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Binding pancreaticojejunostomy – a safe and reliable anastomosis procedure

SY Peng[1,2], JW Wang[1], JT Li[1], YP Mou[2], YB Liu[1] and XJ Cai[2]

[1]General Surgery Department, Second Affiliated Hospital and; [2]General Surgery Department, Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University, Hangzhou, China

Background

Over the past one hundred years, the development of pancreaticoduodenectomy (PD) has always involved the struggle against pancreatic leakage. Until now, leakage of the pancreatic anastomosis has remained a common and serious complication after PD. Various methods of dealing with the pancreatic stump for prevention of pancreatic anastomotic leakage have been described. No matter which method is used, however, pancreatic anastomotic leakage is still most likely to occur when anastomosis involves a normal and soft pancreas.

Methods

To perform a safe and reliable pancreaticoenteric anastomosis, we investigated the risk factors and potential mechanisms of occurrence of pancreatic leakage, including leakage from the needle hole and from the seam between two anastomosed structures, blood supply to the anastomosis and tension at the anastomosis. Based on these findings, we established a new pancreaticoenteric anastomosis procedure – binding pancreaticojejunostomy. The unique aspects of this procedure are as follows. The sero-muscular sheath of jejunum is bound to the invaginated pancreatic stump, so as to seal the gap between them; mucosa of the segment of jejunum that would eventually be in contact with the pancreatic stump is destroyed either chemically or by electric coagulation to promote healing. There is no needle hole on the jejunal surface of the anastomotic site.

Results

From 1996 to 2003, a total of 227 consecutive patients were treated with this type of pancreaticojejunostomy in this institution. None of the patients developed a pancreatic anastomotic leak.

Discussion

Binding pancreaticojejunostomy is a safe and reliable anastomotic procedure to effectively minimize leakage even when the texture of the pancreas is soft and normal.

Keywords

pancreas, anastomotic leakage, binding pancreaticojejunostomy, pancreaticoduodenectomy

Introduction

One hundred and five years ago, the first attempt to partially excise the pancreas and duodenum was conducted by Codivilla (1898), who has been credited by some authors as the pioneer of that procedure [1], although he only closed the stump of the pancreas by suture and did not perform pancreaticoenteric anastomosis. In 1912, Kausch successfully performed a partial pancreaticoduodenectomy, and implanted the pancreatic stump into the jejunal stump by utilizing a two-stage operation [2]. In 1946, Whipple completed the one-stage pancreaticojejunostomy that is, today, called Whipple's procedure [3]. In 1943, Cattell first stated that pancreaticoenteric anastomosis was indispensable, maintaining that the leakage of pancreatic juice accounted for many postoperative complications and deaths after pancreaticoduodenectomy [4].

Pancreaticoduodenectomy has now become popularised as the standard treatment for various benign and malignant diseases of the pancreatic head and periampullary region, although the development of pancreaticoduodenectomy has always involved a struggle against complications, especially pancreatic leakage, which is thought to be the most important determinant for morbidity and mortality. Although the rate of pancreatic fistula may be as low as 1.6–3.2% in extremely skilled hands with meticulous technique [5, 6], in recent years a pancreatic fistula rate of 10–20% after pancreaticoduodenectomy has been reported even in specialised centres [7–11], resulting in postoperative morbidity approaching 40–50% [8–14]. Therefore pancreaticoen-

Correspondence to: *Shu You Peng, Department of Surgery, Second Affiliated Hospital, School of Medicine, Zhejiang University, 88# Jie Fang Road, Hangzhou, Zhejiang, PR China 310009 (e-mail: zrwkpsy@zjuem.zju.edu.cn.)*

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teric anastomosis is still considered to be the 'Achilles heel' of the pancreaticoduodenectomy. We investigated the potential mechanisms of pancreatic leakage and established a new pancreaticoenteric anastomosis procedure – binding pancreaticojejunostomy.

A variety of factors related to pancreatic leakage has been described in the literature. The following are most frequently mentioned: pancreas factors (pancreatic texture, blood supply, pathology, pancreatic duct size, pancreatic juice output); patient characteristics (age, gender, jaundice level, combined illness); operation factors (operative time, blood loss, anastomosis procedure, drainage of pancreatic duct), and so on. Among them, pancreatic texture, pancreatic duct size, pancreas stump blood supply and pancreatic juice output have been significantly emphasised. It is widely accepted that a fibrotic pancreatic remnant facilitates the pancreaticoenteric anastomosis, whereas a soft and fragile pancreatic parenchyma frequently makes the anastomosis difficult to perform. Yeo and co-workers found that none of 53 patients with hard pancreatic remnant developed pancreatic leakage, whereas 19 of 75 (25%) patients with soft pancreatic texture developed pancreatic leakage [8]. Berge Henegouwen and co-workers found that small pancreatic duct size (<2 mm) and ampullary carcinoma were risk factors [15]. Strasberg and colleagues emphasised the importance of optimisation of blood supply to the anastomosis [7]. Furthermore, the high pancreatic juice secretion in the soft pancreas was thought to be a factor contributing to anastomotic leakage [16]. Ishikawa and co-workers significantly reduced pancreatic fistula rate by way of preoperative radiation therapy [17].

As regards operative technique, the management of the pancreatic stump, anatomosis procedure and meticulous technique are the important points investigated to prevent anastomotic leakage. As a matter of fact, some of the aforementioned risk factors – i.e. soft pancreatic texture, non-dilated pancreatic duct and high pancreatic juice secretion – are closely correlated. In other words soft pancreatic texture is the basic risk factor, as the other conditions frequently coexist with normal (soft) pancreatic texture. Then why is it that they are risk factor? In the final analysis, it might well be the sutures that tend to lacerate the fragile pancreatic parenchyma. Thus, if sutures are not placed carefully and properly the suture itself lacerates the gland and a pancreatic fistula may occur from the area of the suture placement.

The primary approach to pancreatic fistulas should be prevention. According to a review of the Medline database from 1990 to 2000 concerning studies on the prevention of pancreatic anastomotic leakage, the routine use of octreotide in pancreaticoduodenectomies cannot be recommended [5]. However, some retrospective or non-randomized prospective studies suggested that technical modifications could reduce the leakage rate. Reported techniques cover a spectrum of complexity ranging from simple 'parachuting' of the pancreatic stump into the jejunum to a more elaborate four-layer end-to-side ductal mucosa anastomosis [8, 10, 11, 18]. Apparently all the methods to connect pancreas with jejunum (or stomach) by suture, as mentioned above, may result in pancreatic fistula from the area of suture placement.

Accordingly, meticulous suture is emphasised [7, 19–21]. In recent years the tendency to lower fistula rate might be attributed to the use of atraumatic sutures, where the size of the thread is similar to that of the needle hole, i.e. the needle hole can be filled up by the suture, leaving no space around the thread in the needle hole. Nevertheless, there is still the probability that the needle might inadvertently penetrate a pancreatic ductule, resulting in pancreatic leak if at the same time the jejunal intraluminal pressure is high for any reason. Furthermore, the seam between the two anastomosed structures can be the potential site giving rise to the development of a leak.

Based on these hypotheses, we suggested a new procedure – binding pancreaticojejunostomy – where needles holes do not appear on the surface of the anastomotic site and the anastomotic seam between the sutured structures is substituted by a circular gap between the intussuscepting jejunal stump and the intussuscepted pancreatic stump [22, 23]. The gap is easily sealed up by compression from outside with a binding ligature to achieve a watertight closure.

Methods

Preparation of the jejunum for binding anastomosis

The stump of the jejunum is everted for 3 cm; this can be achieved by suturing the jejunal cut edge to a point at the jejunum 6 cm from the edge. Two such sutures are done and tied loosely, rendering 3 cm of the jejunum everted

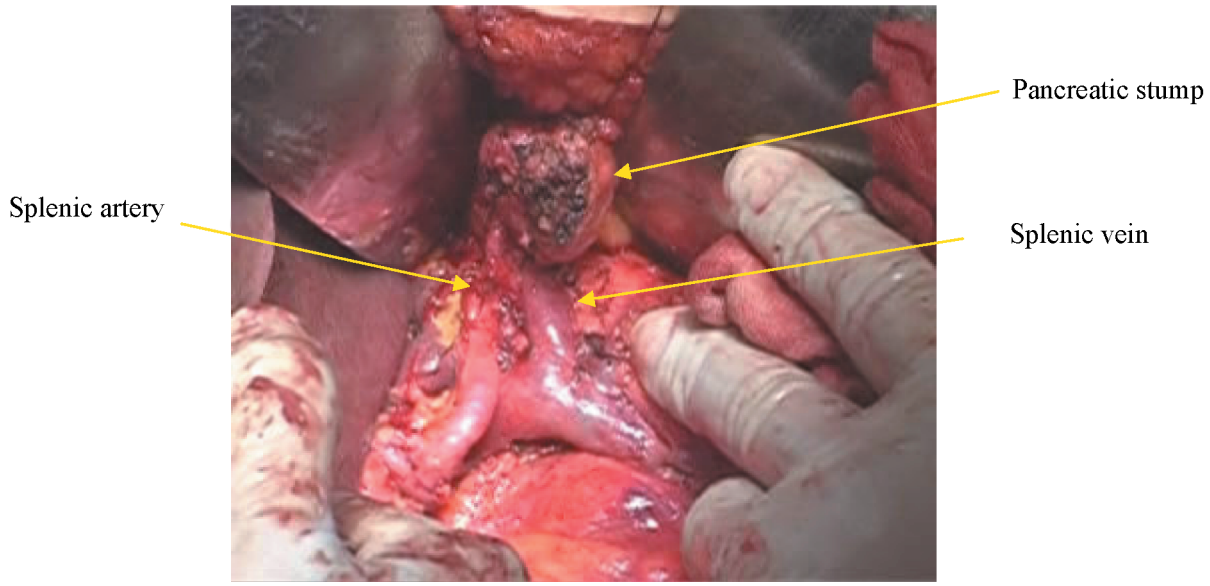

Figure 1. *Pancreatic stump is adequately isolated for 3 cm.*

with its mucosa exposed, which then is destroyed by electric coagulation or by 10% carbolic acid and rinsed immediately with 75% alcohol and normal saline.

Preparation of the pancreas stump

The remnant of the pancreas is isolated for a distance of 3 cm, usually two to three small veins between the pancreas and the splenic vein are dissected and ligated. After adequate isolation when the isolated pancreatic remnant is raised forward, the splenic artery and splenic vein can be seen and separated by a small area of pancreas which is the site for fixing the posterior cut edge of the jejunum (Figure 1).

Two stumps sutured

The pancreatic stump and the everted jejunum are brought together and sutured continuously or intermittently with silk in a circular fashion, care is taken to suture the mucosa only and to avoid penetrating the muscular and serosa layer of the jejujnum. The anterior or posterior lip of the pancreatic duct should be involved in the anterior or posterior row of sutures, respectively, whenever possible.

Intussusceptions

The two sutures for everting the jejunum are cut before the everted jejunum is restored to its normal position, so as to wrap over the pancreatic stump (Figure 2). With a few stitches the cut end of the jejunum is fixed onto the pancreas. Special attention is paid to the posterior fixing point as mentioned above.

Binding

At 1.5–2 cm from the cut edge of the jejunum, an absorbable tie is looped around the jejunum circumferentially together with the intussuscepted pancreas. The ligature is just tight enough to allow the tip of a haemostatic clamp to pass underneath the ligature (Figure 3). Blood supply to the jejunum distal to the binding ligature is ensured by preserving a bundle of vessels for that portion of jejunum. This means that the thread for making the binding ligature is placed through a hole at the jejunal mesentery between the last two groups of vessels near the cut edge (Figure 4).

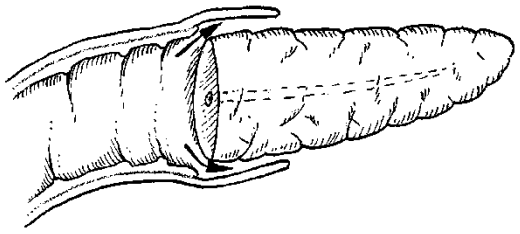

Figure 2. *The gap between the intussuscepting jejunum and the intussuscepted pancreas can be sealed up by compression from outside with a binding ligature.*

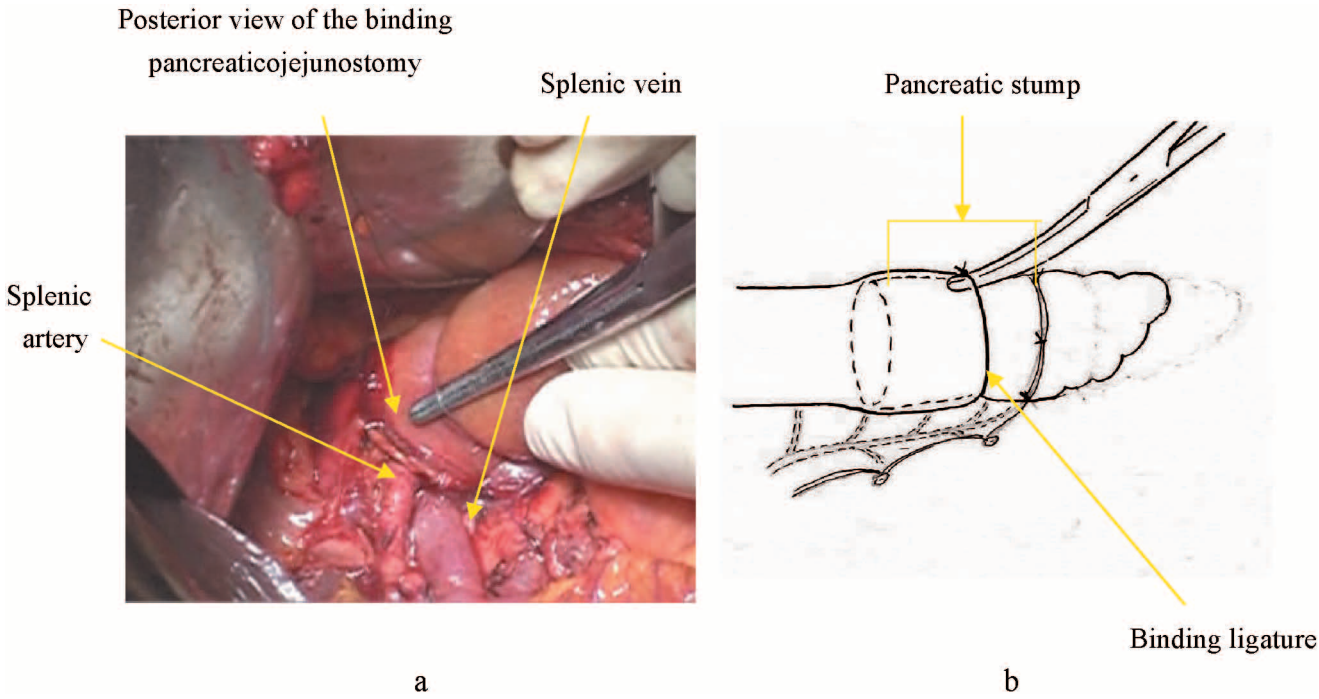

Figure 3. *(a) Posterior view of anastomosis; (b) anterior view of anastomosis. The tip of a clamp is allowed to pass underneath the binding ligature.*

Jejunostomy

After completion of the anastomosis, a tube is inserted, through the site where choledocojejunostomy is intended to be constructed, for injection of saline to test for a watertight closure (Figure 5). Jejunostomy through the defunctionalised loop with a catheter left in place about 12 cm distal to the choledocojejunostomy is performed for decompression and X-ray study postoperatively.

Drainage

A Jackson-Pratt drainage tube is placed near the anastomosis. The volume and amylase content of the drainage fluid are measured every day. Pancreatic leaks were defined as a significant increase in the volume or a change in the nature of the effluent from the surgical drain, or the persistence of amylase-rich drainage output out in excess of 50 ml/day and amylase more than

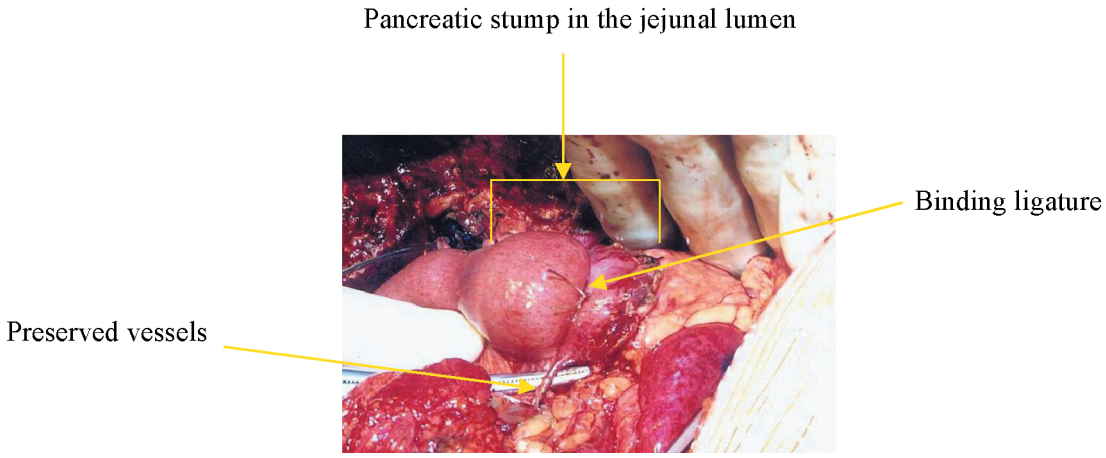

Figure 4. *Pancreatic stump is intussuscepted well into the jejunum lumen, no needle hole on the surface of the anastomotic site. Vessels preserved for jejunal cut edge.*

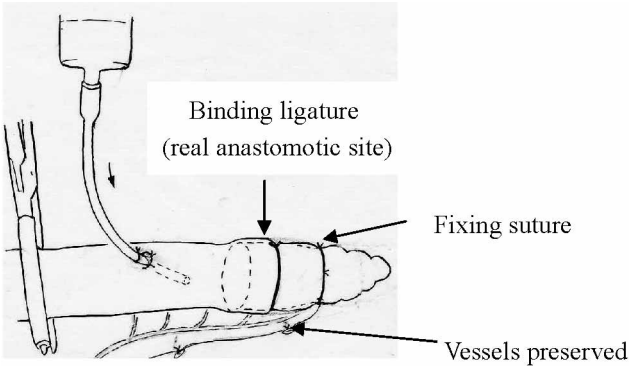

Figure 5. *Injection of dyed solution into jejunal lumen to confirm watertight closure of the anastomosis. The binding ligature is the real anastomotic site.*

1000 IU/L. In cases suspected of an anastomotic leak, X-ray studies are carried out for confirmation.

Mortality was defined as any death within 30 days of the procedure.

In the majority of cases a pancreatic duct stent was not used. The aim of using the stent was not for minimising anastomotic leak, but for withstanding the compression from outside, in an attempt to prevent pancreatic duct stricture, especially during the early period of this study when the binding ligature was made rather tight to ensure watertight closure of the gap between the intussuscepting jejunum and the intussuscepted pancreas.

Follow-up

Except anastomotic leakage, the major concern with binding pancreaticojejunostomy is the possibility of constriction of the pancreatic duct due to the compressing binding ligature. For the particular purpose of observing this possibility, the first 100 patients who underwent binding pancreaticojejunostomy were closely followed up for 1 year at 3-month intervals with ultrasonography, sometimes combined with CT or MRCP. The diameter of the pancreatic duct was measured for comparison with that observed pre-operatively. Generally after resection of the lesion, the dilated pancreatic duct gradually resumed its normal size. In cases where the dilated duct did not shrink in size or the originally normal-sized pancreatic duct became dilated postoperatively, it was considered to be the result of the operation, provided that there was no local recurrence detected.

Results

From January 1996 to July 2003, a total of 227 consecutive patients was treated with this type of pancreaticojejunostomy, including typical pancreaticoduodenectomy in 188 patients hepatopancreaticoduodenectomy (HPD) in 20, pylorus-preserving pancreaticoduodenectomy (PPPD) in 15 and duodenal-preserving resection of the head of the pancreas (DPRHD) in 4. None of the patients developed pancreatic anastomotic leak. There were five postoperative deaths, giving a mortality rate of 2.2% (5/227). One patient died of aspiration pneumonia 4 weeks postoperatively; one patient died of anaesthetic accident. Two patients died of hepato-renal failure 27 and 29 days postoperatively; one patient who was complicated 2 weeks after PD with ruptured splenic artery aneurysm, died of multi-organ failure. The overall morbidity was 31.28% (71/227). The following complications occurred: gastrointestinal bleeding in 8 patients, ruptured spenic artery aneurysm in one patient, pulmonary infection in 16, wound infection in 24, biliary leakage in 8 confirmed by X-ray study, delayed gastric emptying in 6, incision dehiscence in 4, hepatic insufficiency in 3 and renal insufficiency in 2. The mean postoperative hospital stay was 21.3 ± 4 days.

Postoperative follow-up did not show pancreatic duct dilatation except for one patient in whom the preoperative pancreatic duct was normal in size, asymptomatic pancreatic duct dilatation was observed after PD. Therefore if the binding ligature is not too tight, i.e. allowing the tip of a vascular clamp to pass underneath the binding ligature, there is no need to stent the duct.

Discussion

Binding pancreaticojejunostomy is a safe, simple and effective technique which can be used in most circumstances when pancreaticoduodenectomy is performed. Pancreatic anastomotic leakage can surely be avoided regardless of the texture of the pancreas, be it hard or soft, also regardless of the pancreatic duct, be it dilated or small. The procedure should be conducted correctly paying attention to adequate isolation of the pancreatic stump, appropriate tightness of the binding ligature and especially the cut edge of the jejunum, which must be completely included in the binding ligature. As a result, pancreaticoduodenectomy has been used increasingly in recent years. In this series, PD has been used for the treatment of late cases of carcinoma of gallbladder and cancer of stomach as well with good results.

To the best of our knowledge, this procedure is being performed in 83 hospitals in China. Altogether 1020 cases underwent binding pancreaticojejunostomy, with pancreatic anastomotic leak occurring in 4 cases (0.39%). Among them, one was due to inadequate isolation of the pancreas remnant, resulting in the anastomosis coming off; 3 cases were due to incomplete binding (a part of the posterior cut edge of the jejunum was not included in the binding ligature), which also resulted from inadequate isolation of the pancreas remnant. Apparently, it is of paramount importance to isolate the pancreas stump adequately for a distance of 3 cm so as to ensure the fastness and reliability of the binding ligature.

Strasberg and co-workers [7] emphasise the importance of optimisation of blood supply to anastomoses – would the isolation of pancreas stump for such a length compromise blood supply? The answer is no, because the anastomotic line is not actually at the cut end of the pancreas although it is the site of suturing with jejunal mucosa. Instead, the real anastomotic line is just beneath the binding ligature, merely 1–2 cm from the base of the isolated pancreas stump with adequate blood supply. In the initial period of this study the remnants of pancreas and jejunum were anastomosed sequentially at three sites by different methods: (1) jejunal mucosa sutured to the cut edge of pancreas; (2) jejunal cut edge sutured regularly onto the pancreas body; (3) binding ligature as described above. As a matter of fact, any of the three sites (methods) of anastomosis can act as an independent anastomosis. Being recognised as mutually supporting measures against anastomotic leakage, they were put together to form a comprehensive procedure in an effort to eradicate the life-threatening anastomotic leakage. Afterwards, anastomosis (2) was omitted and substituted with only a few stitches just for fixation in an attempt to avoid too many needle holes on the pancreas, although these needle holes do not communicate with the jejunal lumen. Our second thought as mentioned above has been proven to be correct by the clinical outcome of the patients undergoing the procedure. As a result, the procedure became composed of two anastomoses and is termed type I binding pancreaticojejunostomy. Later on, we tried to further simplify the procedure by omitting anastomosis (1), as we were convinced that it is the binding ligature that is the most important safeguard against anastomotic leakage. In the past 2 years we have already operated on 52 patients in whom the jejunal mucosa was not sutured to the pancreatic cut edge, with the binding ligature as the sole safeguard against anastomotic leakage. We term this procedure as type II binding pancreaticojejunostomy [24]. The results were as good as those for type I. With regard to the jejunal cut end, blood supply is also kept normal by preserving a bundle of vessels to that portion. The other major concern over binding panceaticojejunostomy is the tightness of the binding ligature. If it is too loose, watertight closure cannot be achieved, resulting in anastomotic leakage. If it is too tight, the pancreatic duct might be compressed, resulting in stricture of the duct. What are the criteria for appropriate tightness?

For a ligature that is not too tight: 1. The binding ligature is tied until the two organs are in close contact with each other. 2. The jejunum is compressed circumferentially down, forming a circular dent for 1–2 mm. 3. The tip of a vascular clamp can pass underneath the binding ligature. It is of paramount importance that this is not too loose: watertight closure is tested by ballooning the jejunum with dyed saline, intraluminal pressure reaching 40 cmH_2O.

In conclusion, binding pancreaticojejunostomy can definitely minimise pancreatic anastomic leakage by avoiding any needle hole through the full thickness of jejunum and achieving watertight closure of the gap between the intussuscepting jejunum and the intussuscepted pancreatic remnant. This procedure for pancreaticoduodenectomy is safe and reliable not only when the texture of the pancreas is hard; it is equally safe and reliable when the pancreas texture is soft and normal with non-dilated duct.

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