approximately 5 cm into the jejunal lumen, and then the anterior anastomosis of the pancreatic-duodenal junction was continuously sutured using the same technique (Figures 1c-d).

Secondary layer of purse-string suturing: Using a 4-0 Prolene thread, a continuous purse-string suture was applied again 0.5 cm from the first anastomosis site, ensuring complete envelopment and adherence of the jejunum around the residual pancreatic end. Starting from the jejunal end, the needle traversed through the muscular layer of the jejunum and emerged at a 0.5 cm from the first anastomosis site. Using the same needle, the pancreatic capsule was penetrated at a corresponding point 0.5 cm away from the first anastomosis site, passing through the pancreatic parenchyma and exiting 0.5 cm from the needle entry point. After tightening the suture, the posterior anastomosis of the pancreatic-duodenal junction was completed. Following a similar approach, the anterior muscular layer of the jejunum was continuously sutured to the corresponding pancreatic parenchyma. The suture was gradually tightened, and upon completion of the knotting, the second layer of purse-string sutures was completed, thus concluding the pancreatic-duodenal anastomosis process. Upon the completion of continuous purse-string suturing between the residual pancreatic end and the jejunal

muscular layer, the muscular layer of the jejunum will create an "invaginated cuff," resembling an inwardly folded sleeve, allowing the residual pancreatic end to be fully encapsulated within this "cuff." Finally, bilioenteric and gastroenteric anastomoses were created, achieving reconstruction of the gastrointestinal tract (Figures 1e-f).

RESULTS

Patient Characteristics and Perioperative Conditions

⁸ The mean age of the patients was 59.12 (± 8.08) years. Forty males and 25 females were included, and the mean body mass index (BMI) was 21.61 kg/m² (± 2.74). A total of 41.53% of patients had a pancreatic duct diameter of 3 mm or less. The mean surgical time was 263.83 min (± 59.46), and the mean bleeding volume was 318.4 ml (± 163.50). All patients underwent placement of internal stents within the pancreatic duct.

Outcomes

After undergoing surgery, three (3/65, 4.62%) patients showed grade B POPF, while no patients showed grade C POPF. Five patients (5/65, 7.69%) were diagnosed with postoperative haemorrhage. Six patients (6/65, 9.23%) were diagnosed with delayed gastric emptying. Four patients (4/65, 6.15%) showed postoperative pulmonary infection. Four patients (4/65, 6.15%) showed postoperative abdominal infection. Two patients (2/65, 3.08%) showed postoperative pulmonary infection.

DISCUSSION

Pancreaticoduodenectomy (PD) is the main surgical procedure for benign or malignant tumours around the head of the pancreas, the lower bile duct and ampulla. The procedure involves the ² removal of numerous organs and reconstruction of various digestive tract segments, including the pancreas, biliary tract, and gastrointestinal tract, and it is associated with a high risk of postoperative complications, with an incidence of 30%- 60%^[11]. In fact, ⁶ postoperative pancreatic fistula (POPF) remains the most common complication after pancreatic surgery, occurring in up to 30% of patients, even in high-

volume centers^[12, 13]. Pancreatojejunostomy, as an independent risk factor for the development of POPF after PD, is considered the most controllable factor, and choosing to forego the procedure is the key to effectively preventing pancreatic fistula^[8, 14]. Several pancreaticojejunostomy methods and their modifications, including pancreaticogastrostomy, duct-to-mucosa pancreaticojejunostomy and invagination pancreaticojejunostomy, have been proposed to reduce the incidence of pancreatic fistula^[15, 16]. However, none of the pancreaticojejunostomy techniques can achieve significant results^[17]. Based on its unique advantages and relatively low incidence of pancreatic fistula, invagination pancreaticojejunostomy has been shown to be a safe and reliable procedure^[18]. However, there have been discussions regarding the practical use of invagination pancreaticojejunostomy, including the problem associated with cutting sutures. Haemorrhage of the pancreatic stump due to immersion of the stump in the intestinal cavity and problems such as leakage of pancreatic fluid between sutures caused by intermittent sutures have not been adequately addressed.

¹In this study, we used a novel invagination procedure to completely invaginate the pancreatic stump into the jejunal lumen. Remarkably, only three patients exhibited grade B pancreatic fistula (POPF), with no instances of grade C POPF being observed. Postoperative haemorrhage was diagnosed in five patients. Delayed gastric emptying was identified in six patients. Four patients manifested postoperative pulmonary infection, while four patients experienced postoperative abdominal infection. Additionally, two patients displayed postoperative pulmonary infection. The data in this study showed that the novel invagination procedure ¹is safe and simple to perform, irrespective of the pancreatic stump condition.

Compared to previous pancreaticojejunostomy, this procedure has the following differences: ①The surface of the pancreatic remnant exhibits numerous small arteries and pancreatic duct branches. By focusing on the main pancreatic duct as the core, we close the residual glandular tissue with continuous sutures, thereby preventing pancreatic fluid secretion leakage at the pancreatic-enteric anastomosis site. Simultaneously, this approach reduces the exposed surface area of the pancreatic

remnant, enhancing its resilience and minimizing the risks of postoperative pancreatic fistula and haemorrhage. Furthermore, there is no risk of cutting damage to the fragile pancreatic tissue during the pancreatic-enteric anastomosis process. ②By employing continuous purse-string sutures, the gaps between the anastomotic sites are eliminated, thereby reducing the risk of leakage of pancreatic fluid. Additionally, continuous suturing ensures consistent tension without the need for repeated knotting, thus reducing the overall procedural time. ③During the double purse-string procedure for pancreatic-enteric anastomosis, the pancreatic parenchyma is intimately connected to the muscular layer of the jejunum through a transfixing suture technique, ensuring close apposition between the pancreatic remnant and the jejunum. ④The double purse-string procedure effectively reduces tension at the anastomotic site while preserving the intact blood supply to the pancreatic remnant, thereby meeting the histological requirements for optimal tissue healing. ⑤During the suturing process, the assistant ensures tight closure of the sutures by applying moderate knotting force, thereby minimizing the cutting effect of the suture on the pancreatic parenchyma. By utilizing a fine needle and sparse suturing technique, the damage to the pancreatic parenchyma caused by the suture is reduced. Employing continuous suturing for pancreatic-enteric anastomosis significantly reduces the accumulation of pancreatic fluid and its corrosive effect on the anastomosis.

From the perspective of pancreatic-enteric anastomotic healing, regardless of the specific technique employed, the primary components consist of mucosal healing, which is achieved when the inner layer of the jejunal mucosa covers the pancreatic remnant, and fibrous healing between the outer layer of the jejunal serosa and the pancreatic remnant^[14, 19]. While duct-to-mucosa anastomosis achieves direct pancreatic-enteric alignment, inadequate length of the pancreatic duct can compromise its blood supply, thereby affecting the healing rate of the anastomosis^[20, 21]. On the other hand, there are no restrictions on the diameter of the main pancreatic duct when selecting to perform the NIP technique. Leveraging the rapid regenerative capacity of the jejunal

mucosa, it allows permanent biological healing along the pancreatic duct and is conducive to supporting the tube and the residual pancreatic tissue.

CONCLUSION

In conclusion, based on the preliminary results, this pancreaticojejunostomy is safe and reliable and has high clinical application value. It can be used as a standardized surgical method in clinical practice.

ARTICLE HIGHLIGHTS

Research background

Postoperative pancreatic fistula(POPF) stands as the most formidable complication following PD.Among the risk factors influencing the occurrence of POPF, the pancreaticojejunostomy method stands out as a significant, modifiable factor and serves as the pivotal aspect in preventing pancreatic fistula.

Research motivation

Detail the surgical procedure and technical intricacies of the novel invagination technique for pancreaticojejunostomy, and assess its safety and efficacy.

Research objectives

Through the innovative optimization of pancreaticojejunostomy, reduce the incidence of postoperative complications, and enhance the long-term prognosis for patients.

Research methods

This study employs a single-arm retrospective cohort study methodology to assess the effectiveness and safety of the novel invagination technique for pancreaticojejunostomy during PD.

Research results

Following the novel invagination technique for pancreaticojejunostomy , only three patients demonstrated Grade B postoperative pancreatic fistula (POPF), with no instances of Grade C POPF observed.

Research conclusions

The novel invagination procedure for pancreaticojejunostomy demonstrates safety, reliability, and significant clinical applicability, thereby qualifying as a standardized surgical approach in clinical practice.

Research perspectives

By establishing a standardized and homogenized pancreaticojejunostomy method, conducting a multicenter randomized controlled study to further clarify its advantages, and subsequently employing animal experiments to elucidate the specific mechanisms and principles.

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