Title

Laparoscopic-adapted Blumgart pancreaticojejunostomy in laparoscopic pancreaticoduodenectomy

Short running head

Laparoscopic Blumgart pancreaticojejunostomy

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**ABSTRACT**

**Background**: Laparoscopic pancreaticoduodenectomy (LPD) is a complex procedure that is becoming increasingly popular among surgeons. Postoperative pancreatic fistula (POPF) remains the most feared specific complication in reconstruction after PD. The Blumgart anastomosis (BA) has been established as one of the safest anastomosis for pancreas remnant reconstruction, with low rates of POPF and postoperative complications. The procedure for performing this anastomosis by laparoscopic approach has not been reported to date. **Methods**: We describe our technique of LPD with laparoscopic-adapted BA (LapBA) and present the results obtained. A case-match analysis with open cases of BA is also reported. **Results**: Since February 2013 to February 2016, thirteen patients were operated of LapBA. An equivalent cohort of open PD patients was obtained matching by age, sex, ASA, pancreas consistency and main pancreatic duct diameter. Severe complications (grades III-IV) and length of stay were significantly lesser in LapBA group. No differences in POPF, readmission, reoperation rate and mortality were detected.

**Conclusions**: The LapBA technique we propose can facilitate the pancreatic reconstruction after LPD. In this case-match study, LPD shows superior results than open PD in terms of less severe postoperative complications and shorter length of stay. Randomized control trials are required to confirm these results.

**Key words**: Laparoscopic pancreaticoduodenectomy; Pancreaticoduodenectomy; Blumgart pancreaticojejunostomy; Blumgart anastomosis; Pancreatic fistula

**Lexicon of abbreviations**

PD: pancreaticoduodenectomy

OPD: open pancreaticoduodenectomy

LPD: laparoscopic pancreaticoduodenectomy

OBA: open Blumgart anastomosis

LBA: laparoscopic-adapted Blumgart anastomosis

PG: pancreaticogastrostomy

PJ: pancreaticojejunostomy

POPF: postoperative pancreatic fistula

DTM: duct-to-mucosa

## INTRODUCTION

Although some controversy surrounds the real advantages of the laparoscopic approach in pancreaticoduodenectomy (PD) [1-5], laparoscopic PD (LPD) has become increasingly popular among surgeons in the last decade [6-9], with year-on-year increases in its use of around 50% in USA [7]. Postoperative

pancreatic fistula (POPF) remains the main concern related to PD, both in open and in laparoscopic surgery, with rates ranging from 10% to 50% [1, 10-15] and 3%-8% related mortality [4, 6-7], depending on the series. What is the best technique for performing the pancreatic anastomosis after PD is still a matter of debate [14, 16-18]. Although some meta-analyses suggest that pancreaticogastrostomy (PG) has lower rates of clinically relevant POPF than pancreaticojejunostomy (PJ) (10, 19), the latter remains the most frequently performed anastomosis after PD at most high-volume centers worldwide [13, 20-22].

A new duct-to-mucosa PJ was described by Blumgart et al. in 2000 (Blumgart Anastomosis - BA), and proposed as an alternative to the classical Cattell-Warren technique [23]. Subsequent studies by other authors have confirmed that BA and its variants reduce the rate and severity of POPF [24-27].

The aim of our study is to describe our adaptation of the BA to the LPD, and to compare the results obtained with this technique and those obtained with open surgery by a case-matched analysis.

## METHODS

### Patients

In February 2010 we adopted the BA to our current practice and consider it as the technique of choice for pancreatic reconstruction after PD. After consolidating the BA in open PD (OBA) with 25 cases, in February 2013 we adapted this technique to the laparoscopic approach and made our first

reconstruction with a laparoscopic-adapted Blumgart anastomosis (LBA). Since then, we have performed 61 PD undergoing reconstruction with BA: 41 open, 13 laparoscopic and 7 converted. Selection of the patients for laparoscopic approach was done in the setting of an ongoing randomized controlled trial comparing open vs laparoscopic PD (*PADULAP* trial, CCT-NAPN-23575). We consider conversion from laparoscopic to open surgery as the use of any incision made to perform the pancreatic anastomosis, regardless of the length of the incision, and even if the resection was performed entirely by laparoscopy. Because the study is focused only in the pancreatic anastomosis, for the analysis of the results, patients treated by laparotomy or assisted incision were classified in the open surgery group. Informed consent was obtained from all patients. For the definition of postoperative complications (POPF, delayed gastric emptying, post-pancreatectomy hemorrhage) the ISGPF classification was applied [28-30], considering POPF grades B and C as clinically relevant. For the grading postoperative complications, the De Oliveira-Clavien classification was used [31]. All patients were operated by two surgeons from the same team following the same criteria and using the same anastomosis technique, although all laparoscopic procedures were performed by a single surgeon. The choice of pancreatic anastomosis performed (PG, PJ or sealing the stump) was decided after resection at the discretion of the main surgeon. The pancreatic duct was considered narrow if it measured ≤ 3 mm. As regards consistency, the pancreas was considered either firm/hard or normal/soft.

**Surgical technique**

LPD is performed with the patient in supine, with the legs apart and in a slight anti-Trendelenburg position. The surgeon stands between the patient's legs with an assistant on either side. The scrub nurse stands to the right of the surgeon. Five trocars are used to perform the resection (Fig. 1): three 12 mm trocars (umbilical, right and left upper quadrants) to introduce a 30º telescope (0º endo-eye 3D Olympus, in the last 5 cases) and staplers; and two 5 mm trocars in the right and left flanks. Once the resection is complete, a transverse suprapubic 5 cm incision is made for removal of the specimen and intraoperative study of the margins. Once this incision is closed, the digestive tract is reconstructed laparoscopically in a single loop Child manner. For PJ, the jejunal loop is ascended through behind the mesentery.

**Fig. 1**. Placement of the trocars for LPD. An additional epigastric 5 mm trocar is used for performing the LBA and to externalize the transpancreatic stitches.

To perform a LBA, an additional 5 mm trocar is inserted in the epigastrium, just in front of the planned PJ (Fig. 1). Through this trocar, the 2-needle polypropylene 2-0 MH 36mm 1/2 c 90 cm transpancreatic stitches are externalized (Fig. 2). Two transpancreatic stitches are performed, one on either side of the pancreatic duct, taking minimum 1 cm in width of the pancreas. If the pancreas remnant is wide or if the pancreatic duct is not centered, additional stitches may be needed on one or both sides. The pancreatic stump is mobilized at least 3 cm from the section margin of the pancreas. First, a double needle stitch is passed through the jejunal loop and is then crossed over the

pancreas, at a distance of at least 1 cm from the section margin of the neck of the pancreas without crossing the pancreatic duct (in case of doubt, a stent can be inserted). Once the pancreas is crossed, the suture thread is externalized with its needle (uncut) via the trocar placed in the epigastrium (Fig. 2). The same maneuver is performed with the other side of the double needle stitch, once again first crossing the jejunal loop (at a distance of at least 1 cm from the previous stitch) and then the pancreas, parallel to the anterior, so that both ends are externalized together through the trocar (Fig. 2 and 3). Same maneuver is repeated with the subsequent transpancreatic stitches, starting at the lower border of the pancreas and moving towards the upper border. Once these stitches are made, traction is applied on all of them from the outside to allow the jejunal loop to fit in behind the posterior face of the pancreas (Fig. 5A). When the pancreatic stump is attached to the jejunal loop, the orifice in the jejunum for the duct-to-mucosa (DTM) is made just in front of the pancreatic duct. After creating this orifice, the traction on the externalized sutures is relaxed so that the jejunum and pancreas separate once more (Fig. 5B). This maneuver has the advantage over the classical technique that the jejunum and pancreas are not yet sutured by their posterior face; this facilitates the creation of the posterior face of the DTM. The DTM anastomosis is made with 5-0 polyglactin TF Plus 13mm ½ c (coated violet Vicryl, Ethicon). Interrupted stitches of the posterior face are made and tied after all have been passed (Fig. 5B). The traction of the externalized transpancreatic stitches allows the reinsertion of the jejunal loop in the posterior face of the pancreas, and the stitches of the posterior face of the DTM are then tied without tension (Fig. 5C). A lost stent is usually placed into the pancreatic duct. Latter, the stitches of the anterior face of

the DTM are performed in the same manner. The cranial stitch of the DTM, which often presents technical difficulties because of its location, can be performed straightforwardly by introducing the needle holder through the epigastric trocar via which the transpancreatic threads are externalized. Once the DTM anastomosis is completed (Fig. 5D), the externalized threads are reintroduced one by one, and the jejunum is again crossed on its anterior face (Fig. 5E). When all the needles have been passed and cut, the stitches are tied on the jejunum, leaving the neck of the pancreas sandwiched into the jejunum (Fig. 3, 4 and 5F).

**Fig. 2**. Two 2-needle transpancreatic stitches, one on either side of the pancreatic duct, are externalized through the trocar inserted in the epigastrium.

**Fig. 3**. Once the duct-to-mucosa anastomosis is completed and the externalized threads reintroduced in the abdominal cavity, the jejunum is again crossed on its anterior face by the 2-needle stitches.

**Fig. 4**. When all the needles have been passed and cut, the stitches are tied on the jejunum, leaving the neck of the pancreas sandwiched into the jejunum.

**Fig. 5A-D**. Main pancreatic duct (yellow arrow). Consecutive steps of the LBA (5A-D)

**Fig. 5E-F**. Stitches reinserted into the abdominal cavity and crossing the anterior face of the jejunal limb (5E). Final result of the LBA (5F).

After completing the PJ, the biliary and duodenal (or gastric) reconstructions are sequentially performed. Systematically, two low pressure closed suction drains are inserted, one on the right that serves the anterior face of the hepatico-jejunostomy and the upper border of the PJ, which is externalized via the 5 mm trocar in the right flank; and the other on the left in the posterior face of the pancreatic anastomosis and in front of the porto-mesenteric vessels, which is externalized through the 5 mm trocar in the left flank.

**Postoperative management**

Antibiotic prophylaxis comprises intravenous administration of 2 g Amoxicillin-Clavulanic at the time of anesthesia induction, with a 1 g booster four hours after the skin incision. Patients carrying a biliary stent receive Imipenem (1 g/8h/iv) for five days. The only setting in which somatostatin analogs are used is for treatment of POPF with an output of more than 100 cc/day, not as a prophylaxis. The nasogastric tube is removed in the first 48 hours after PD if possible. If on postoperative day 3 it has not been possible to remove the tube, or if it needs to be re-introduced, total parenteral nutrition is initiated. The drains are kept in place for at least three days and are removed when they are not productive. If they remain productive after day 3, amylases of the drain are determined for diagnosis of POPF.

**Study design**

Comparison between all 47 patients operated by OBA and 13 LBA has been initially done. Posteriorly, it has been done a case-matched analysis between 13 LBA and 13 correlative OBA. OBA patients were matched according to age, sex, BMI, pancreas consistency and size of the pancreatic duct. For statistical analysis was used the SPSS 17 software package. Non-parametric Mann-Whitney U and Fisher's Exact tests were used for analyzing quantitative and qualitative variables.

## RESULTS

Between February 2010 and February 2016 we performed a total of 88 PD with different types of pancreatic anastomosis: 61 BA PJ, 6 Cattell-Warren PJ, 14 PG, 6 sealing of the remnant and 1 dunking PJ. At present, outside controlled studies, we no longer perform sealing of the stump due to its high rate of clinically relevant POPF (66%, 1 grade B and 3 grade C) and one procedure-related death. Although the results with PG have been satisfactory regarding a low rate of clinically relevant POPF of 14% (2 grade A), we had 3 cases of post-pancreatectomy hemorrhage (grade C) with one procedure-related death. As a result, we do not currently consider PG as the anastomosis of choice.

In 80% of all cases the diagnosis was a malignant tumor. Twenty operations were initiated by laparoscopy, seven of which were converted. The reasons for conversion were: 3 due to slow progression/technical difficulty, 2 to control bleeding (one emergent conversion), and 2 due to suspected venous invasion.

Details of patient characteristics and results obtained in patients undergoing PJ performed by open approach (OBA) or by laparoscopy (LBA) are shown in table 1. The OBA sample is broken down further into those initially receiving open surgery and those who were converted.

**Table 1**. Clinical demographic characteristics of all patients included in the study.

* mean (SV); † n (%); ǂ median [p25-p75]; BMI: Body mass index; PDAC: Pancreatic Ductal Adenocarcinoma; PF: Pancreatic fistula; DGE: Delayed gastric emptying; PPH: Post-pancreatectomy hemorrhage.

Table 2 shows the results of the case-matched study between BA and Lap-BA. As expected, no differences between groups were found according to age, sex, BMI, consistency of the pancreas and diameter of the pancreatic duct. Statistical differences were found in favor of lap-BA group in severe postoperative complications (Clavien III-IV) and length of stay.

**Table 2**. Clinical demographic characteristics in matched case control study in terms of: sex, ASA, kind of pancreas and size of the Wirsung. * mean (SV); †n (%); ǂ median [p25-p75]; BMI: Body mass index; PDAC: Pancreatic Ductal Adenocarcinoma; PF: Pancreatic fistula; DGE: Delayed gastric emptying; PPH: Post-pancreatectomy hemorrhage.

## DISCUSSION

Determining the best anastomosis for pancreatic reconstruction after PD remains a controversial issue today. Meta-analyses of recent prospective randomized studies suggest that PG anastomosis achieves a lower rate of POPF [10, 19], although the risk of postoperative hemorrhage is higher [14]. PJ remains the most frequently performed pancreatic anastomosis world-wide. Among the different types of PJ, the most common are the Cattell-Warren and Blumgart reconstructions. A prospective randomized study comparing these two methods (the PANasa trial) is currently underway [16].

It is well known that the risk of POPF depends less on the surgical technique used than on specific patient characteristics such as: pancreas consistency, duct size, obesity, and diabetes [11, 24, 32, 33]. Some studies recommend adjusting the type of reconstruction to the characteristics of the pancreas/patient, and also favor the use of POPF risk scores [13, 18, 33].

In a multicenter study compiling the results of 187 consecutive patients undergoing BA, Grobmyer et al. [24] obtained an overall rate of POPF of 20.3%, with clinically relevant POPF (grades B and C) in 6.9% and postoperative bleeding (none related to the fistula) in 3.2%; reoperation was 10%, in-hospital mortality 1.6%, and the mean length of stay was 10 days. This was a retrospective study, but these results improved on those obtained previously by other groups with regard to clinically relevant POPF (10-15%) [34-35]. Recently,

a single high-volume center reported overall and clinically relevant POPF rates of 23.6% and 19.8% respectively in 808 patients with classical PJ [13].

One of the main factors that has limited the spread of LPD is the difficulty of reconstructing the digestive tract – especially the creation of the pancreatic anastomosis, which is the main cause of serious postoperative complications. Selected series have published excellent results [36-37], but they couldn't be reproduced at other centers. Vast experience in pancreatic and laparoscopic surgery is needed, and the learning curve is too long and risky for most surgeons to contemplate [38]. Although several variants of PJ have been described [15], OBA is now becoming consolidated as one of the most popular and has obtained satisfactory results when applied by different groups [24, 26-27]. Recently, new variants have even been proposed for its implementation by laparoscopy [39]. In our experience, the laparoscopic approach to classical PJ has two main drawbacks: the need to leave multiple small sutures untied and the difficulty of creating the posterior face of the DTM anastomosis when the capsular stitches on the posterior face have previously been tied. With our proposed modification, the external traction performed with the transpancreatic stitches externalized through the trocar makes the jejunal loop fit into the posterior face of the pancreatic remnant, and the DTM is performed with the pancreatic duct and the jejunal orifice properly aligned.

Although our series is small, so far we have only had two relevant POPF (16.6%), both Grade B and Clavien II, without related postoperative bleeding.

There was no need for reoperation, and mortality was zero. These results are particularly interesting given that most patients in the LBA group had a high risk pancreas for POPF (normal/soft pancreas 77%, narrow duct 69%). In contrast, in the OBA group most patients had a low risk of POPF (normal/soft pancreas 35%, narrow duct 46%). This was the reason for doing a case-matched additional study. In our experience, the probability of conversion is higher in patients with firm/hard pancreas and wide ducts, who tend to present more pancreatic atrophy and associated chronic pancreatitis, as in the case of pancreatic ductal adenocarcinoma. However, conversion was not associated with a higher rate of POPF, postoperative complications or even hospital stay, which was actually shorter than in patients who initially underwent open surgery. The mean postoperative length of stay was significantly shorter in patients operated laparoscopically (table 2).

The adoption of LBA appears to improve on the results presented in other studies [1, 5, 7]. The comparison of results between centers is difficult; although some high-volume centers have apparently shorter postoperative length of stay of only seven days, readmission rates can reach up to 23% in the first month. Most of these readmissions are attributable to procedure-related infections and usually occur within a week of discharge [40].

One of the main shortcomings of the study is that all patients in LBA group (including converted patients) were operated by a single surgeon, while in OBA another surgeon participated. Although both surgeons had the same expertise in open pancreatic surgery and operate together side-by-side both open and laparoscopic cases, personal skills in advanced laparoscopic were different from each one.

## CONCLUSIONS

The adapted to laparoscopic technique we propose for performing the LBA simplifies and facilitates the creation of the PJ in LPD. The rates of clinically relevant POPF are comparable with those obtained by open surgery, while severe postoperative complications (Clavien III-V) and length of stay are reduced in the LPD. As a result, the use of LBA may contribute to a significant reduction in the mean postoperative hospital stay and severe postoperative complications in LPD. Randomized controlled trials are needed to assess the true value of the laparoscopic approach in PD.

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