



Fish-Mouth Closure of the Pancreatic Stump and Parachuting of the Pancreatic End with Double U Trans-Pancreatic Sutures for Pancreatico-Jejunostomy

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Purpose: Leakage of pancreatico-jejunal anastomosis (PJ) remains the primary cause of morbidity and mortality after Whipple's operation. To reduce the occurrence thereof, the present author recently began to apply a modification of the Blumgart method of anastomosis after Whipple's operation (hereinafter referred to as Lee's method), with very good results.

Materials and Methods: The modified method and technique utilizes fish-mouth closure of a beveled pancreatic stump and parachuting of the pancreatic end with double U trans-pancreatic sutures (symmetric horizontal mattress-type sutures between the full thickness of the pancreas and the jejunal limb) after duct-to-mucosa pancreatico-jejunostomy.

Results: Eleven cases of pylorus preserving Whipple's operation have been performed without a clinically significant postoperative pancreatic fistula.

Conclusion: This new method (Lee's method) may dramatically reduce the occurrence of postoperative pancreatic fistula after Whipple's operation.

Key Words: Pancreatico-jejunostomy, Blumgart anastomosis, fish-mouth closure of pancreatic stump, post-operative pancreatic fistula (POPF), Whipple's operation

INTRODUCTION

Although mortality after Whipple's pancreatico-duodenectomy, including pylorus preserving pancreatico-duodenectomy (PPPD), has been reduced to less than 5%, morbidity is still high at 30-50%. The Achilles heel of this operation, pancreatico-jejunal anastomosis (PJ) remains the main cause of mor-

bidity. Leakage of PJ, with subsequent fistula, abscess formation, sepsis, or bleeding remains the most important source of morbidity and death after pancreaticoduodenectomy. Various methods have been attempted to lessen this morbidity. In 2002, Blumgart at Memorial Sloan-Kettering Cancer Center, New York devised a simple and effective method of PJ anastomosis with jejunal covering of the raw surface of the pancreas.¹ Results of this anastomosis have started to emerge recently and seem to be favorable. Before applying Blumgart's anastomosis (BA), the present author, along with many other surgeons, have performed pancreatico-jejunostomy (PJ) exclusively with a modified Cattel-Warren anastomosis. The present author has applied BA since 2016 with some favorable results, although some cases of pancreatic leaks and fistulas, especially at the anterior aspect of anastomosis, have been encountered.

The present author has recently begun to apply a modification of the BA method with very good results. To date, 11 cases applying the modified method were completed without a post-

Received: May 25, 2018 **Revised:** June 21, 2018

Accepted: July 6, 2018

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•The author has no financial conflicts of interest.

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operative pancreatic fistula with B or C ($\geq B$).² Since this is the experience of a single surgeon, comparative study with adequate numbers or randomized controlled trials would be required to determine the superiority of this anastomosis over others.

This article describes the methods and materials for the modified BA technique (hereinafter referred to as Lee's method), which was designed and applied by author since November 2017.

MATERIALS AND METHODS

From November 2017, we have performed 11 cases of pylorus preserving Whipple's operation with Lee's method (7 male and 4 female patients). The age distribution spanned 47–85 years. Among the 11 patients, there were four pancreatic head cancers, five distal common bile duct (CBD) cancers, one duodenal cancer, and one ampulla of Vater cancer.

Modified BA (Lee's method)

Mobilization of the pancreatic remnant

After the resection phase by PPPD and after the specimen is retrieved, we prepared for PJ anastomosis. For easy PJ anastomosis, the pancreatic remnant should be mobilized off the splenic vein by approximately 2–3 cm. The previously placed hemostatic sutures prior to neck transection are used to slightly elevate the gland away from the venous confluence.

Transection of the pancreas and fish-mouth closure of the stump

Two stay sutures are placed on the superior and inferior margins of the pancreatic remnant (hemostatic sutures). The pancreatic parenchyma is then transected with a sharp knife and/or electrocautery at the neck of the pancreas (Fig. 1A). After hemostasis, the pancreatic cut stump is beveled in a manner that creates a "fish-mouth" wedge shaped carving on the cut pancreatic surface using a loop electrode, except the immediate area around the main pancreatic duct (MPD), in order to bring the anterior and posterior edges together with interrupted sutures (Fig. 1B). Usually, we create the fish-mouth

shaped edge of the pancreas after we have performed conventional pancreatic parenchymal transection and hemostasis using an electrode tip (wire loop electrode made with tungsten) specially designed for carving the pancreatic stump edge (Figs. 2 and 3). When we are using the Valleylab tungsten loop electrode on electrocautery pencils, we usually set the energy level at 60 to 80 watts depending on the patient's weight: a maximum level of energy of 80 watts for cutting and 70 watts for coagulation is recommended when using the tungsten loop electrode, which is almost twice that of regular laparotomy settings. After achieving local hemostasis and before starting the PJ anastomosis, the beveled stump of the pancreatic end is closed with 4-0 Prolene vertical mattress sutures (fish-mouth approximation), except for the area around the MPD (Figs. 1C and 4). I recommend using monofilament sutures to avoid laceration of the pancreas parenchyma. To complete this phase, a jejunal single limb is moved to the cut pancreatic end via a trans-mesocolic route and is prepared for PJ anastomosis: the jejunal limb is brought in a retro-colic fashion to the right side of the middle colic vessels.

Jejunal enterotomy with a mucosa squeeze-out technique for PJ duct-to-mucosa anastomosis (Figs. 5 and 6)

Enterotomy is usually made using a "mucosa squeeze-out" technique, as originally described by Sugiyama, et al.³ This mucosa squeeze-out technique is used for placing jejunal stitches. While a surgeon grasps the jejunum around the opening, an incision equal to the pancreatic duct diameter is made on the seromuscular layer of the jejunum at the planned site of duct-to-mucosa anastomosis using electrocautery. Thus, the jejunal mucosa becomes squeezed-out. Next, a small incision is made on the tip of the squeezed-out mucosa, and the mucosa is thereby everted. The enterotomy should be placed approximately 0.5–1 cm away from the line of horizontal sutures to allow for tension-free duct-to-mucosa adaptation.

Posterior U suture (trans-pancreatic suture with U-shaped jejunal seromuscular sutures) (Fig. 7)

The PJ anastomosis is performed in two layers (inner PJ duct-

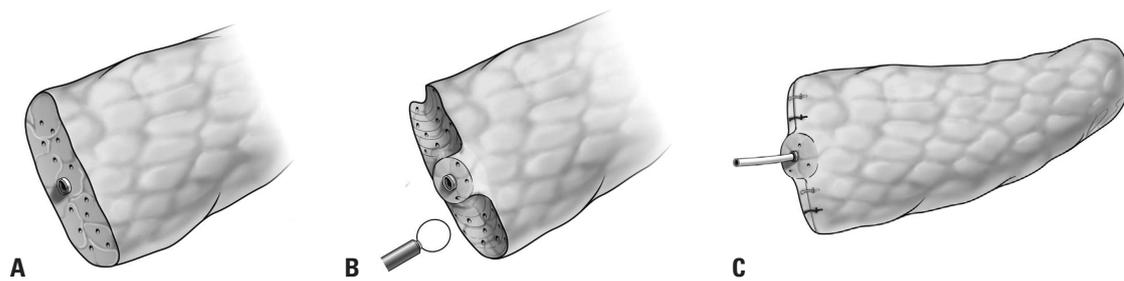


Fig. 1. Fish-mouth closure of the pancreatic stump. (A) Pancreatic stump with raw cut surface after cutting at the neck. (B) Fish-mouth wedge shaped by carving with a loop electrode. (C) The beveled edge of the pancreatic stump is closed with interrupted 4-0 Prolene vertical mattress sutures (fish-mouth approximation), except for the area around the main pancreatic duct.

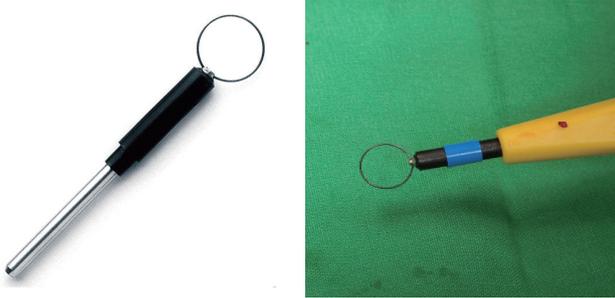


Fig. 2. Valleylab tungsten loop electrode and a loop electrode on an electro-surgical pencil.



Fig. 5. Depiction of the mucosa squeeze-out technique.

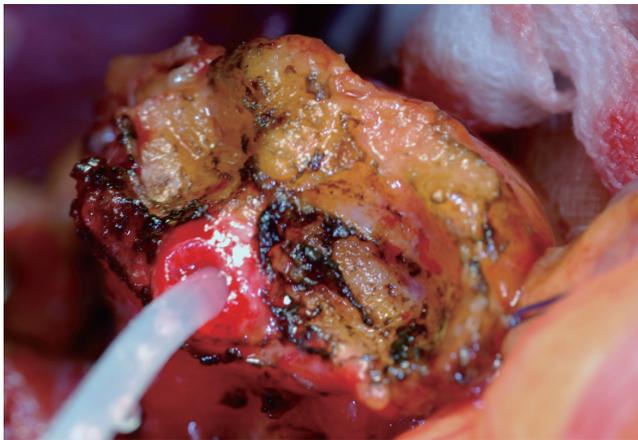


Fig. 3. Image of a beveled pancreatic stump carved with a loop electrode before fish-mouth closure.



Fig. 6. Images of the mucosa squeeze-out technique.

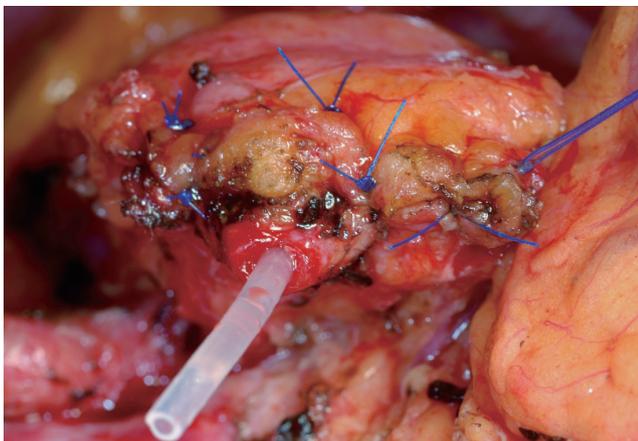


Fig. 4. Image of a pancreatic stump that has been closed in a fish-mouth fashion with a short silicone tube stent prior starting pancreatico-jejunal duct-to-mucosa anastomosis.

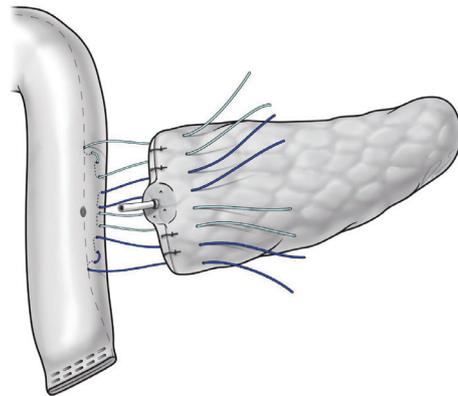


Fig. 7. Starting the pancreatico-jejunosomy using U sutures (posterior trans-pancreatic U suture) with 3-0 Prolene.

to mucosa anastomosis and outer PJ approximation for covering the pancreatic cut stump). The posterior part of the outer layer consists of trans-pancreatic horizontal mattress sutures placed through the pancreas approximately 1.5-2 cm distal from the cut transection edge of the pancreas neck. We use double-armed 3-0 Prolene sutures (monofilament polypropylene) or 3-0 PDS for this layer. It may be helpful to straighten the curved needle (ski needle) to allow for a perpendicular

path of the suture through the pancreas. It is important to start 1.5-2 cm away from the edge anteriorly and exit the gland posteriorly at the same distance away from the transection edge. After the needle is passed through the pancreas, a U-shaped horizontal seromuscular mattress stitch is placed through the jejunal limb close to the mesentery approximately 3 cm away from the stapled transected edge of the jejunum. The needle is then passed again through the pancreas, entering the posterior surface and exiting the anterior surface, again keeping 1.5-2 cm away from the cut edge (posterior U sutures-first U suture). This creates a horizontal mattress-type suture between the full thickness of the pancreas and jejunal limb (posterior trans-pancreatic U suture with seromuscular jejunal layer). In most cases, the pancreas accommodates two

or three such sutures inferior to the MPD and one or two sutures superior to the MPD (usually 3–5 sutures for whole PJ approximation). For the most superior and inferior U sutures, after making a horizontal mattress seromuscular jejunal U stitch (posterior U suture), one more vertical continuing seromuscular stitch is placed in a vertical fashion through the jejunum about 0.5–1 cm superior and inferior to the pancreatic edge, guiding the needle anteriorly by crossing the vertical line of the jejunum before the ski needle passes again through and exits the pancreas. This vertical jejunal seromuscular stitch serves to wrap the jejunum around the superior and inferior edge of the pancreas.

The posterior U sutures are not tightened before PJ duct-to-mucosa anastomosis (differing from the original BA). Instead, the posterior U sutures are towed for approximation of the pancreas and jejunum, conferring great help in avoiding MPD lacerations.

Duct-to-mucosa pancreatico-jejunostomy (second inner layer of PJ)

Once this initial layer (posterior U suture; posterior part of the first outer layer) is complete, our attention is turned toward anastomosis of the PJ duct-to-mucosa inner layer (second inner layer of PJ). While towing the penetrating posterior U sutures, the MPD is approximated to a small full-thickness enterotomy in the jejunum with 5-0 Prolene and/or 5-0 PDS sutures. Normally, depending on the size of the MPD, four to eight sutures are placed to fully approximate the MPD to the jejunum: two at each corner at 3, 9 o'clock and one to three placed anteriorly and posteriorly, with the upper corner defined as 12 o'clock.

The MPD with a small amount of pancreatic parenchyma is anastomosed to the full thickness of the jejunum using interrupted 5-0 Prolene or PDS sutures. Once the posterior inner layer of PJ duct-to-mucosa sutures are complete and tied down (before corner stitches are tied down), one to three anterior sutures can be placed through the jejunum and tied from the corner stitch to complete the anterior inner layer of PJ duct-to-mucosa anastomosis.

Stent into the pancreatic duct

If the MPD diameter is less than 4 mm, we usually insert a short silicon tube catheter through the anastomosis into the MPD and jejunum. We usually use a short silicon tube catheter stent (5–10 cm), depending on the diameter of the MPD. The short silicone tube is fixed with a pre-tied posterior suture at 6 o'clock using 5-0 absorbable PDS sutures.

Anterior U suture (completion of symmetric double U suture) (Fig. 8)

After completion of duct-to-mucosa PJ anastomosis, we start the anterior PJ approximation using the same previously un-tightened 3-0 Prolene posterior U sutures in the same manner

of the horizontal seromuscular mattress suture (anterior U suture-second U suture). This is performed far enough away from the pancreas to allow the jejunum to fold over the anterior surface of the pancreas (completion of the first layer of PJ anastomosis). For symmetric U sutures, we use the same technique as that for the most superior and inferior sutures before making jejunal horizontal mattress U stitches at the anterior part of the jejunum. One vertical continuing seromuscular stitch is placed in a vertical fashion through the jejunum about 0.5–1 cm superior and inferior to the pancreatic edge, guiding the needle anteriorly by crossing the vertical line of the jejunum (symmetry between anterior and posterior U sutures). This vertical stitch serves to wrap the jejunum around the superior and inferior edges of the pancreas.

Parachuting the pancreas with double U sutures (horse saddle shape approximation of the jejunum over the fish-mouth closed pancreatic stump)

After making double U sutures of symmetric horizontal mattress-type suture between the full thickness of the pancreas and the jejunal limb, the sutures are tightened to approximate the gland and the jejunum by parachuting (horse-saddle shape) with tension evenly distributed across four suture sites

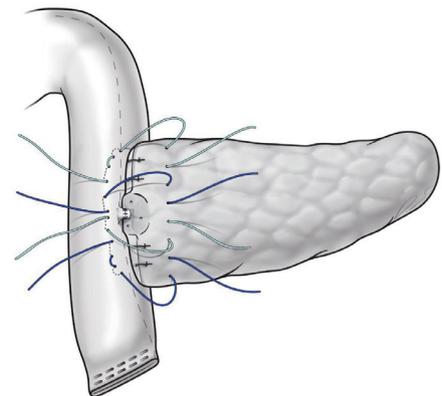


Fig. 8. Anterior U suture after duct-to-mucosa pancreatico-jejunostomy.

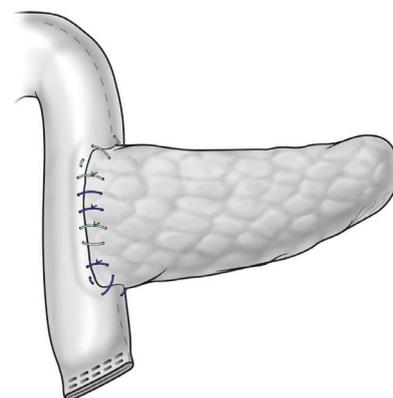


Fig. 9. Pancreatico-jejunostomy after the double U sutures are tightened at a final step to approximate the gland and the jejunum by parachuting (horse saddle shape) with tension evenly distributed across four suture sites.

(8 needle points/12 needle points at the superior and lower pancreatic edges) by tightening the 3-0 Prolene sutures all together with the posterior and anterior symmetric U sutures of the horse saddle shape (Fig. 9).

Hepatico-jejunostomy is then performed with posterior continuous and anterior interrupted absorbable sutures, and duodeno-jejunostomy is performed by an ante-colic route, approximately 40 cm distal to the hepatico-jejunostomy with the same jejunal limb.

We usually insert a transient silicon tube (silicone L tube) with a Witzel style gastrostomy through the skin and anterior wall of the stomach for treatment of delayed gastric emptying. In all cases, two Jackson Pratt drains were placed to lie above and below the completed PJ.

RESULTS

Since November 2017, we have performed 11 cases of pylorus preserving Whipple’s operation with Lee’s method. The diameter of the MPD ranged from 2–5 mm, and nine of the 11 cases had a soft pancreas. Postoperatively, no clinically significant postoperative pancreatic fistula with B or C ($\geq B$) has been recorded. Nine of the 11 cases had no postoperative pancreatic leakage: two experienced biochemical leak (BL) according to the new classification system of the international study group and grading of postoperative pancreatic fistula.² We have been able to remove the peripancreatic drain on about postoperative day 7, and only one case had drains for 12 days due to postoperative pancreatic fistula of BL without significant clinical problems. Among the 11 patients, minor complications (1 transient bile leak, 1 pleural effusion, 2 fevers, 1 transient delayer gastric emptying) were treated with ease. No postoperative mortality has occurred. The mean and standard deviation and means of the fifth, sixth, and seventh case’s values of amylase/lipase at postoperative days 3, 5, and 7 are shown in Table 1: because of one case of high levels of amylase/lipase in drain fluid, the mean was a little high.

DISCUSSION

BA is a simple and effective method of PJ anastomosis with a jejunal covering of the raw surface of the pancreatic cut

stump. In the original BA, prior to completion of PJ duct-to-mucosa anastomosis, trans-pancreatic 3-0 PDS horizontal mattress sutures are tightened to allow the jejunum to slide under the posterior aspect of the pancreas. After ductal anastomosis is complete, the previously placed and tightened 3-0 PDS sutures are used to complete the anterior row of anastomosis. In 2009, Grobmyer, et al.⁴ proposed modification to the original BA method, primarily to anterior closure of PJ approximation. The present author has applied both the original and modified BA since 2016 with some favorable results; however, some cases of pancreatic leakage and fistula, especially at the anterior aspect of anastomosis, have been encountered. Even though BA is an easy and simple method, I feel that the jejunal serosa covering the raw surface of the pancreatic cut stump is insufficient to protect against pancreatic leakage from the minor pancreatic ducts at the pancreatic cut surface, especially with the original BA method. Moreover, the uneven distribution of tension between the posterior and anterior U sutures introduces problems of pancreatic injury and uneven coverage of jejunal serosa to the cut pancreatic surface.

Previously, I had the opportunity to perform a re-do operation after PPPD (completion total pancreatectomy due to pancreatic body cancer 6 years after PPPD and PJ anastomosis with a conventional method during a Cattel-Warren PJ procedure due to an intraductal papillary mucinous tumor of the pancreatic head). In doing so, I discovered that the pancreatic stump was not adhered to the serosal surface of the jejunum (Fig. 10). Only the pancreatic duct was connected to the bowel, and the stump of the pancreas had healed after primary closure of the pancreatic stump (Fig. 10). Accordingly, I have deduced that approximation between the pancreas and jejunum or stomach has only a transient covering effect at an early stage of wound healing after an approximation or dunking.

Lee’s method improves upon the BA technique in two ways. 1) To protect against minor pancreatic leakage at the cut pancreatic surface after PJ, I have sought to close the end of the pancreatic stump with fish-mouth closure, except for the area of the MPD, and cover the closed pancreatic end with a jejunal covering instead of the raw surface of cut pancreatic surface. The difference between Blumgart’s and Lee’s method for PJ is that the minor pancreatic ducts are exposed and covered by a jejunal serosal patch with Blumgart’s method; however,

Table 1. Serum Amylase and Lipase Values after Operation

	Serum amylase (U/L)			Serum lipase (U/L)		
	POD #3	POD #5	POD #7	POD #3	POD #5	POD #7
Mean	1227	7744	45	1402	1012	106
Standard deviation	2061	1900	29	1921	1073	98
Mean of 5th, 6th & 7th cases	692	97	41.5	678	287	95

POD, postoperative days.

Reference value: amylase, 30–115; lipase 5.0–60.0.

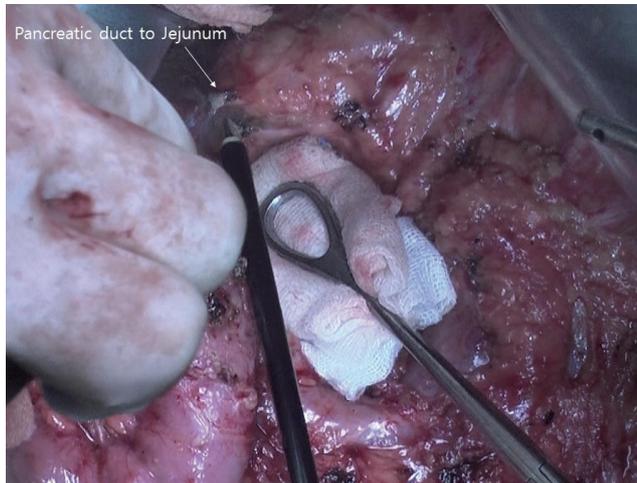


Fig. 10. Image showing that only the pancreatic duct is connected to the jejunum and that the stump of the pancreas has not adhered to the serosa of the jejunum.

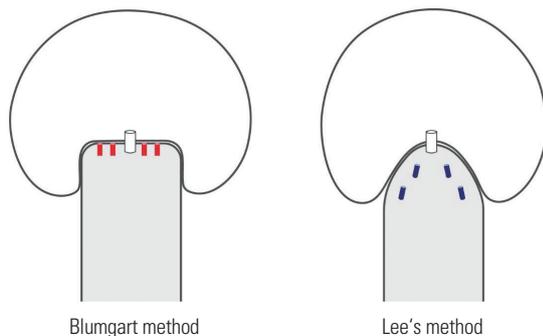


Fig. 11. Difference between the Blumgart and Lee's method of pancreatico-jejunostomy after U suture. Minor pancreatic ducts are exposed and covered by a jejunal serosal patch with BA. With Lee's method, the minor ducts are closed with a fish-mouth closure and covered by a jejunal serosal patch.

with Lee's method, the minor ducts are closed with a fish-mouth closure method and covered by a jejunal serosal patch (Fig. 11). 2) I have modified the original U suture to a symmetric double U suture for even tension between the pancreas and jejunum by knot-tying at the final step of PJ approximation instead of knot-tying the posterior U suture before starting the inner PJ duct-to-mucosa anastomosis.

Blumgart usually does not recommend a pancreatic stent for PJ anastomosis, except for a very small pancreatic duct. Compared to Western patients, however, the majority of whom present with pancreatic ductal adenocarcinoma, we encounter many patients with distal CBD cancer or ampulla of Vater cancer with soft pancreases and small pancreatic duct sizes. Therein, PJ duct-to-mucosa anastomosis without stenting can present some difficulty.

Summary of the author's modifications to Blumgart's method

The first modification is that we usually use short, silicone

tube catheter stents (5–10 cm, depending on pancreatic duct size) for PJ duct-to-mucosa anastomosis in cases with a MPD diameter less than 4 mm, and we try to decrease the number of sutures for PJ duct-to-mucosa anastomosis. We intend to develop a method of PJ anastomosis without suturing using a specially designed stent in the near future. The second modification is that we cut the pancreatic stump to a fish-mouth shape using a tungsten loop electrode, and the beveled stump of the pancreatic end are closed with 4-0 Prolene vertical mattress sutures (fish-mouth approximation), except the area of the MPD. The third modification is that we do not tighten the 3-0 Prolene posterior sutures before PJ duct-to-mucosa anastomosis. After duct-to-mucosa anastomosis has been completed, the untightened 3-0 Prolene sutures are used in a horizontal mattress fashion (second anterior U suture) far enough away from the pancreas to allow the jejunum to fold over the anterior surface of the pancreas. After the last anterior suture is placed, mirroring the posterior suture (symmetric double U suture), the 3-0 Prolene sutures are tightened and the anastomosis is completed. Combining the second and third modifications provides a beautiful PJ without tension differences along the four suture sites (8 needle stitches) of double U sutures. I wish to call this technique as “parachuting the pancreatic end with double U sutures (symmetric horizontal mattress-type suture between the full thickness of the pancreas and the jejunal limb) after fish-mouth closure of the pancreatic stump or “horse-saddle” shape approximation of the jejunum over the pancreas using symmetric double U sutures.

If performed correctly, the seromuscular edge of the jejunum should roll over onto the pancreatic capsules on the anterior and posterior surfaces.

In conclusion, the present author has recently begun to apply a modified version of the Blumgart method of anastomosis after Whipple's operation, with very good results. The modified method and technique utilizes fish-mouth closure of a beveled pancreatic stump and parachuting of the pancreatic end with double U trans-pancreatic sutures (symmetric horizontal mattress-type sutures between the full thickness of the pancreas and the jejunal limb) after duct-to-mucosa pancreatico-jejunostomy. Eleven cases of pylorus preserving Whipple's operation have been performed without a clinically significant postoperative pancreatic fistula. This new method may dramatically reduce the occurrence of postoperative pancreatic fistula after Whipple's operation.

ACKNOWLEDGEMENTS

The author would like to thank Dong-Su Jang, MFA (Medical Illustrator, Medical Research Support Section, Yonsei University College of Medicine, Seoul, Korea) for his help with the illustrations.

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