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REVIEW ARTICLE

Binding pancreaticoenteric anastomosis: from binding pancreaticojejunostomy to binding pancreaticogastrostomy

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Abstract Potential mechanisms of occurrence of pancreatic leakage mainly include leakage from the needle hole and from the seam at the adjacent stitch, anastomotic blood supply, tension at the anastomosis, poor anastomotic healing, etc. Binding pancreaticojejunostomy (BPJ) is a safe and effective technique that avoids the primary complication of pancreatic anastomosis leakage. There are two problems with BPJ: a high discrepancy in the size of pancreas stump and the jejunal lumen; sutures on to the pancreas for fixation might cause exudation of pancreatic juice into the abdominal cavity. In order to avoid these two problems, binding pancreaticogastrostomy (BPG) is designed and successfully performed clinically with encouraging results. BPG is good for accommodating a large pancreas stump, and the binding technique is very helpful in minimizing the leak rate of pancreaticogastrostomy.

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Introduction

About 100 years ago, the first attempt to partially excise the pancreas and duodenum were conducted by Codivilla (1898), who has been recognized as the pioneer of pancreaticoduodenectomy [1], although he only closed the cut surface of the pancreas by suture and did not performed pancreaticoenteric anastomosis. Kausch [2] successfully performed a partial pancreaticoduodenectomy, and implanted the pancreatic stump into the duodenal stump by utilizing a two-stage operation. Whipple [3] completed the one-stage pancreaticojejunostomy that is, today, called, Whipple's procedure. About six decades have passed since Cattell [4] first stated that pancreaticoenteric anastomosis was indispensable, maintaining that the leakage of pancreatic juice accounted for many postoperative complications and deaths after pancreaticoduodencetomy (PD) in 1943.

Pancreaticoduodencetomy has become popularized as the standard treatment for various benign and malignant disease of pancreatic head and periampullary region, whereas the development of PD has all the while involved the struggle against complications, especially pancreatic leakage. Pancreatic leakage is thought to be the most important determinant for morbidity and mortality. Although a low mortality rate has been achieved, the postoperative morbidity remains high, approaching 40–50% even in recent studies [5–14]. Leakage of the pancreatic anastomosis still occurs in 2.5–20% [5, 6, 8–11].

Therefore pancreaticoenteric anastomosis is considered to be the "Achilles heel" of the PD. The importance of

prevention of the leak from a pacreaticoenteric anastomosis (PEA) after PD will never be overemphasized.

Risk factors of PEA leakage

A large amount of factors related to pancreatic leakage have been described in the literature. The following factors were analyzed: disease factors (pancreatic texture, 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. Especially, pancreatic texture, pancreatic duct size and pancreatic juice output have been significantly emphasized. It is widely accepted that a fibrotic pancreatic remnant facilitates the PEA, whereas a soft and fragile pancreatic parenchyma frequent makes the anastomosis difficult to perform. Yeo et al. [6] found none of 53 patients with hard pancreatic remnant developed pancreatic leakage, whereas 19 of 75 (25%) patients with soft pancreatic texture occurred pancreatic leakage. van Berge Henegouwen et al. [15] found small pancreatic duct size (<2 mm) and ampullary carcinoma were risk factors. Furthermore, the high pancreatic juice secretion in the soft pancreas was thought to be a factor contributing to anastomotic leakage [16]. Ishikawa et al. [17] significantly reduced pancreatic fistula rate in patients who received preoperative radiation therapy.

From the viewpoint of operative technique, the disposal of pancreatic remnant, anatomosis procedure and meticulous technique all along are the important hotpots investigated to prevent the PEA leakage.

Potential mechanisms and preventive measures for PEA leakage

Pancreaticoenteric anastomoses currently is widely employed in combination of various surgical techniques, depending on the site of anastomosis, the direction of anastomosis, and method of suturing. Generally, the types of pancreaticojejunostomy anastomoses can be divided into end-to-side, duct-to-mucosa, or end-to-end (dunking) or end-to-side invagination. The method of suturing used mostly are the one-layer suture, in which pancreatic parenchyma and intestinal wall are sutured around the cut surface of the pancreas; or the two-layer suture, in which pancreas and intestinal wall are sutured at second time to cover the first one-layer-suture. The pancreaticogastrostomy has been used as an alternative anastomotic technique, in which the pancreatic stump is anastomosed to the posterior wall of stomach [18, 19].

The problem with the aforementioned anastomosis techniques is that there is always potential gap between the adjacent stitches, which could become the breaking point of PEA leakage. Furthermore, there are needle holes on the surface of the anastomotic site after needle penetrating the sero-muscular layer. In case the needle penetrates a small branch of pancreatic duct, pancreatic juice could leak from the needle hole. Ohwada et al. [20] devised duct-to-mucosa anastomosis by continuous running suture and parachuting, which can obviate the gap between the adjacent stitches; however, the needle holes are still there causing problem. Kakita et al. [10] simplified the duct-to-mucosa anastomosis: fixation of the pancreatic duct and jejunal mucosa with sutures after insertion of a pancreatic tube, and approximation of pancreas and jejunal wall with penetrating sutures.

Several factors could increase intra-luminal pressure at the anastomosis site, such as the digestive juice accumulation in the defunctionalized loop, intestinal loop distortion, intra-abdominal hernia, and so forth. The increased tension on the suture line would eventually result into PEA breakdown. Therefore, some authors [21, 22] employed external drainage through pancreatic and biliary anastomosis to decompress the defunctionalized proximal jejunum by decreasing the intra-lumal pressure.

The small branches of pancreatic duct at the pancreatic remnant of neck or incompletely resected uncinate process can engender pancreatic leakage. Sung et al. [22] substantiated there are considerable leakage from numerous branches of small arteries and small ducts at the cut end of the pancreas, hereby, placed a row of interlocking horizontal mattress sutures across the gland on both sides of the pancreatic remnant to reduced leakage. And, Ohwada et al. [20] meticulously sutured the small branches of pancreatic duct at the cut surface of the pancreas remnant and used fibrin glue to seal these small ducts without closing the remnant.

The normal pancreatic parenchyma is fragile, and if the pancreatic stump was contracted with sutures or clamped with forceps, pancreatic laceration or impaired circulation in the stump may occur [23]. Furthermore, as pancreatic juice has a potent proteolytic action, reduced blood flow in the stump causes autolysis resulting in pancreatic leakage [24]. From the anatomical point of view, the pancreatic neck is a vascular watershed between celiac and superior mesenteric arterial supply. Strasberg et al. [11] alluded that anatomosis ischemia at the course of pancreatic neck transection may contribute to the development of pancreatic leakage. They employed a technique that combines meticulous attention to placement and suture tying under magnification coupled with optimization of blood supply, achieved a very low rate of anastomotic failure (3.2%).

Although various measures were adopted with the attempts to eliminate pancreatic leakage, none of them can resolve all the comprehensive potential mechanisms of

occurrence of pancreatic leakage. Moreover, these forementioned measures not only are very demanding technically, but also need precise manipulation performed by professional hands, therefore, do not facilitate the popularization.

Establishment of binding pancreaticojejunostomy

It occurred to us that leakage from a pancreatic anastomosis can start at a point where a needle inadvertently penetrates a pancreatic ductule, or a suture lacerates the fragile pancreatic parenchyma on suturing or on tying a knot. The resultant minor leak in pancreatic juice gradually leads to a gross anastomoses leakage as a consequence of autodigestion around the anastomoses. Such a hypothesis forms the basis of the binding pancreaticojejunostomy (BPJ). In this technique, the cut edge of the pancreas is sutured only to the mucosa of the jejunum. Thus, if there is a leakage, the pancreatic juice goes into the gut lumen. The jejunum, with its mucosa destroyed, is wrapped over the pancreatic remnant. The gap between these two structures is sealed by compressing from the outside with a binding ligature. Healing between the jejunum and the pancreas is promoted by destroying the jejunal mucosa with carbolic acid. The real anastomotic site is at the binding ligature where no sutures are applied. The reason why the anansstomosis can be established only by a binding ligature is that the pancreas is a solid instead of a hallow organ. Otherwise, it will not do. Compression from outside exerted by the binding ligature onto the intussuscepting and intussuscepted organs, i.e. the jejunum and the pancreas remnant, can seal the gap in between, rendering them to be approximated closely, so as to create a water-tight closure. This is why the probability of pancreatic anastomotic leakage can be eradicated, as there is no way left for the leakage to develop [25] (Fig. 1).

Animal experiment has shown that the anti-explosion strength of BPJ is 3–4 times higher than that of non-BPJ. This phenomenon illustrates that the safety of binding's procedure chiefly relies on the technique of binding as an essential and crucial step. There were two cases undergoing re-exploration when the defunctionalized loop was markedly distended, yet the anastomosis was in its complete integrity [26], indicating the highly reliability of binding procedure.

Owing to the superiority at safety and simplicity, this technique is widely used in China and elsewhere. From a French prospective study, Buc and colleagues [27] confirm that Peng's BPJ is a safe and secure technique for reconstruction after PD. It is a worthwhile procedure to decrease the rate of pancreatic fistula, especially in case of soft texture of the pancreas and normal MPD.

Evolution of binding pancreaticogastrostomy

The observations from a large-cohort series verified that BPJ can be used in most circumstances when PD is indicated [26, 28]. Pancreatic anastomatic leakage can surely be avoided regardless of the pancreas, be it hard or soft, also regardless of the pancreatic duct, be it dilated or small.

However, there are two problems with BPJ: first when the pancreas stump is too large it might be difficult to be inserted into the jejunal lumen. Buc [27] also suggested that a high discrepancy in the size of the diameter of pancreas to the diameter of jejunum may be considered as a contraindication for BPJ; secondly sutures on to the pancreas for fixation might cause exudation of pancreatic juice into the abdominal cavity.

To solve these problems, Binding Pancreaticogastrostomy (BPG) is developed, in which the stump of pancreas is inserted into stomach and held in place with only two purse-string sutures which do not penetrate the pancreas. The two purse-string sutures are, respectively, called outer or sero-muscular purse-string suture and inner or mucosal purse-string suture. The mechanism for its effective prevention of anastomotic leak lies in the fact that the inner or

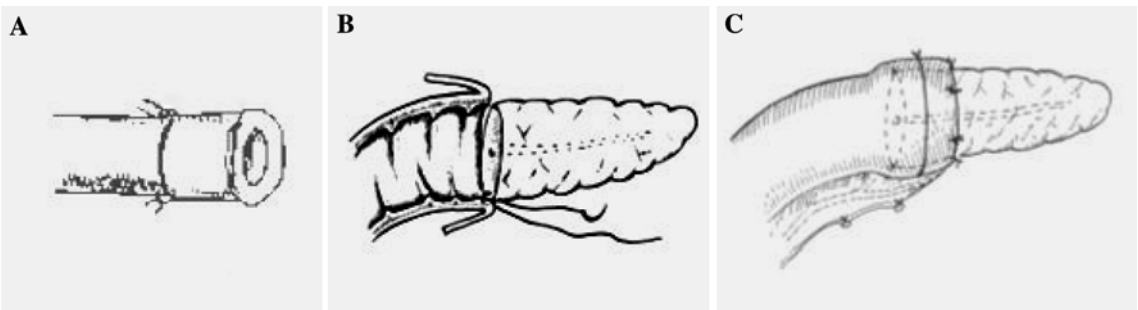

Fig. 1 **a** The everted jejunal muscoma has been destroyed. **b** Mucosa of the jejunum is sutured to the cut end of pancreas. Care is taken not to penetrate the sero-muscular layer of the jejunum. **c** The remnant of the pancreas and the covering jejunum are looped around and ligated together. A bundle of vessels is spared for an intact blood supply to the jejunum end

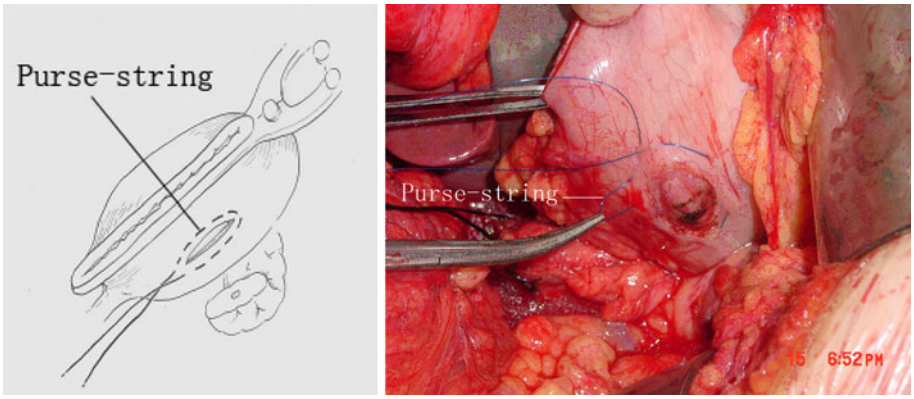

Fig. 2 A piece of seromuscular layer of the posterior gastric wall is excised around which a purse-string suture is pre-placed

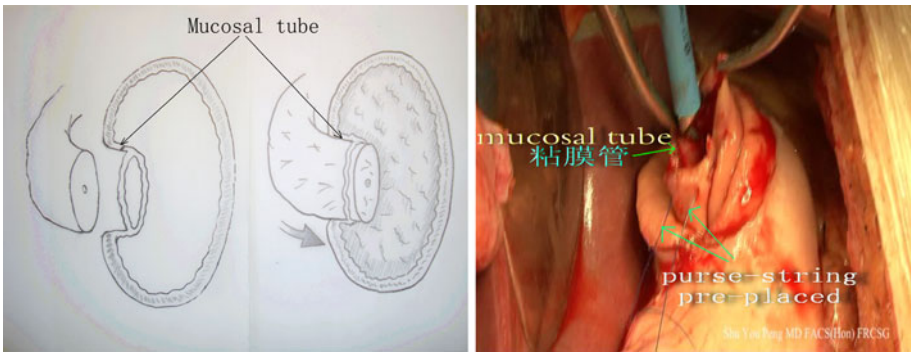

Fig. 3 In the gastric cavity, the edge of the mucosal opening at the posterior gastric wall is held up by forceps forming a mucosal tube, around which the second purse-string suture is pre-placed

mucosal purse-string suture can achieve a water-tight closure of the gap between the pancreas and the mucosal opening, while the outer or sero-muscular purse-string suture ensure the pancreas stump be closely in contact with gastric sero-muscular layer, without mucosa in between resulting in a better healing. Clinical use has proved it to be very effective, safe and even easier than BPJ to perform [29].

Four steps are included:

1. Isolation of pancreatic stump for 2 cm.
2. A piece of sero-muscular layer at the posterior gastric wall is excised, the size being equivalent and the location being opposite to the pancreas stump. Around the sero-muscular defect a purse-string suture is pre-placed A small incision is made later at the mucosa layer to accommodate pancreas stump (Fig. 2).
3. An incision is made at the anterior gastric wall. In the gastric cavity, the edge of the mucosal opening at the posterior gastric wall is held up by forceps forming a mucosal tube, around which the second purse-string suture is pre-placed (Fig. 3).
4. Binding anastomosis: After the pancreas remnant is pulled into the gastric lumen (Fig. 4). The first purse-string suture is tied (outer binding) and then the second one is also tied (inner binding). Pancreaticogastrostomy is thus easily and reliably established [30] (Fig. 5).

Results

So far, 105 cases of suture-less pancreaticogastrostomy were performed, including 97 PD cases and 8 middle pancreatectomy. All the procedures were performed successfully. No mortality. The amylase level of abdominal drain was in normal range in all cases postoperatively, except four cases, due to traumatic damage to the pancreas during dissection (Fig. 6). However, there was no PEA leakage.

Summary

Potential mechanisms of occurrence of pancreaticoenteric anastomosis leakage mainly include leakage from the needle hole and from the seam at the adjacent stitch, poor anastomotic blood supply, increased tension at the anastomosis, poor anastomotic healing, etc. BPJ is a safe and effective technique that avoids the primary complication of pancreatic anastomosis leakage. There are two problems

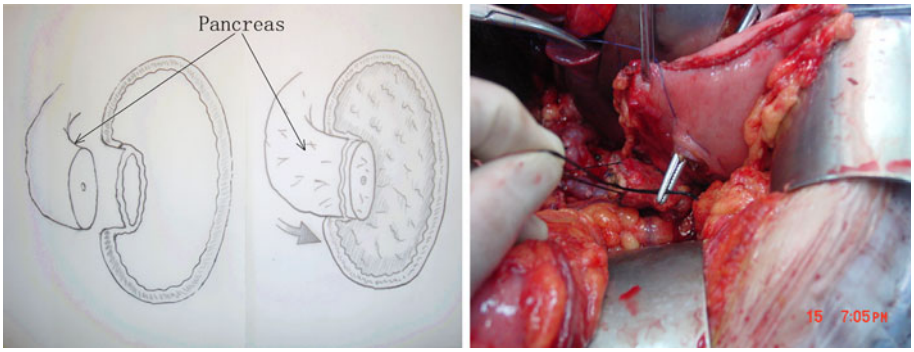

Fig. 4 The pancreas remnant is pulled into the gastric lumen through the posterior gastric wall including gastric mucosal tube

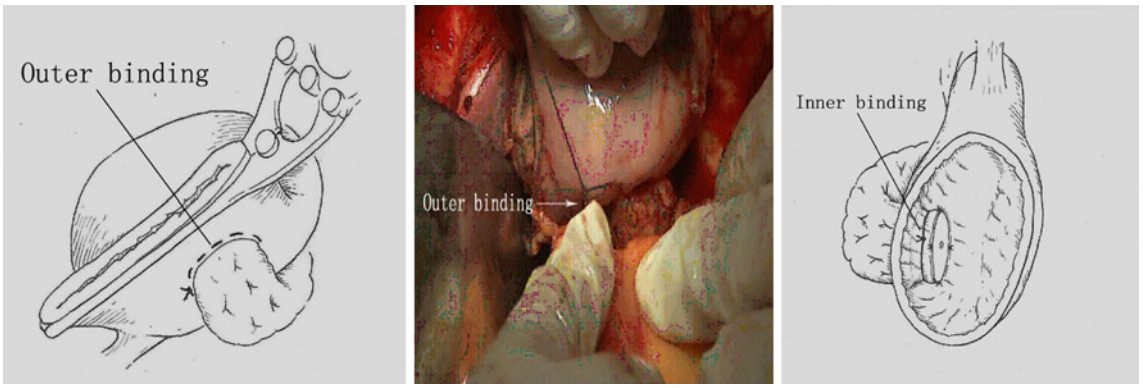

Fig. 5 The outer purse-string suture is tied (outer seromuscular binding) and then the inner purse-string suture around the gastric mucosal tube and the pancreatic stump is tied (inner mucosal binding)

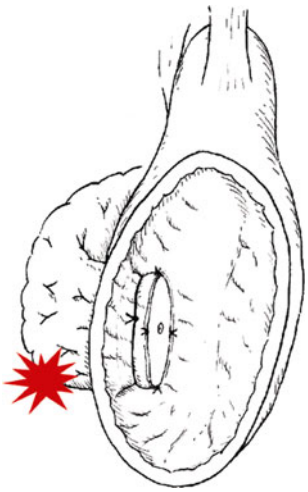

Fig. 6 Location (asterisk) where exudation of pancreatic juice might occur due to traumatic damage during dissection. However, it is outside of the anastomosis

with BPJ: a high discrepancy in the size of pancreas stump and the jejunal lumen; sutures on to the pancreas for fixation might cause exudation of pancreatic juice into the abdominal cavity. Taking these problems into account, BPG is designed and successfully performed clinically with encouraging results. Both BPJ and BPG are simple and secure technique contributing to prevent anastomotic leakage worthy of further investigation.

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