



Managing complex pancreatic anastomoses after minimally invasive pancreaticoduodenectomy

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Abstract: The process of creating a pancreatic anastomosis (PA) is a pivotal and challenging part of the reconstruction phase following minimally invasive pancreaticoduodenectomy (PD). This particular step is notably associated with the potential development of postoperative pancreatic fistula, a complication that is more common when dealing with high-risk pancreatic stumps. Currently, there is still lack of consensus on what constitutes the safest method for PA. The best approach might vary depending on the unique intra-operative findings and the surgeons' individual experience. In our study, we delve into the key challenges and the most relevant features to be considered when choosing the appropriate type of PA. We pay particular attention to complex cases, such as those involving bulky-fatty pancreases or non-visible Wirsung duct, as well as patients with a significant burden of comorbidities. We discuss the primary considerations necessary in these scenarios and suggest ways to overcome their associated challenges, by tailoring known techniques to suit each unique case. While our recommendations are also relevant for open surgery, we emphasize the minimally invasive approach in this study. Our goal is to encourage surgeons to strongly consider the later approach, even in situations that present high levels of complexity and require technical precision. To aid in understanding, we provide specific multimedia educational material to highlight relevant findings and demonstrate the methods we propose. This additional support is designed to enhance the learning experience and offer practical guidance for surgeons.

Keywords: Mini-invasive pancreaticoduodenectomy (MIPD); pancreatic anastomosis (PA); pancreaticogastrostomy (PG); total pancreatectomy; fatty pancreas

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Introduction

Several pancreatic anastomoses (PAs) types have been described after mini-invasive pancreaticoduodenectomy (MIPD). These seek to reduce the incidence of post operative pancreatic fistula (POPF) (1-5). In most cases, the choice of the PA is mainly driven by the surgeon's experience and habits. However, in some situations, the selection of the PA should be driven either by the type of pancreatic stump or by the high comorbidity of the patient.

The main features of the pancreatic stump contributing to complex PAs include the presence of a bulky-fatty pancreatic stump, the absence of a visible main pancreatic duct on the pancreatic surface, presence of ongoing acute pancreatitis of the pancreatic stump, or in POPF cases requiring reintervention where an anastomosis could be considered. All these situations require a case-by-case analysis of the surgical strategy.

In the following sections, we describe strategies to be adopted to deal with such complex PAs after MIPD,

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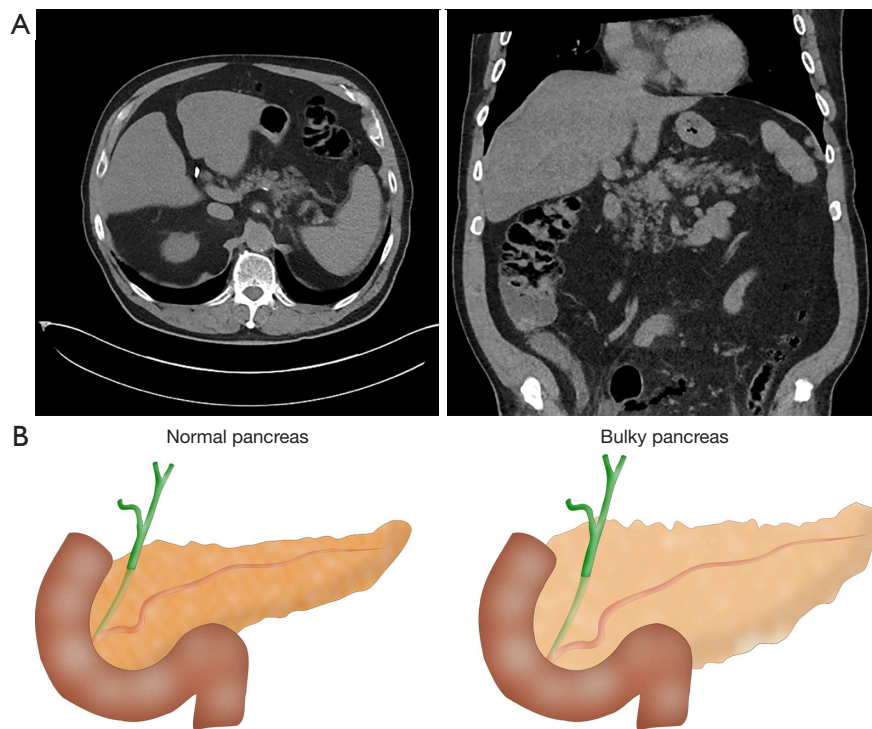
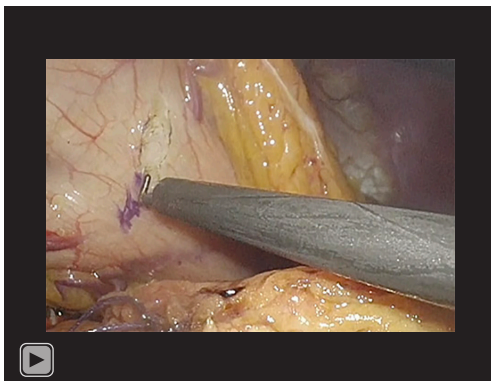


Figure 1 Radiologic and anatomic traits of a fatty-bulky pancreas. (A) CT scan showing a fatty pancreas (axial and coronal view); (B) a sketch to demonstrate a normal size pancreas and a bulky pancreas. CT, computed tomography.



Video 1 Bulky pancreas, pancreaticogastrostomy.

focusing on both pancreatic stump complexity and/or associated comorbidities.

Managing PAs with complex pancreatic remnant

Fatty-bulky pancreas

Obesity and an increasingly aged population are the main factors associated with the presence of the fatty pancreas

(6-8), which increases the risk of POPE. The amount of fatty tissue in the pancreatic remnant can be evaluated preoperatively by magnetic resonance imaging (MRI) or computed tomography (CT) scan (9,10) (*Figure 1A*).

A fatty pancreas is frequently associated with a bulky pancreatic stump. In such cases, the diameter of the pancreatic stump exceeds the height of the small bowel, which precludes performing some of the most common pancreaticojejunostomies (PJ), such as Blumgart, Peng, etc. (*Figure 1B*). Pancreaticogastrostomy (PG) is an alternative to PJ for fatty-bulky pancreas.

In *Video 1* we show a case of fatty-bulky pancreas. In the video we also describe a few technical details pivotal to achieving a safe PG: (I) the mobilization of the pancreatic stump from both the splenic vein and artery should be enough to avoid the so called “Pisa Tower Effect”: when the angle between the pancreatic surface and splenic vessels is smaller than 90 degrees, case in which the PG anastomosis is subject to excessively imbalanced tensions; (II) the incision on the posterior wall of the stomach should be of the same length of the stump to facilitate the intussusception; (III) a purse-string technique should be adopted avoiding stitches which can easily tear the

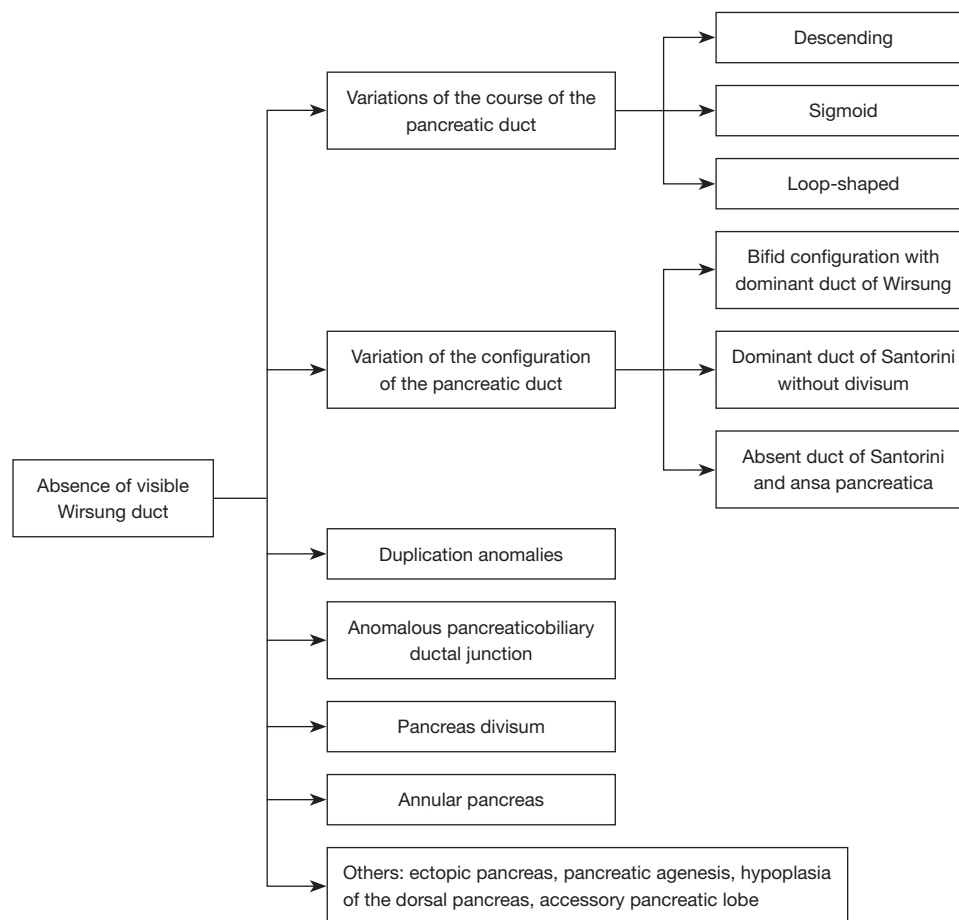


Figure 2 Main anatomic variations and developmental anomalies of the pancreas and pancreatic duct.

pancreatic stump, as shown in the video.

No visible main pancreatic duct

Anatomical variations and developmental anomalies of the pancreas and pancreatic duct can lead to differences in the duct's course despite most of these variations do not cause symptoms (11-13) (*Figure 2*).

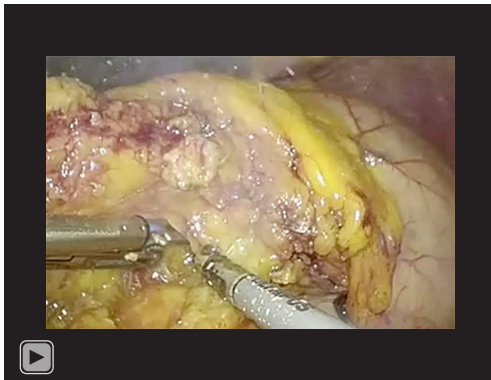
Pancreaticoduodenectomies (PDs) are sometimes performed for benign or border-line tumors such as endocrine or ampullary tumors. In these cases, the main pancreatic duct may be thin and sometimes not visible on the remaining pancreatic stump. In rare instances, the duct could be absent or duplicated (11-13). In all these situations, a duct-to-mucosa PJ (classical or modified Blumgart) cannot be performed, requiring the surgeon to consider alternatives like dunking PJ (1) or PG. Both of these techniques involve the invagination of a portion of the remaining pancreas into

the small intestine or stomach, eliminating the need for a formal anastomosis on the Wirsung duct.

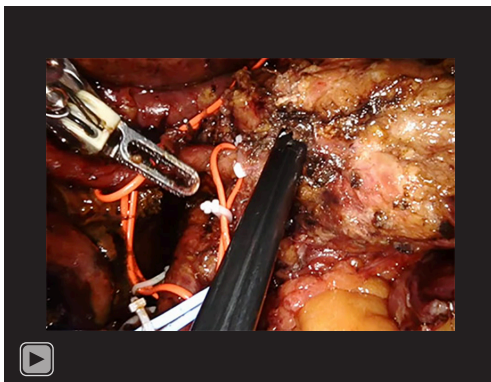
Acute pancreatitis of pancreatic stump

Acute pancreatitis has been reported as an intraoperative finding during PD. In some cases, after completing the resection phase of PD, an inspection of the remaining pancreas and nearby tissues reveals areas of steatonecrosis and/or noticeable swelling and inflammation, especially in those cases where several preoperative attempts of endoscopic retrograde cholangiopancreatography have been performed.

There is no definitive evidence-based guidance on whether to perform a PA or a total or near total pancreatectomy in such critical and uncommon challenging situations. It is important, however, to weigh the consequences of such an aggressive treatment, including severe comorbidities such as brittle diabetes. The decision should be based on



Video 2 Pancreatitis of pancreatic stump, total pancreatectomy.



Video 3 High risk of postoperative pancreatic fistula, total pancreatectomy.

the surgeon's experience and evaluated on a case-by-case basis. The second video herein presented (*Video 2*) shows a patient with a bulky and fatty pancreas stump with signs of acute pancreatitis on the stump. In this case, a total pancreatectomy was finally performed.

Nowadays it is still under debate whether total pancreatectomy is superior to PA. However, in our experience and opinion, in such challenging cases total pancreatectomy represents an effective alternative, decreasing the early post operative morbidity-mortality.

Failure of previously performed PA

A failure of a previous PA can happen in two different situations: (I) during re-operation, due to severe POPF or postoperative bleeding associated with it; or (II) during surgery when the PA looks clearly not safe and effective.

First, in the case of reoperation, rarely a re-anastomosis

is feasible (12-23). In most cases, a total or sub-total pancreatectomy is the preferred strategy. In the case of intra-operative failure of PA, the options are: (I) re-cutting the edge of the pancreatic stump and, after further mobilization from the splenic vessels, re-do the PA; (II) near total pancreatectomy or total pancreatectomy.

Recently, Ielpo *et al.* (17) have shown encouraging results with radiofrequency ablation of the main pancreatic duct in case of failure of PA, in both scenarios, during surgery or during reoperation. The latter approach has the potential to become a good alternative to pancreatic totalization in the complex cases discussed here as they seem to preserve the islets of Langerhans, and consequently the endocrine function.

Managing high-morbidity patients

Grade C POPF remains the primary cause of severe postoperative complications after PD, with mortality related mainly to the “failure to rescue” concept. This idea emphasizes that timely and effective treatment of postoperative complications can prevent death. Moreover, the development of Grade C POPF in patients with high comorbidity (e.g., obesity, cardiopathy, sarcopenia) increases the risk of postoperative death. Various scoring systems can predict POPF occurrence aiming to identify high-risk cases (15,16). If a high risk for POPF is found in a patient with high comorbidity, the surgeon should consider performing a total pancreatectomy (18,19).

Once again, there are two possible scenarios: (I) the decision to perform a total pancreatectomy is made preoperatively; or (II) the decision is made intraoperatively after evaluating the quality of the pancreatic stump, bleeding, and the challenges encountered during the procedure. In the first scenario, a total spleen-preserving pancreatectomy may be recommended, while in the second scenario, a classical total pancreatectomy seems more appropriate as shown in the last video (*Video 3*).

Finally, early experimental results using preoperative endoluminal radiofrequency ablation in animal models indicate a reduction in POPF preserving the endocrine function (24). Thus again, endoluminal radiofrequency ablation bears great promise as a complementary tool in these complex cases.

Conclusions

Pancreatic surgeons often encounter complicated situations

Table 1 Summary of cases & findings and the corresponding suggested approaches discussed in this article

Intraoperative findings	Suggested approach
Fatty-bulky pancreas	Pancreaticogastrostomy
No visible main pancreatic duct	Dunking pancreaticojejunostomy
	Pancreaticogastrostomy
Acute pancreatitis of pancreatic remnant	Total pancreatectomy
Failure of previously performed pancreatic anastomosis	Re-do the pancreatic anastomosis
	Near total pancreatectomy
	Total pancreatectomy
	Radiofrequency ablation of the main pancreatic duct
High-morbidity patients/high-risk for POPF	Total pancreatectomy with/without splenic preservation
	Radiofrequency ablation of the main pancreatic duct

POPF, post operative pancreatic fistula.

during PAs that require unconventional approaches. This article presents various alternative strategies (summarized in *Table 1*) that can help handle the most challenging cases providing multimedia support illustrating such strategies in detail.

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committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for publication of this article and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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