



Barbed vs conventional sutures in bariatric surgery: a propensity score analysis from a high-volume center

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Abstract

The use of barbed sutures for constructing an anastomosis is favoured by a few bariatric surgeons as compared to conventional sutures. The aim of this study is to assess safety and efficacy of barbed sutures to close the gastric pouch–jejunal anastomosis (GPJA) in laparoscopic gastric bypass (Roux-en-Y gastric bypass—RYGB, and One-Anastomosis gastric bypass—OAGB) using propensity score-matching (PSM) analysis. A retrospective analysis of patients who underwent primary laparoscopic gastric bypasses between January 2012 and December 2017 was performed. Patients were divided into two different groups (RYGB-G and OAGB-G). PSM analysis was performed to minimize patient selection bias between the two types of sutures (barbed—BS and conventional—CS) in each group. A total of 808 patients were reviewed. After PSM, 488 (244 BS vs 244 CS) patients in RYGB-G and 48 in OAGB-G (24 BS vs 24 CS) patients were compared. Median operative time was significantly shorter ($p < 0.001$) for BS in RYGB-G. In OAGB-G, BS were associated with a shorter operative time, although no significant difference was observed ($p = 0.183$). Post-operative hospital stay was significantly shorter for BS in both the groups ($p < 0.001$). Post-operative 30th-day complications were comparable: no leakage or bleeding of GPJA was observed in BS groups. At median follow-up of 28.78 months, no late complications were observed. Barbed sutures appear to be effective to close GPJA during gastric bypass and as safe as conventional suture. Further studies are necessary to draw definitive conclusions.

Keywords Roux-en-Y gastric bypass · One-anastomosis gastric bypass · Barbed sutures · Stratafix™ · Bariatric surgery

Introduction

Excess weight and obesity are the fifth global leading risks for death [1–5]. Conservative treatment of obesity (including restrictive calories intake, physical activity and medication) fails to achieve significant and long-lasting weight loss [6]. Current evidence has validated bariatric surgery as the best hope for the morbidly obese patients to achieve substantial

and sustainable weight loss [7]. Roux-en-Y (RYGB) and One-Anastomosis (OAGB) Gastric bypasses are two of the most performed bariatric procedures, with the excellent long-term weight loss with a low rate of post-operative complications and metabolic disorders [7–11]. Even though the procedures are quite standardized, there are two different techniques for the construction of the gastric pouch–jejunal anastomosis (GPJA): mechanical (circular or linear stapler) or hand-sewn GPJA [12]. To date, laparoscopic approach for these procedures is considered the “standard” all over the world [13]. Latero-lateral GPJA using a linear stapler requires closure of the enterotomies with sutures in narrow and restricted spaces [14]. Laparoscopic suturing is widely considered one of the most difficult and time-consuming tasks in laparoscopic surgery. The main reason for this is the need to tie a knot in a confined space, often with limited view. Furthermore, even in experienced hands, laparoscopic knot tying has been shown to have a high rate of failure [14–17]. Knot integrity is particularly important in bowel

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anastomosis, because failure may cause serious complications that could need further surgery and thus leading to prolonged recovery and increased health care costs [18]. Laparoscopic devices have been developed to improve quality of knots, such as Endo-Stich (Covidien, Mansfield, MA, USA), Lapra-ty absorbable suture clips (Ethicon Endo-Surgery, Inc., Cincinnati, OH) and extracorporeal knot pushers. Recently, unidirectional and bidirectional barbed sutures, a new kind of easy-to-perform continuous suture, became available for wound closure and are well described in plastic, gynecologic, and urological literature [19–24]. Although the use of this suture to close mesentery or abdominal walls was reported, to date, there is little evidence about its use for intestinal suture [25]. The use of unidirectional absorbable 2/0 suture (Stratafix™, Ethicon Endosurgery, Inc., Cincinnati, OH, USA) as innovative biotechnologies to close the enterotomies at the end of GPJA could make the suturing technique easier by avoiding knotting and minimizing external help during anastomosis construction. The aim of this study is to assess safety and efficacy of barbed sutures compared to conventional sutures to close the GPJA in patients undergoing gastric bypass (RYGB and OAGB), by evaluating the impact of the procedure on operative time and related post-operative complications, using propensity score-matching (PSM) analysis to reduce sample selection bias.

Methods

We conducted a retrospective review of prospectively collected data into a dedicated bariatric database of patients who underwent primary bariatric surgery, between January 2012 and December 2017 at the Foundation Gemelli Hospital, Catholic University of the Sacred Heart, a tertiary referral center for bariatric surgery. All procedures were performed by two minimally invasive bariatric surgeon experts and a resident, using the same standardized technique. Patients included in this study met the consensus criteria for bariatric surgery and fulfilled the national guidelines of Italian Society of Bariatric Surgery (SICOB), and underwent primary gastric bypass (RYGB and OAGB). Patients were fully informed of the surgical technique, anesthesia, effects, and complications. Multidisciplinary bariatric evaluation (in a team consisting of a surgeon, an endocrinologist, a dietician, and a psychologist) was performed for each patient, to have a personalized bariatric process. The preoperative workup consisted of upper endoscopy, ultrasound of the abdomen, upper gastrointestinal (UGI) contrast study, blood analysis, respiratory investigation, nutritional status appraisal, psychological, and cardiac evaluation. A side-to-side GPJA was created using a laparoscopic linear stapler. A double-layer running suture was performed to close the enterotomies of GPJA. Monofilament absorbable 3/0 PDS

(Ethicon, Cincinnati, OH, USA) was routinely used until December 2014, and 2/0 monofilament unidirectional barbed absorbable suture (Stratafix™) was used from January 2015 to December 2017 in all patients. In case of RYGB, side-to-side jejunojunal anastomosis was created, with the same linear stapler (Echelon Flex Powered® 60 mm introduced for only 35 mm, blue cartridge 3.5 mm size). A double-layer monofilament absorbable 3/0 PDS™ running suture was performed to close the enterotomies of this anastomosis. All patients had intraoperative methylene blue test to test possible leakage from the staple line and/or anastomosis. A drainage along the GPJA was systematically positioned. A standard post-operative protocol personalized for bariatric patients was used. Patients were routinely placed on proton pump inhibitors (e.g., pantoprazole 40 mg) therapy once a day for 1 month. All patients remained nil per os until the second post-operative day (POD), where UGI contrast study was performed. The contrast study was performed in POD 1 or 2 depending on radiology services scheduling. UGI contrast studies were performed with water-soluble contrast (Gastrografin®, Bracco SpA, Milan, Italy). Liquid diet was started on POD 2 if no leak was observed and if clinical course was uneventful. Routine complete blood examination and blood count were obtained on POD 1 in all patients. Further personalized examinations were obtained on the basis of the clinical aspects of the patients. For example, patients with symptoms and signs of suspected leak despite negative UGI contrast had indication for further evaluation [abdominal computed tomography (CT) with intravenous and oral contrast material and/or surgical exploration]. The presence of one or more of the following features on abdominal CT is suggestive of fistula: extravasation of the contrast material outside the gastric remnant, presence of collections along the surgical area, free intrabdominal fluid, and/or free intrabdominal gas. Anastomotic leak was defined in according to the UK Surgical Infection Study Group as “the leak of luminal contents from a surgical joint between two hollow viscera” [26]. The severity of post-operative complications was rated according to the Clavien–Dindo classification [27]. Routine follow-up with blood test analysis and physical examination were performed on the 30th day, then every 3 months for the first year, every 6 months for the second year, and then annually, according to the SICOB guidelines [28]. Basic demographic and clinical data were collected through review of patient charts and electronic databases. Other parameters, such as post-operative pain (pain scale 0–10), nausea, vomiting, drain output, urine output, hemoglobin level, white blood cell level, need for blood transfusion, and reoperative findings (when further surgery was needed), were also registered. We conducted a retrospective case control study, using propensity score matching (PSM) to randomization. Statistical analysis and PSM were conducted by the SPSS 22.0 software for Windows (SPSS Inc,

Chicago, III). Patients were divided into two groups, according to the surgical procedure: Roux-en-Y Gastric Bypass-group (RYGB-G) and One-Anastomosis Gastric Bypass group (OAGB-G). Type of suture (barbed—BS, or conventional—CS) to close the GPJA was entered into the regression model of the propensity score as the binary treatment variable. Matching of the propensity score was obtained with the “1:1 nearest neighbor” matching method (discard = both groups, caliper = 0.2). Baseline characteristic, and operative and post-operative variables were compared using a bivariate analysis. The presence of a normal distribution was assessed using the Shapiro–Wilks test. We referred to a 5% significance level. Chi-square test was used to compare categorical variables. Continuous variables were expressed as mean \pm standard deviation (range) in case of normal distribution, otherwise, as median (interquartile range, IQR). We used *t* test or Mann–Whitney test to compare continuous variables, depending on data distribution into the analyzed population. The primary study endpoint was the safety of the barbed sutures analyzing the complication rate, and the secondary endpoint was the influences of barbed sutures on operative time and post-operative hospital stay.

Results

During the study period, over 1523 primary bariatric procedures were performed, and a total of 808 patients (214 men, 594 women) met inclusion criteria. The demographics of the patients were grouped as follows: median age of 43 (35–50) years, median preoperative weight of 123 (110–140) kg and median preoperative BMI of 44.1 (40.6–48.4) kg/m². Obesity-related comorbidities were present in 495 (61.3%) patients: type 2 diabetes mellitus in 178 (22%) patients, hypertension in 284 (35.1%) patients, and obstructive sleep apnea in 338 (41.8%) patients. Smoking was present in 404 (50%) patients. The previous abdominal non-bariatric procedure was reported in 716 patients, 410 of which was performed in laparoscopy. All bariatric procedures were performed laparoscopically, and no conversions were registered. 706 patients underwent RYGB and 102 OAGB. Simultaneous cholecystectomy was performed in 11 (1.4%) cases. To close the enterotomies of GPJA, conventional (not barbed) sutures were used for the first 288 cases, and barbed sutures for the last 520. The median operative time was 70 (57.25–91.00) min. No intraoperative deaths occurred. No intraoperative leaks were detected at the methylene blue test. Post-operative complications were registered in 26 patients; in particular, we had 2 cases of leakage from GPJA and 2 cases of leakage from jejunojejunal anastomosis in RYGB. Further laparoscopic surgery was needed in all of these cases to perform a new anastomosis. Other post-operative complications were the following: three cases of jejunal–jejunal anastomosis’s stenosis; six cases of

self-limiting intraluminal bleeding; six cases of extraluminal bleeding; one case of pulmonary embolism; two cases of pneumonia; and one case of incisional hernia. The latter required urgent surgical revision. No case of GPJA’s stenosis was detected. Unfortunately, we observed one post-operative death, as elsewhere reported [29]: a 38-year-old patient with a body mass index of 46.8 kg/m² that underwent RYGB; on POD 2, he developed fever (38 °C). Empiric antibiotics were started. On POD 3, the radiographic study showed a leak at the lateral side of the gastric pouch. The patient underwent laparotomy and repair of the fistula. He was transferred to the intensive care unit (ICU), where he developed a systemic inflammatory response syndrome (SIRS). On POD 4, CT scan showed a 5.4 cm collection on the posterior layer of the gastric remnant and free abdominal air. The patient underwent surgical drainage of the collection. No leaks were observed. SIRS persisted, with hemodynamic instability requiring vasopressors and onset of acute renal injury requiring dialysis. After, he developed hemophagocytic lymphohistiocytosis and died in POD 67 despite intensive hemodynamic and transfusion support.

Median follow-up time was 28.78 (15–2) months. All data are shown in Table 1. After PSM, the study population was composed by 536 patients: 288 for the RYGB group (RYGB-G) and 48 for the OAGB group (OAGB-G). Tables 2 and 3, respectively, report data and statistical analyses of each group. Patients were comparable, in each group, for age, gender, weight, BMI, previously abdominal non-bariatric surgery, smoking, comorbidities, and eventual simultaneous cholecystectomy. In RYGB-G, the median operative time was significantly shorter for BS, 61.50 (50–78.75) min vs 95 (79.25–120) min, $p < 0.001$. In OAGB-G, BS were associated with a shorter operative time, although no significant difference was observed. Both in RYGB-G and OAGB-G, the median post-operative hospital stay was significantly shorter for BS. Obviously, median follow-up was significantly shorter for BS in each group. Post-operative complications were similar for BS and CS: 8 vs 9 ($p = 0.875$) in RYGB-G and 0 vs 1 ($p = 0.312$) in OAGB-G. We registered 2 cases of GPJA’s leakage in CS for RYGB-G ($p = 0.156$) and 0 case of GPJA’s leakage in OAGB-G. Furthermore, we reported two cases of jejunojejunal anastomosis’s leakage in RYGB-G: one for BS and one for CS ($p = 1$). No case of GPJA’s stenosis nor late complications were observed in each group.

Discussion

RYGB and OAGB are safe procedures with good long-term results, but have technically demanding steps in the construction of GPJA that require significant experience in laparoscopic surgery [30–34].

Table 1 Characteristics of population's study

Patients	808
Age (years)	43 (35–50)
Weight (kg)	123 (110–140)
BMI (kg/m ²)	44.1 (40.6–48.4)
Male/Female	214 (29.8%)/594 (70.2%)
Smoking (yes/no)	404 (50%)/404 (50%)
Previously non-bariatric abdominal surgery (yes/no)	716 (88.6%)/92 (11.4%)
Comorbidities (yes/no)	495 (61.3%)/313 (38.7%)
Hypertension (yes/no)	284 (35.1%)/524 (64.9%)
Type 2 diabetes mellitus (yes/no)	178 (22%)/630 (78%)
Obstructive sleep apnea (yes/no)	338 (41.8%)/470 (58.2%)
RYGB/OAGB	706 (87.4%)/202 (12.6%)
Barbed sutures/Conventional sutures	288 (35.6%)/520 (64.4%)
Simultaneous cholecystectomy (yes/no)	11 (1.4%)/797 (98.6%)
Operative time (min)	70 (57.25–91.00)
Post-operative intensive care units (yes/no)	11 (1.4%)/797 (98.6%)
Post-operative 30th day Complications (yes/no)	26 (3.2%)/782 (96.8%)
GPJA's leakage (yes/no)	2 (0.2%)/806 (99.8%)
Jejunojejunal anastomosis's leakage (yes/no)	3 (0.4%)/805 (99.6%)
GPJA's stenosis (yes/no)	0 (0%)/808 (100%)
Jejunojejunal anastomosis's stenosis (yes/no)	3 (0.4%)/805 (99.6%)
Intraluminal bleeding (yes/no)	6 (0.7%)/802 (99.3%)
Extraluminal bleeding (yes/no)	6 (0.7%)/802 (99.3%)
Pulmonary embolism (yes/no)	1 (0.1%)/807 (99.9%)
Pneumonia (yes/no)	2 (0.2%)/806 (99.8%)
Trocar site hernia (yes/no)	1 (0.1%)/807 (99.9%)
30th day post-operative mortality (yes/no)	1 (0.1%)/807 (99.9%)
Follow-up (months)	28.78 (15–42)

The use of mechanical or hand-sewn techniques varies worldwide [12]. Barbed sutures have been introduced, in this context, to facilitate laparoscopic suturing [14]. The idea of barbed sutures was first conceptualized in 1951 for tendon repairs. The first barbed suture approved by the Food and Drug Administration (FDA) was Quill™ bidirectional barbed polydioxanone suture of Angiotech Pharmaceuticals in 2004 followed by V-Loc™ of Covidien in 2009 [35]. The latest FDA-approved barbed suture is Stratafix™ from Ethicon Johnson&Johnson. To date, efficacy and suitability of barbed sutures have been reported in gynecologic, plastic, urologic, and orthopedic surgery [14, 36]. In general and digestive surgery, use of barbed sutures has been recently reported in colorectal surgery, where they have been used safely during closure of pelvic cavity after abdominoperineal resection [37] and rectal wall closure in transanal endoscopic microsurgery [38]. Barbed devices do not need knots at the beginning nor at the end of the suture line: eliminating knots reduces technical difficulties and knot-related complications. Furthermore, BS distributes tension across the suture line and provides fixation with every passage. This allows

approximation of the wound safely with no need for external traction by an assistant to prevent slippage.

Milone et al. [30] reported the first prospective randomized controlled study evaluating the efficacy of V-Loc suture on gastrojejunal anastomosis in 60 patients undergoing RYGB. Operative and suturing times were the primary outcomes of this study, while incidence of leakage, bleeding, and stenosis was the secondary outcomes. The time required to perform anastomosis was significantly lower in the group of barbed sutures rather than in the control group, whereas no significant differences were found between the two groups for the operative time. De Blasi et al. [14] conducted a comparative study in 100 candidates for gastric bypass. A gastrojejunostomy with interrupted absorbable stitches was performed in 50 patients, while barbed running suture was used in other 50. Both times spent to perform the anastomosis and material cost to complete reconstruction were significantly shorter in the barbed suture group; however, total operative time was not significantly reduced. In their retrospective study, Tyner et al. [18] compared standard absorbable monofilament sutures vs barbed sutures in gastric pouch–jejunal anastomosis and jejunojejunal anastomoses.

Table 2 Data and statistical analysis of RYGB-G

	CS	BS	<i>p</i>
Patients	244	244	
Age (years)	42 (35–49)	43 (35–50)	0.376
Weight (kg)	120 (109–135)	120 (110.00–137.75)	0.452
BMI (kg/m ²)	43.3 (40.3–47.3)	43.8 (40.5–47.4)	0.283
Male/female	65 (26.6%)/179 (73.4%)	62 (25.4%)/182 (74.6%)	0.757
Previously non-bariatric abdominal surgery (yes/no)	222 (27.5%)/22 (72.5%)	214 (87.7%)/30 (12.7%)	0.393
Comorbidities (yes/no)	88 (43.6%)/155 (56.4%)	96 (39.3%)/148 (60.7%)	0.514
Simultaneous cholecystectomy (yes/no)	3 (1.2%)/241 (98.8%)	2 (0.8%)/242 (99.2%)	0.653
Operative time (min)	95 (79.25–120.00)	61.50 (50.00–78.75)	<0.001
Post-operative intensive care units (yes/no)	3 (1.2%)/241 (98.7%)	3 (1.2%)/241 (98.7%)	1
Post-operative hospital stay (days)	5 (4–6)	3 (3–4)	< 0.001
Post-operative 30th day complications (yes/no)	9 (3.7%)/235 (96.3%)	8 (3.3%)/236 (96.7%)	0.156
GPJA's leakage (yes/no)	2 (0.8%)/242 (99.2%)	0 (0%)/244 (100%)	0.156
Jejunojejunal anastomosis's leakage (yes/no)	1 (0.4%)/243 (99.6%)	1 (0.4%)/243 (99.6%)	1
GPJA's stenosis (yes/no)	–	–	
Jejunojejunal anastomosis's stenosis (yes/no)	1 (0.4%)/243 (99.6%)	2 (0.8%)/242 (99.2%)	0.562
Intraluminal bleeding (yes/no)	1 (0.4%)/243 (99.6%)	2 (0.8%)/242 (99.2%)	0.317
Extraluminal bleeding (yes/no)	1 (0.4%)/243 (99.6%)	1 (0.4%)/243 (99.6%)	1
Pulmonary embolism (yes/no)	1 (0.4%)/243 (99.6%)	0 (0%)/244 (100%)	0.317
Pneumonia (yes/no)	0 (0%)/244 (100%)	1 (0.4%)/243 (99.6%)	0.317
Trocar site hernia (yes/no)	1 (0.4%)/243 (99.6%)	0 (0%)/244 (100%)	0.317
Follow-up (months)	47 (42–53)	20 (11–27)	<0.001

Table 3 Data and statistical analysis of OAGB-G

	CS	BS	<i>p</i>
Patients	24	24	
Age (years)	42 (35.25–47.75)	46 (35.25–53.50)	0.502
Weight (kg)	130 (120.00–146.25)	134.50 (124.00–161.25)	0.529
BMI (kg/m ²)	45.8 (42.1–50.7)	49.3 (42.3–52.2)	0.523
Male/Female	7 (29.2%)/17 (70.8%)	8 (33.3%)/16 (66.7%)	0.755
Previously non-bariatric abdominal surgery (yes/no)	20 (83.3%)/4 (16.7%)	21 (87.5%)/3 (12.5%)	0.685
Comorbidities (yes/no)	8 (33.3%)/16 (66.7%)	9 (37.5%)/15 (62.5%)	0.763
Operative time (min)	76.5 (66.0–103.5)	70 (51.0–94.5)	0.183
Post-operative intensive care units (yes/no)	0 (0%)/24 (100%)	1 (4.2%)/23 (95.8%)	0.312
Post-operative hospital stay (days)	4 (3–5)	3 (2–4)	< 0.001
Post-operative 30th day Complications (yes/no)	1 (4.2%)/23 (95.8%)	0 (0%)/24 (100%)	0.312
GPJA's leakage (yes/no)	–	–	–
GPJA's stenosis (yes/no)	–	–	–
Intraluminal bleeding (yes/no)	–	–	–
Extraluminal bleeding (yes/no)	1 (4.2%)/23 (95.8%)	0 (0%)/24 (100%)	0.312
Pulmonary embolism (yes/no)	–	–	–
Pneumonia (yes/no)	–	–	–
Trocar site hernia (yes/no)	–	–	–
Follow-up (months)	38 (37.0–45.7)	17 (7–28)	<0.001

For primary procedures, the mean operative time was slightly shorter in the barbed suture group. In a prospective cohort study, Constantino et al. [4] reported the largest consecutive series of the use of barbed suture in RYGB and compared it to a multifilament conventional suture. There was a statistically significant anastomotic time reduction in the barbed suture group. In our series, in RYGB-G, the median operative time was significantly shorter for BS; in OAGB-G, BS was associated with shorter operative time, although the result was not statistically significant, probably due to the small sample size. This could be explained by the knotless technique and the no need for assistance to maintain suture tension. Although it is really difficult to evaluate the relationship between external help and barbed suture use, we could suggest that a suture performed by the operator himself reduces operative time and has a positive impact on post-operative results.

In our series, we did not observe GPJA's leakage in BS groups, both in RYGB-G and OAGB-G. No case of GPJA's stenosis has been registered. Similar results are reported in the literature. For example, Milone et al. [30] reported no significant differences in complications between the two groups; De Blasi et al. [14] found that no fistula nor anastomotic stenosis occurred at 6 months after surgery in either group; for Tyner et al. [18], no significant difference in the overall complication rate between the two groups was observed at 30-day follow-up. No complications due to the jejunojejunal anastomosis or gastric pouch–jejunal anastomosis closure were reported. No anastomotic leak or stenosis occurred in each group.

In the series of Palmisano et al. [39], the authors decided to secure the end of the barbed suture with an absorbable clip, because little data with short follow-up had been previously published supporting the use of this suture for totally hand-sewn intestinal anastomosis. Indeed, Blanc et al. [40] reported their results after performing laparoscopic gastric bypass anastomosis in 50 consecutive patients, using barbed, absorbable, bidirectional, and monofilament sutures (Stratafix™) for antecolic and antegastric anastomoses. They showed a mean operative time of 60 min, a hospital stay of 3 days, and no post-operative complications. They supported their use arguing, among other advantages, a short learning curve, and absence of slippage. Inflammatory response to a specific suture material is known to play an important role in scar formation. Surgical technique is an important factor contributing to the anastomotic quality [40]. Their results are similar to ours: our overall stenosis incidence was nil compared to the rate of some series, ranging 3–27% [41, 42].

We reported statistically shorter post-operative hospital stay for barbed sutures in both groups (RYGB-G and OAGB-G), as reported in other series [18, 40, 43]. Shortening of hospital stay observed in the barbed sutures group is

probably due to an enhanced recovery after surgery, which we acquired through the years.

It is important to specify that, due to the ongoing dexterity improvement in the surgical procedures, the study was performed after the RYGB- and OAGB-learning curves were achieved. As a matter of fact, our first goal was not to influence the outcome of the study; to minimize statistical influence between two consecutive groups of patients, we used PMS analysis.

One of the main problems of this type of suture is the impossibility to remove it once inserted: cutting the suture and performing a new one are the general procedures to extract it. This mechanism could, in theory, alter the surrounding tissues and interfere with the subsequent cicatrization. As far as we know, some cases of secondary obstruction following the use of barbed sutures have been reported in the literature, probably due to the contact between barbed material and bowel loops and its ability to attract them because of their surface features [44–46]. The surgeon must deal with this problem and have a high index of suspicion in case of post-operative obstruction.

Even if in this study, we did not perform a cost analysis, globally, the use of barbed sutures did not modify the economic burden of the procedures: in fact, the major cost of the suture is counterbalanced by the minor operative time, which reduces the overall utilization of the operative room.

An important limit of this study is its retrospective design conducted on a period of time of 6 years, where patients' groups (CS vs BS) were consecutive.

In conclusion, our study supports the use of barbed sutures to close the enterotomies of GPJA as a safe and effective technique that may be comparable to the conventional sutures for operative time, post-operative complications, and hospital stay. Further prospective randomized studies with a higher number of patients are needed to evaluate long-term outcomes and to perform a cost analysis.

Author contributions Study conception and design: FP and LS. Acquisition of data: PG and FP. Analysis and interpretation of data: PG and LC. Drafting of manuscript: FP and LS. Critical revision of manuscript: RB and MR

Compliance with ethical standards

Conflict of interest All authors mentioned in this study do not have any competing interest. This specific report does not endorse any specific Company.

Research involving human participants and/or animals This article does not contain any studies with animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants for whom identifying information is included in this article.

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