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ORIGINAL CONTRIBUTIONS

Variation of Laparoscopic Roux-en-Y Gastric Bypass Techniques: a Survey of 518 Bariatric Surgeons

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Abstract

Introduction Surgical technique varies dramatically in the performance of laparoscopic Roux-en-Y gastric bypass (LRYGB) and these differences can potentially lead to variation in outcomes. The objective of this study was to characterize surgical techniques used during LRYGB.

Methods An anonymous 44-question survey was distributed by email to all bariatric surgeons with membership in the ASMBS, SAGES, and ACS from April to June 2020. Questions were designed to evaluate surgeon demographics, experience, and variation of techniques. Only surgeons who performed LRYGB within the past year were included for analysis.

Results A total of 534 (18.8%) surgeons responded and the majority (97.0%) reported performing LRYGB in the past year. Surgeons were predominantly from the USA (77.8%). For preoperative work-up, 20.1% performed upper gastrointestinal series while 60.8% performed esophagogastroduodenoscopy. Limb length evaluation revealed mean Roux and biliopancreatic limb lengths of 124.1 ± 29.4 cm and 67.4 ± 32.2 cm, respectively. The gastrojejunostomy was most commonly formed using a linear stapler with handsewn closure of the common enterotomy (53.1%) and the jejunojejunostomy using a linear stapled anastomotic technique with handsewn closure of the common enterotomy (60.6%). The majority of surgeons closed the jejunojejunostomy mesenteric defect (91.1%) and one of the antecolic or retrocolic mesenteric defects (65.1%). Intraoperative leak tests were performed in 95.9% of cases. Only 22.1% of surgeons routinely performed upper gastrointestinal swallow studies postoperatively.

Conclusions There are wide variations in pre- and intraoperative practice patterns for LRYGB. Further clinical trials designed to evaluate the impact of these practice pattern differences on patient outcomes are warranted.

Keywords Laparoscopic Roux-en-Y gastric bypass · Bariatric surgery · Surgical techniques

Introduction

Obesity is a growing epidemic and bariatric surgery remains the only successful long-term treatment for obesity and its metabolic complications [1–4]. Laparoscopic Roux-en-Y gastric bypass (LRYGB) is the second most commonly performed bariatric procedure [5] and recent evidence suggests that LRYGB provides significant advantages for long-term weight loss and comorbidity resolution compared with sleeve gastrectomy [6–10]. Although LRYGB is commonly performed, there are many variations in the surgical techniques employed among surgeons without a consensus on the best approach. Knowledge of the most common techniques can therefore inform the variation in practices among surgeons performing bariatric surgery. Additionally, it can help guide research evaluating the impact of the various surgical techniques on outcomes.

The importance of understanding current LRYGB practices was previously analyzed by Madan et al., who performed a survey in 2006 of 215 bariatric surgeons to understand the variation of techniques among surgeons [11].

Key points
- Survey of 518 bariatric surgeons on laparoscopic Roux-en-Y gastric bypass technique.
- Gastrojejunostomy technique has shifted towards more linear vs circular staplers.
- A total of 91.1% closed jejunojejunostomy defect; 65.1% closed antecolic/retrocolic defect.
- Substantial variance exists for both gastric pouch sizing and shape.

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However, bariatric surgical technique has evolved since 2006 with many alterations in technique since that time. For example, in these survey findings, most surgeons performed their gastrojejunostomy using the circular stapler technique [11]; newer evidence demonstrated that circular staplers are associated with higher rates of infection, bleeding, and marginal ulceration [12–15]. Other recommendations include the use of a 25-mm circular stapler to reduce stoma stenosis compared to the 21-mm circular stapler [16–18]. The Madan et al. survey also reported relatively short Roux and biliopancreatic limb lengths [11]. Considering the rising prevalence of super-obesity [19–21] and evidence demonstrating that increased limb lengths may improve metabolic outcomes, it is of interest to evaluate if technical changes have occurred [22, 23]. Overall, LRYGB practices have changed drastically, and an updated evaluation of techniques is required to guide current practice and future areas for investigation.

The objective of this study was to define how LRYGB is currently being performed through a comprehensive survey of active bariatric surgeons. These results are compared to those from the study completed in 2006 to evaluate how LRYGB practices have evolved since that time [11].

Methods

Study Design

This is a voluntary response survey study developed according to the American Association for Public Opinion Research (AAPOR) Reporting Guidelines for Survey Studies [24]. The primary study outcome was to assess variations in LRYGB techniques in current practice and characterize trends to past results reported by Madan et al. in 2006 [11]. The protocol for this study was approved by the University of Alberta Research Ethics Board (Pro00096507). Responding surgeons provided informed consent for participation and their responses remained confidential.

Survey Development

This comprehensive and anonymous 44-question survey was intended for bariatric surgeons who currently perform LRYGB and developed based primarily on the Madan et al. study in order to enable comparisons over time [11]. Modifications to this survey were done through expert consensus of four surgeons experienced with LRYGB. Our expert surgeons debated including questions on robotic approaches but decided against it as it would have increased the length and reduced the focus of the survey. Additionally, robotic approaches comprised less than 10% of LRYGB procedures in North America [25]. The final survey is included in the Supplementary Material.

We collected surgeon demographics including years of experience, number of LRYGB procedures done in the past year, and primary country of practice. Study outcomes of interest included preoperative work-up, gastric pouch shape and sizing methods, limb lengths and positioning, gastrojejunostomy and jejunojejunostomy techniques, gastrojejunostomy anastomosis sizing and intraoperative leak tests, and mesenteric defect closure techniques. Additional operative and postoperative characteristics included operative time, postoperative length of stay, performance of anastomosis testing, and follow-up.

The survey was distributed through Research Electronic Data Capture (REDCap) survey and data administration software (Vanderbilt University, Nashville, TN, USA). The survey was sent to all bariatric surgeons of the American Society of Metabolic and Bariatric Surgeons (ASMBS), Society of Gastrointestinal and Endoscopic Surgeons (SAGES), and the American College of Surgeons (ACS) ($n=2848$) [26, 27]. This survey sample was intended to be an accurate representation of current North American bariatric surgeons. The survey was sent by email on April 1, 2020 and was available until June 30, 2020. Surgeons were eligible for inclusion in the analysis if they had performed LRYGB within the past year. No other exclusion criteria were applied and respondents reporting to practice outside of North America were included.

Statistical Analyses

Statistical analyses were performed through STATA v17 (StataCorp, College Station, TX, USA). Categorical data were expressed as absolute counts with percentages and continuous data expressed as means and standard deviations. Medians and interquartile ranges (IQRs) were presented in the event of skewed distributions. "Other" responses to categorical questions were assigned to a priori categories by hand or pooled into new categories where appropriate to accurately present all responses.

Differences between our results and those from the Madan et al. paper were compared through simple differences in values reported (percentages for categorical data and means for continuous data). Percentages from Madan et al. were calculated to further decimal places from the count data provided in their study to improve comparisons when possible [11]. Ranges were reported when other measures of variability were not available.

Results

Survey Response and Demographics

In total, 534 of 2848 (18.8%) surgeons responded. The majority of responding surgeons ($n=518$, 97.0%) reported

performing LRYGB in the past year (Fig. 1). Respondents were mostly from the USA (77.8%), followed by Canada (4.1%) and Mexico (2.7%), with additional regions reported in the Supplementary Material (Table S1). Surgeons had a mean 14.7 ± 7.2 years of experience and performed a median 40 procedures (IQR 20–80) in the past year (Table S1).

Preoperative Work-up

Preoperatively, only 20.1% of respondents reported performing upper gastrointestinal series with the majority (60.8%) performing esophagogastroduodenoscopy. Esophageal manometry ($n = 9$, 1.7%) and 24-h pH studies ($n = 7$, 1.4%) were rarely done routinely, with other preoperative work-up reported in Table 1.

Table 1 Preoperative work-up reported from survey respondents for laparoscopic Roux-en-Y gastric bypass

Preoperative work-up[a]	Survey responses
Esophagogastroduodenoscopy	315 (60.8%)
Upper gastrointestinal series	104 (20.1%)
Esophageal manometry	9 (1.7%)
24-h pH study	7 (1.4%)
Other	
Abdominal ultrasound	11 (2.1%)
Helicobacter pylori test	5 (1.0%)
Colonoscopy	1 (0.2%)
Other work-up	1 (0.2%)
Nothing performed routinely	8 (1.5%)

[a]Total percentage ≠ 100 as each question was individually answered in the affirmative or negative and some "other" responses were assigned to multiple different categories by hand

Operative Characteristics

Surgeons preferred a short and small pouch (70.5%) compared to a long and elongated shape (24.1%). The gastric pouch was most often sized using the distance from the gastroesophageal junction (48.2%) and number of vessels off the lesser curvature (31.8%), similar to results from Madan et al. (49.3% and 31.6% respectively) [11]. Gastric pouch shape and sizing details are included in Table 2.

The mean Roux limb length reported was 124.1 ± 29.4 cm and the mean biliopancreatic limb length was 67.4 ± 32.2 cm, increases of 10.1 cm and 19.4 cm, respectively, from the past survey. Limb length was predominantly measured using the length of the grasper (78.4%), with a 34.0% decrease in frequency of using an open grasper. Antecolic Roux limb positioning increased to 92.4% of cases [11]. Table 3 includes all limb length and positioning details.

The gastrojejunostomy was performed using a linear stapler with handsewn of the common enterotomy (53.1%), whereas circular stapler use decreased to 22.3% of surgeons. Of the surgeons performing the circular stapler technique, the 25-mm stapler was being used more often than the 21-mm stapler (81.1% vs 18.9%). The jejunojejunostomy was performed using the linear stapler technique with handsewn common enterotomy (60.6%), whereas the double-staple technique with handsewn common enterotomy has decreased to only 3.9% [11]. Complete gastrojejunostomy and jejunojejunostomy techniques are reported in Table 4.

The gastrojejunostomy anastomosis was most often not sized (40.5%); however, a bougie was the most utilized tool by respondents (31.4%). Endoscopy was the most common intraoperative leak test performed (43.4%), with a significant reduction in the use of oral or nasogastric tubes testing for leaks (23.8% from 45%) [11]. Gastrojejunostomy sizing and testing methods are included in Table 5.

The jejunojejunostomy mesenteric defect was closed by in 91.1%, in keeping with the past survey's results of 91.0%. There was an increase in closure of the colon and Roux limb defects (45.8% vs 18.5%) and decrease in mesocolic defect closures (11.4% vs 41.0%) compared to the past study [11]. As a whole, the majority of surgeons routinely closed antecolic or retrocolic mesenteric defects (65.1%). More than

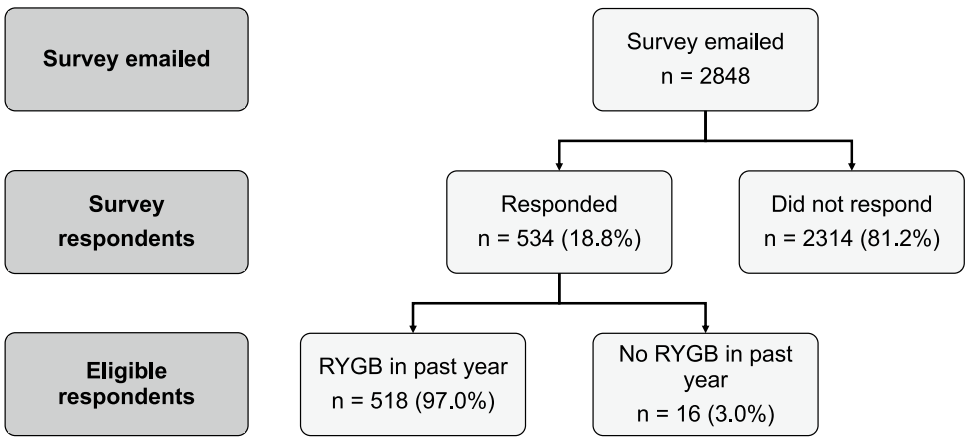

Fig. 1 Respondents for survey of differences in laparoscopic Roux-en-Y gastric bypass techniques. RYGB: Roux-en-Y gastric bypass

Table 2 Gastric pouch shape and sizing methods reported from survey respondents for laparoscopic Roux-en-Y gastric bypass with comparison to previous survey (11)

Gastric pouch shape and sizing	Survey responses	Madan et al. survey responses[b]	Difference
Shape			
Long and elongated (similar to a sleeve)	125 (24.1%)	-	-
Short and small (similar to an egg)	365 (70.5%)	-	-
Other	29 (5.6%)	-	-
Sizing method*[a]			
Distance from gastroesophageal junction	248 (48.2%)	106 (49.3%)	−1.1%
Mean distance[†]	7.9 ± 43.4 cm	-	-
Number of vessels off lesser curvature	164 (31.8%)	68 (31.6%)	+0.2%
Median number of vessels[‡]	2	-	-
As small as possible	36 (7.0%)	51 (23.7%)	−16.7%
Sizing balloon	26 (5.0%)	40 (18.6%)	−13.6%
Mean size	26.5 ± 9.2 cm^3	-	-
Other			
Bougie or other tube	24 (4.7%)	21 (9.8%)	−5.1%
Other gastric anatomical landmarks	17 (3.3%)	4 (1.9%)	+1.4%
Estimate	7 (1.4%)	6 (2.8%)	−1.4%
Stapler length	3 (0.6%)	2 (0.9%)	−0.3%

*515 surgeons responded.

†235 surgeons responded.

‡161 surgeons responded.

[a]Total percentage > 100 as some "other" responses were assigned to multiple different categories by hand.

[b]Comparisons are limited as Madan et al. initially allowed > 1 response per surgeon

Table 3 Limb length and positioning reported from survey respondents for laparoscopic Roux-en-Y gastric bypass with comparison to previous survey (11)

Limb length and positioning	Survey responses	Madan et al. survey responses	Difference
Mean length			
Roux*	124.1 ± 29.4 cm	114 cm (35–225)	+10.1 cm
Biliopancreatic[†]	67.4 ± 32.2 cm	48 cm (10–250)	+19.4 cm
Common limb measured[‡]	32 (6.2%)	4 (1.9%)	+4.3%
Common limb length[§]	185.1 ± 152.2 cm	-	-
Measuring technique[‡]			
Length based on grasper	402 (78.4%)	-	-
Open grasper	59 (11.5%)	92 (45.5%)	−34.0%
Umbilical tape or suture	13 (2.5%)	15 (7.4%)	−4.9%
Other			
Visual estimate	22 (4.3%)	-	-
Markings on grasper	12 (2.3%)	-	-
Ruler	3 (0.6%)	-	-
Length on screen	2 (0.4%)	-	-
Position of Roux limb[‖]			
Antecolic	477 (92.4%)	129 (64.5%)	+27.9%
Retrocolic	39 (7.6%)	71 (35.5%)	−27.9%

*509 surgeons responded.

†511 surgeons responded.

‡513 surgeons responded.

§22 surgeons responded.

‖516 surgeons responded

Table 4 Gastrojejunostomy and jejunojejunostomy techniques reported from survey respondents for laparoscopic Roux-en-Y gastric bypass with comparison to previous survey (11)

Gastrojejunostomy and jejunojejunostomy techniques	Survey responses	Madan et al. survey responses	Difference
Gastrojejunostomy technique*[b]			
Linear stapler with handsewn common enterotomy	274 (53.1%)	83 (41.1%)	+12.0%
Circular stapler	115 (22.3%)	86 (42.6%)	−20.3%
Totally handsewn[c]	108 (20.9%)	42 (20.8%)	+0.1%
Other			
Totally linear stapled	19 (3.7%)	-	-
Size of circular stapler†			
21 mm	21 (18.9%)	37 (41.6%)	−22.7%
25 mm	90 (81.1%)	52 (58.4%)	+22.7%
Gastrojejunostomy stapler‡[a]			
Medtronic	204 (54.5%)	-	-
Ethicon	161 (43.0%)	-	-
Intuitive	13 (3.5%)	-	-
Other	5 (1.3%)	-	-
Jejunojejunostomy§[b]			
Stapled anastomosis with handsewn common enterotomy	312 (60.6%)	106 (52.7%)	+7.9%
Triple-staple technique	144 (28.0%)	27 (13.4%)	+14.%
Double-staple technique with handsewn common enterotomy[d]	20 (3.9%)	72 (35.8%)	−31.8%
Totally handsewn	7 (1.4%)	1 (0.5%)	+0.9%
Other			
Stapled anastomosis with stapled common enterotomy	27 (5.2%)	-	-
Other techniques	5 (1.0%)	-	-
Jejunojejunostomy stapler‖[a]			
Medtronic	200 (43.7%)	-	-
Ethicon	213 (46.5%)	-	-
Intuitive	32 (7.0%)	-	-
Other	25 (5.5%)	-	-

*516 surgeons responded.

†111 surgeons responded.

‡374 surgeons responded.

§515 surgeons responded.

‖458 surgeons responded.

[a]Total percentage > 100 as some "other" responses were assigned to multiple different categories by hand.

[b]Comparisons are limited as Madan et al. initially allowed > 1 response per surgeon.

[c]$n = 3$ responses represent surgeons who described using robotic handsewn anastomoses.

[d]$n = 1$ response represents a surgeon who described using a robotic handsewn anastomosis

half (60.2%) routinely closed both jejunojejenostomy and antecolic/retrocolic mesenteric defects. Most (89.7%) surgeons used a handsewn running closure method to close mesenteric defects. Table 6 includes all mesenteric defect closure details.

Additional Results

Average LRYGB operative time was reported as 100.2 ± 35.9 min with an average length of hospital stay of 1.6 ± 1.1 days. A total of 22.1% of respondents reported performing a postoperative swallow study (Table 7). This evaluation was not surveyed by Madan et al. [11]. Surgeons reported following up with postoperative patients for a median of 3 years.

Table 5 Gastrojejunostomy anastomosis sizing and intraoperative leak testing reported from survey respondents for laparoscopic Roux-en-Y gastric bypass with comparison to previous survey (11)

Gastrojejunostomy anastomosis sizing and testing	Survey responses	Madan et al. survey responses[b]	Percent difference
Sizing*			
Do not size	209 (40.5%)	-	-
Bougie[†]	162 (31.4%)	43 (41.0%)	−9.6%
Mean size of bougie	34.7 ± 4.1	-	-
Nasogastric tube[‡]	22 (4.3%)	9 (8.6%)	−4.3%
Mean size of nasogastric tube	23.3 ± 8.0	-	-
Endoscopy	39 (7.6%)	23 (21.9%)	−14.3%
Other			
Markings on stapler	64 (12.4%)	9 (8.6%)	+3.8%
With other tube	20 (3.9%)	19 (18.1%)	−14.2%
Intraoperative leak test*[a]			
Endoscopy	224 (43.4%)	75 (38%)	+5.4%
Oral or nasogastric tube with air	123 (23.8%)	89 (45%)	−21.2%
Oral or nasogastric tube with dye	135 (26.2%)	51 (26%)	+0.2%
Do not perform	22 (4.3%)	-	-
Other			
Bougie with air	19 (3.7%)	-	-
Other tests	5 (1.0%)	-	-

*516 surgeons responded.

†161 surgeons responded.

‡21 surgeons responded.

[a]Total percentage > 100 as some "other" responses were assigned to multiple different categories by hand.

[b]Comparisons are limited as Madan et al. initially allowed > 1 response per surgeon, excluded "do not size or test" responses from reported percentages, and reported percentages were used for the "intraoperative leak test" question as exact percentages were not calculable

Table 6 Mesenteric defect closure techniques reported from survey respondents for laparoscopic Roux-en-Y gastric bypass with comparison to previous survey (11)

Mesenteric defect closure techniques	Survey responses	Madan et al. survey responses[b]	Percent difference
Closure of mesenteric defects[a]			
Jejunojejunostomy defect	472 (91.1%)	182 (91.0%)	+0.1%
Mesocolic (retrocolic)	59 (11.4%)	82 (41.0%)	−29.6%
Petersen's (retrocolic)	128 (24.7%)	78 (39.0%)	−14.3%
Colon and Roux limb (antecolic)	237 (45.8%)	37 (18.5%)	+27.3%
Other			
Not performed	5 (1.0%)	12 (6.0%)	−5.0%
Other closures	2 (0.4%)	-	-
Closure method*			
Handsewn running	452 (89.7%)	-	-
Handsewn interrupted	42 (8.3%)	-	-
Clips	1 (0.2%)	-	-
Staples	0 (0%)	-	-
Other			
Both running and interrupted	5 (1.0%)	-	-
None	4 (0.8%)	-	-

*504 surgeons responded.

[a]Total percentage ≠ 100 as each "closure of mesenteric defects" question was individually answered in the affirmative or negative and some "other" responses were assigned to multiple different categories by hand for both questions.

[b]Madan et al. also initially allowed > 1 response per surgeon

Table 7 Additional operative and postoperative characteristics reported from survey respondents for laparoscopic Roux-en-Y gastric bypass

Operative and postoperative characteristics	Survey responses
Average operative time*	100.2 ± 35.9 min
Average postoperative length of stay†	1.6 ± 1.1 days
Postoperative swallow assessment for anastomoses‡	114 (22.1%)
Median day performed postoperatively§	1 day
Median follow-up duration	> 3 years

*514 surgeons responded.

†515 surgeons responded.

‡517 surgeons responded.

§111 surgeons responded

Discussion

This study provides an important update evaluating current LRYGB techniques among North American bariatric surgeons and outlines key changes in practice since the last survey done in 2006 [11]. We found several important differences in practice, including less use of circular staplers for construction of the gastrojejunostomy, increased lengths of Roux and biliopancreatic limbs, and changes to the type of mesenteric defect being closed.

In terms of anastomotic stapling techniques, there was a dramatic decrease in the use of circular staplers for construction of the gastrojejunostomy. This is likely driven by recent evidence indicating that circular stapler use increases wound infection risk, postoperative bleeding, and stricture formation compared to other stapling techniques [12–15]. When circular staplers were used, the 25-mm size was the most common. This is consistent with evidence demonstrating decreased risk of stenosis with a larger diameter circular stapler [16–18]. Considering this evidence, the use of circular staplers for gastrojejunostomy is decreasing, and in instances where they are used, a larger diameter of 25 mm is preferred.

The average limb length for the Roux limb and biliopancreatic limb has increased over time. A higher average BMI of patients undergoing bariatric surgery may be driving this change [19–21], with evidence suggesting that longer limb lengths provide better metabolic outcomes [22, 23]. In particular, there has been evidence that longer biliopancreatic limbs may lead to better metabolic outcomes and our survey demonstrated that this limb had the greatest increase in length [28].

This survey also revealed other clinically important patterns in LRYGB techniques performed. First, mesenteric defect closure has remained high, likely due to growing evidence supporting a reduction of internal herniation following mesenteric closure [29, 30]. The change towards increased antecolic limb positioning is likely due to its technical ease and lower risk for internal herniation compared to retrocolic limb placement [31, 32]. We also found that only one-fifth of surgeons performed routine postoperative swallow assessments. Although this postoperative test was not investigated in Madan et al. survey, other studies have reported considerably higher use of this test in the past [33, 34]. Decreased use of postoperative swallowing studies is likely because of recent studies demonstrating that such testing provides limited diagnostic information and may increase hospital length of stay [33, 34].

The findings from our study carry important practical value. Our results provide an important basis for future clinical trials to determine the impact of variations in surgical techniques with LRYGB outcomes. Data from our survey suggests that substantial variance exists for both gastric pouch sizing and shape and gastrojejunostomy technique. While many studies have evaluated gastric pouch size and shape techniques [11, 35–37], high quality evidence to inform surgical guidelines is still lacking. Additionally, although it is clear circular staplers should only be used selectively and with larger sizes [12–18], further comparisons between linear and circular staplers may be required to facilitate surgeon consensus.

Limitations

Although the survey was sent to every bariatric surgeon registered in either the ASMBS, SAGES, or ACS, only 18.8% responded. However, this is still a considerably large number of responding surgeons and represents a fair sampling of North American bariatric surgeons. Some comparisons to Madan et al. were limited, as most of their survey questions allowed respondents to answer multiple fields [11]. However, through including an open-response field, we were able to assign instances where surgeons elected to include multiple responses to multiple different categories and pool additional responses into new categories that we did not include in the original survey. Another limitation was that our survey was not designed to capture robotic techniques, which are becoming increasingly common [38]; however, numerous surgeons indicated using this method through the "other" field, which we were then able to include into our data.

Conclusion

This study provides an update on LRYGB surgical technique among bariatric surgeons in North America. We identified variation in anastomotic stapling techniques, limb length, limb positioning, mesenteric defect closure, and postoperative leak test practices. These findings will help direct future

studies to investigate how differences in technique contribute to changes in short- and long-term outcomes of LRYGB.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11695-022-06087-9.

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Declarations

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Conflict of Interest The authors declare no competing interests.

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