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# Procedural Changes to Decrease Complications in Laparoscopic Gastric Bypass

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## ABSTRACT

**Background and Objectives:** Laparoscopic Roux-en-Y gastric bypass (LRYGB) is a complex procedure performed in a patient population with significant medical comorbidities. Evaluation and modification of surgical techniques can minimize the complications associated with the lengthy learning curve for this procedure. The purpose of this study was to evaluate a single surgeon's decade-long experience with LRYGB, to determine whether complications decreased with experience and surgical modifications improved perioperative outcomes.

**Methods:** A retrospective review of all procedures performed by a fellowship-trained surgeon (MK) from December 1, 2000, to October 31, 2013, identified patients who underwent LRYGB. We evaluated perioperative outcomes in 1117 patients and examined the impact of modification of surgical techniques on complications. The patients were divided into 4 groups: cases 1–100 (group 1), cases 101–400 (group 2), cases 401–700 (group 3), and cases 701-1117 (group 4).

**Results:** Operating time decreased significantly after the initial 100 cases, from 179.1 minutes for group 1 to 122.1 minutes for group 4. With experience, early complication rates improved from 25.0% to 5.0%, but the rates of early reoperation increased from 1.0% to 2.2% over the 4 case groups. Late complication and reoperation rates increased from 4.0% to 10.5%. However, rates of bleeding, early stricture, internal hernia, and wound infection all decreased after the modification of surgical techniques.

**Conclusions:** Operating time and early complication rates decreased with operative experience, but late complication and early and late reoperation rates increased. However, after modifications of surgical technique, common complications of LRYGB decreased to rates lower than those reported in several gastric bypass case series in the literature. The findings in this study will be helpful to fellow bariatric surgeons who are refining their strategies for reducing morbidity related to LRGYB.

**Key Words:** Bariatric surgery, Laparoscopic Roux-en-Y gastric bypass, Complications, Morbid obesity, Learning curve.

## INTRODUCTION

Today, 69% of Americans are obese, and 6.6% are morbidly obese, defined as a body mass index (BMI) greater than or equal to 40 kg/m$^2$. Unfortunately, morbid obesity is often refractory to dietary and exercise regimens. Surgical approaches are then used to help achieve meaningful weight loss and decrease medical comorbidities when other weight loss efforts have failed. The obesity epidemic is reflected in the increasing number of bariatric procedures performed in the United States: from 13 365 in 1998 to more than 200 000 in 2008.[1] Today, more than 90% of bariatric surgeries are performed laparoscopically because of fewer wound complications, shorter hospital stays, and more rapid recovery, when compared with open procedures.

The Roux-en-Y gastric bypass (RYGB), initially described by Mason and Ito in 1967,[2] was first performed laparoscopically by Wittgrove and Clark in 1994.[3,4] Since then, it has become the most commonly performed bariatric procedure in the United States. It is among the most complex of laparoscopic procedures, with a learning curve of 75 to 100 cases.[3–6] The learning curve is defined as the number of cases required to achieve a mortality rate <1%, a conversion-to-open rate of 1% to 3%, a major complication rate of <5%, a major leak rate of <2%, and operating time of <2 hours.[3] Fellowship training in advanced laparoscopy skills and high surgeon and hospital case volumes correlate with reduced morbidity and mortality[3,4,7–9] after laparoscopic Roux-en-Y gastric bypass (LRYGB). Nevertheless, improvements in efficiency and modifica-

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tion of the technique, along with progressive experience, can be expected beyond the learning curve.

We report 1 surgeon's experience in performing LRYGB over a 13-year period. We also examine the changes in technique over this time frame and the impact on complication rates.

## METHODS

A prospectively collected database of all procedures performed by 1 fellowship-trained surgeon (MK) from December 1, 2000, to October 31, 2013, was used to identify patients who underwent LRYGB, and the cases were retrospectively reviewed. All patients met the 1991 National Institutes of Health (NIH) Consensus Development Panel criteria for bariatric surgery and successfully completed the interdisciplinary screening and preparation process by a team of health care professionals. Procedures were performed in 1 of 2 high-volume bariatric programs. Testing for the presence of *Helicobacter pylori* was performed before the procedures. Patients recorded in the database who underwent primary RYGB or conversion of a prior bariatric procedure to RYGB were identified. All patients selected for RYGB had been offered a laparoscopic approach. Patients who underwent primary LRYGB are included in the study. Those who converted from a prior bariatric procedure to RYGB, who had significant cardiac disease and were offered an open approach, and who had undergone a robotically assisted procedure were excluded from the study.

Patients provided informed consent to be included in the database and consent for prospective data collection was IRB approved. Data were collected on basic patient demographics, operative details, surgical technique, estimated blood loss, operating time, early and late reoperation rate, morbidity, and mortality. Reoperation, morbidity, and mortality were defined as early if they occurred within 90 days of the operation and as late if they occurred more than 90 days after the operation. Nutritional sequelae of LRYGB are not reported in this study.

Data were analyzed on the basis of chronology. The patients were divided into 4 case groups: cases 1–100 (group 1), cases 101–400 (group 2), cases 401–700 (group 3), and cases 701-1117 (group 4). Data were also analyzed before and after the surgical technique was modified, as will be elaborated in the Results section.

### Perioperative Management

Perioperative management included prophylactic antibiotics for 24 hours, subcutaneous unfractionated heparin throughout the hospital stay, sequential compression devices, proton pump inhibitors, and eradication of *H. pylori* infection if found to be present.

### Surgical Technique

The current LRYGB technique consists of the following. The patient is positioned in a split-leg position. The bladeless trocar technique is used for all 5 trocars: two 12 mm, two 5 mm, and one 15 mm.. The liver is retracted, and a perigastric dissection is performed. The gastric pouch is created with a 3.5-mm (purple) stapler cartridge (Covidien, Mansfield, Massachusetts). All revisions are performed with either a green or black cartridge load (Covidien). A CEEA-25 (Covidien) anvil is inserted orogastrically. The greater omentum is divided with a harmonic scalpel. The jejunum is divided with a 2.5-mm stapler cartridge, 100 cm distal to the ligament of Treitz. The circular stapler is introduced transabdominally in the left upper quadrant, the Roux limb is brought into an antecolic, antegastric position, and the gastrojejunal anastomosis is created. Circumferential absorbable sutures are placed. The cut end of the Roux limb is stapled with a 2.5-mm stapler cartridge after visual inspection of the lumen of the gastrojejunostomy (GJ) for bleeding. The gastrojejunal anastomosis is tested by infusing methylene blue dye across it via an orogastric tube and observing for leakage. The Roux limb is measured for 150 cm, and a jejunotomy is made in the Roux limb, as well as in the proximal jejunal limb. The jejunojejunostomy (JJ) is created with a 60-mm-long, 2.5-mm stapler cartridge, and the resultant opening is closed with another stapler cartridge. Fascial defects of 15 mm or more are closed with Vicryl (Ethicon, Somerville, New Jersey).

### Modification of the Surgical Technique

The technique for LRYGB has evolved with time. The first modification was to apply circumferential sutures to the GJ in an attempt to reduce the bleeding and stricture rate, and later, the JJ was stapled for speed. From 2003 onward, the Roux limb was rotated medially, and mesenteric defects were closed, initially with interrupted sutures and then in a running manner, to minimize the incidence of internal hernia. In 2004, 5 trocars were used instead of 6. In 2005, a Penrose drain was placed in the left upper quadrant after wound infections developed at the circular stapler trocar site, and fascial defects, which were initially closed with Ethibond (Ethicon), were later closed with Vicryl to reduce the incidence of stitch abscess. Last, beginning in 2007, the base of Petersen's space was closed, and local anesthetic and dexamethasone was in-

jected into the left subcostal region to reduce pain and encourage postoperative ambulation.

The limb lengths were planned to be a 100-cm biliopancreatic and a 150-cm Roux limb in all patients except those with a body mass index (BMI) <40. Changes in Roux limb length were decided on during the operation in all other patients on the basis of how the proposed Roux limb reached the gastric pouch and whether there were adhesions in the small intestine or to the pelvis that placed tension on the JJ. Upper gastrointestinal contrast-enhanced imaging series were routinely performed on postoperative day 1 in all the patients as a matter of surgeon preference and to obtain a baseline study. The patients were started on clear liquids (no concentrated sweets) immediately after the upper gastrointestinal series and were discharged home with instructions to remain on the same diet for 10 d after surgery. They then started a pureed diet for 10 days. They were seen during the first and second weeks; then at 6 weeks and 3, 6, 9, 12, 18, 24 months; and then annually.

### Statistical Analysis

For statistical correlations, we used a 2-tailed, 2-sample *z*-test, with statistical significance set at $P < .05$.

## RESULTS

A total of 1163 cases were retrieved from the database. Of these, 1124 (96.6%) were primary RYGB procedures and 39 (3.4%) were revisional procedures (removal of adjustable gastric band and conversion to RYGB). Of the primary RYGB procedures, 1117 (99.3%) were attempted laparoscopically (LRYGB), 2 (0.2%) were robotically assisted, and 5 were converted to open (0.4%). These 1117 (96%) cases were included in the study.

### Primary LRYGB

Of the 1117 cases, 5 were converted to open (2 in group 1, and 1 each groups 2, 3, and 4). Average operating time was 125.6 minutes and average estimated blood loss was 96 mL.

Additional procedures at the time of LRYGB were performed in 110 patients (9.8%), of which 23 had more than 1 additional procedure. These included lysis of adhesions, cholecystectomy, hiatal hernia repair, gastric wedge excision for suspicious lesions, liver biopsy, small bowel resection, enterolysis, reversal of Nissen fundoplication, and incisional hernia repair (**Table 1**). The number of additional procedures performed increased with each case group. Sixty-eight patients in group 4 had at least 1 additional procedure at the time of LRYGB, with 18 in that group undergoing 2 additional procedures (**Table 2A**).

**Table 1.**
Additional Procedures Performed at the Time of Laparoscopic Roux-n-Y Gastric Bypass

| Procedures | Number of Patients |
|---|---|
| Lysis of adhesions | 51 |
| Incisional hernia repair | 28 |
| Cholecystectomy | 26 |
| Hiatal hernia repair | 12 |
| Gastric wedge excision for suspicious lesions | 7 |
| Liver biopsy | 3 |
| Small bowel resection | 3 |
| Enterolysis | 1 |
| Reversal of Nissen fundoplication | 1 |

n = 133.

A total of 96 patients had early complications (8.6%), and 89 had late complications 8.0% (**Table 2B**). The early reoperation rate was 1.7% (n = 19), and the late reoperation rate was 7.9% (n = 88). Of the 88 patients needing late reoperation, 5 underwent more than 1 procedure. The complication frequency for the entire cohort is reported in **Table 3,** where the data refer to the number of the 1117 patients with each complication; some patients experienced more than 1 complication.

Overall, procedure-related mortality during the study period was 0.09% (n = 1). A patient died in the postoperative period of brain death related to postoperative GI bleeding. A transfusion-related acute lung injury (TRALI) developed, and the resulting severe desaturation caused brain death. There were no deaths after the late reoperations.

### Results with Progressive Experience

Operating time decreased significantly as experience progressed past the learning curve of the initial 100 cases (from 179.1 minutes for group 1 to 122.1 minutes for group 4). The early complication rate improved with experience (25.0%–5.0%), but the late complication rate increased (4.0%–10.5%). **Table 4** lists the early and late complications and reoperations by case group.

**Table 2.**
Procedures and Late Reoperations by Group
**A.** Additional Procedures by Case Group

| Group | Patients (n) | Additional Procedures (n) | ≥1 Procedure n (%) | 2 Additional Procedures n (%) |
|---|---|---|---|---|
| 1 | 100 | 6 | 6 (6) | 0 (0) |
| 2 | 300 | 25 | 22 (7.3) | 3 (1) |
| 3 | 300 | 16 | 14 (4.6) | 2 (0.7) |
| 4 | 417 | 86 | 68 (16.3) | 18 (4.3) |

N = 1117.

### Results With Change in Surgical Technique

The incidence of complications as the surgical technique changed is presented in **Table 5**. Since March 2007, the current technique has been used, with a significant improvement in complication rates. In the current series, the early complication and reoperation rates have been 0%, and both the late complication and late reoperation rates have been 3.8%.

## DISCUSSION

The global obesity epidemic has propelled laparoscopic Roux-en-Y gastric bypass to become one of the most commonly performed bariatric procedures. However, LRYGB is one of the most challenging laparoscopic procedures because of the increasing size of obese patients and the associated comorbidities. In addition, the technical complexity of the reconstructive procedure itself, such as gastric pouch and Roux limb creation, 2 anastomoses, and closure of mesenteric defects, require extensive experience to minimize complications.

Common complications of LRYGB include bleeding from staple lines and anastomoses, leaks due to anastomotic or staple line failure, marginal ulcers, bowel obstruction, stricture of the gastrojejunal anastomosis, internal hernias, gastrogastric fistulas, wound infection, abdominal wall hernias, thromboembolic events, and nutritional deficiencies.

Baseline data from the Bariatric Outcomes Longitudinal Database indicate that 14.87% of patients who undergo RYGB experience a complication. Intraoperative complications occur in 1.25%; 5.23% experience a complication before hospital discharge and 9.91% after hospital discharge.[9] Results of this study, with an 8.6% early complication and 8.0% late complication rate, are consistent with these data.

The reported overall morbidity and mortality rates after LRYGB are 14.8% and 0.2%, respectively, according to Higa et al,[10] who studied 1500 patients observed for up to 3 years. Shin[3] evaluated his learning curve with LRYGB. Without modifying his technique, he found a significant reduction in operating time and early complications after just 50 cases. However, Shin found no correlation of mortality, conversion rate, or complication rate with surgeon experience. A direct comparison of data in this series with those reported in other single-surgeon series is difficult for several reasons: discrepancies in technique, reporting, and classification of complications. In addition, most such series report the results for the learning curve only, and many series do not specify how many surgeons were responsible for the data.

Parini et al[11] described their experience with 250 LRYGB in which they incorporated 3 GJ techniques. They reported no mortality, but a 16.4% total complication rate, a 7.2% major complication rate, and a 0.68% conversion rate. Khalaileh et al[7] reported 50 patients operated on by a single surgeon and observed up to 7 months. The complication rate was 10%, and the only complication was early postoperative bleeding, which was managed conservatively. They, too, reported no mortality. Stoopen-Margain et al[5] reported on their first 100 RYGB cases. Their operating time was 228 minutes, conversion to open was 2%, and complications occurred in 10 patients in the perioperative period. The mortality rate in this series was 2%. Sovik et al[6] published a series of 292 patients operated on by 2 surgeons, with a complication rate of 14.7% and no conversions or mortality.

In our series, the early complication rate improved with experience from 25.0% to 5.0%, but the rate of early reoperation remained at 1.0% to 2.2%. The conversion rate improved from 2.0% in the first 100 cases to 0.3% in the other 3 groups. However, the rate of late complication and

**Table 2B.**
Late Reoperations by Case Group

| Group | Procedure (n) |
|---|---|
| 1 | Incisional hernia (3) |
| | Laparoscopic cholecystectomy, LOA, closure of mesenteric defect (1) |
| 2 | Incisional hernia, closure of mesenteric defect (2) |
| | LOA, closure of mesenteric defects (2) |
| | LOA, closure mesenteric defects, laparoscopic cholecystectomy (2) |
| | LOA, laparoscopic cholecystectomy (2) |
| | Incisional hernia (2) |
| | Revision of gastrojejunostomy, hiatal hernia repair (2) |
| | Gastrojejunostomy plication, closure mesenteric defects, umbilical hernia repair (1) |
| | Gastrojejunostomy plication, closure mesenteric defects (1) |
| | Stitch abscess (1) |
| | Laparoscopic cholecystectomy, IOC (1) |
| | Repair of gastric perforation from dilation (1) |
| | Revision of gastrojejunostomy, closure mesenteric defect (1) |
| 3 | Incisional hernia (5) |
| | Endoscopic gastric pouch reduction (4) |
| | Laparoscopic LOA, closure of mesenteric defects (3) |
| | Laparoscopic plication of gastrojejunostomy, closure of mesenteric defects, cholecystectomy (1) |
| | Incisional hernia, laparoscopic cholecystectomy (1) |
| | Incisional hernia, laparoscopic cholecystectomy, closure of mesenteric defect (1) |
| | Laparoscopic closure mesenteric defects, laparoscopic cholecystectomy (1) |
| | Laparoscopic LOA, cholecystectomy (1) |
| | Laparoscopic cecopexy, appendectomy, hiatal hernia repair, closure of mesenteric defect (1) |
| | Laparoscopic hiatal hernia repair, revision of gastrojejunostomy (2) |
| | Laparoscopic revision of gastrojejunostomy, subtotal gastrectomy (1) |
| | Laparoscopic closure of mesenteric defect, umbilical hernia repair (1) |
| 4 | Laparoscopic LOA, closure of mesenteric defects (10) |
| | Laparoscopic cholecystectomy, closure of mesenteric defects (7) |
| | Excision stitch abscess (5) |

B continued on next column.

**Table 2B.** (continued)
Late Reoperations by Case Group

| Group | Procedure (n) |
|---|---|
| | Laparoscopic LOA, incisional hernia repair (3) |
| | Laparoscopic closure of mesenteric defects, incisional hernia repair (3) |
| | Incisional hernia repair (2) |
| | Laparoscopic band around bypass (1) |
| | Laparoscopic cholecystectomy (1) |
| | Laparoscopic cholecystectomy, closure of mesenteric defects, stitch abscess (1) |
| | Laparoscopic closure of internal hernia (1) |
| | Endoscopic gastric pouch reduction (1) |
| | Laparoscopic closure of mesenteric defects, stitch abscess (1) |
| | Laparoscopic LOA (1) |
| | Laparoscopic revision of gastrojejunostomy, hiatal hernia repair, closure of mesenteric defects (1) |
| | Laparoscopic revision of gastrojejunostomy, endoscopy, closure of mesenteric defects (1) |
| | Laparoscopic revision of gastrojejunostomy, hiatal hernia repair, umbilical hernia repair (1) |
| | Laparoscopic revision of gastrojejunostomy, subtotal gastrectomy, cholecystectomy (1) |
| | Laparoscopic closure of mesenteric defects, incisional hernia repair, hiatal hernia repair (1) |
| | Laparoscopic closure of mesenteric defects, appendectomy (1) |
| | Open reversal of bypass, takedown of enterocutaneous fistula, cholecystectomy, jejunostomy tube (1) |

n = 88 (total late reoperations). LOA = lysis of adhesions; IOC = intraoperative cholangiogram.

the need for reoperation increased from 4.0% to 10.5%. There are several possible reasons for the increase in late complication. Starting in 2007, the requirements for long-term follow-up with the BOLD Database (Surgical Review Corporation, Raleigh, North Carolina) were adhered to, with greater outreach to the patients, to encourage their compliance with follow-up visits. Media, Internet blogs, and support groups surrounding weight loss surgery and aftercare, which are still present, may have brought more patients to follow-up. In addition, there were marketing pushes for endoscopic procedures for weight regain as well as the placement of a band around the bypass. In group 4, five of the surgeries were for stitch abscesses that presented well after the original procedure, but such oc-

**Table 3.**
Frequency of Early and Late Morbidity

| Early Complications n (%) | | Late Complications n (%) | |
|---|---|---|---|
| Wound infection | 30 (2.7) | Internal hernia | 26 (2.3) |
| Stricture | 18 (1.6) | Incisional hernia | 22 (2.0) |
| Bleeding | 17 (1.5) | Mesenteric defect | 21 (1.8) |
| Marginal ulcer | 5 (0.45) | Gallstone disease | 15 (1.3) |
| Intra-abdominal abscess | 4 (0.4) | Pouch dilation | 8 (0.72) |
| Pneumonia | 4 (0.4) | Stitch abscess | 8 (0.72) |
| Pulmonary embolism | 4 (0.4) | Hiatal hernia | 6 (0.54) |
| Obstruction | 3 (0.3) | Marginal ulcer | 5 (0.45) |
| Leak | 2 (0.2) | Gastrogastric fistula | 3 (0.3) |
| Atrial fibrillation | 1 (0.09) | Stricture | 1 (0.09) |
| *C. difficile* infection | 1 (0.09) | | |
| Cavernous sinus thrombosis | 1 (0.09) | | |
| Death | 1 (0.09) | | |
| Deep vein thrombosis | 1 (0.09) | | |
| Incisional hernia | 1 (0.09) | | |
| Liver abscess | 1 (0.09) | | |
| Perforation | 1 (0.09) | | |
| Portal vein thrombosis | 1 (0.09) | | |
| Renal failure | 1 (0.09) | | |
| Richter's hernia | 1 (0.09) | | |
| Stitch abscess | 1 (0.09) | | |

Percentages are based on total cases, N = 1117. Data are the patients experiencing each complication; some had more than one. Total patients with early complications = 96 (8.6%); total with late complications = 89 (8.0%).

**Table 4**.
Morbidity with Progression of Experience

| Group | Patients (n) | Early Complications n (%) | Early Reoperation n (%) | Late Complications n (%) | Late Reoperation n (%) |
|---|---|---|---|---|---|
| 1 | 100 | 25 (25.0) | 2 (2.0) | 4 (4.0) | 4 (4.0) |
| 2 | 300 | 32 (10.7) | 5 (1.7) | 18 (6.0) | 18 (6.0) |
| 3 | 300 | 18 (6.0) | 3 (1.0) | 23 (7.7) | 22 (7.3) |
| 4 | 417 | 21 (5.0) | 9 (2.2) | 44 (10.5) | 44 (10.5) |

N = 1117.

currences were eliminated by the change of suturing technique for fascial closure. More patients who underwent post-LRYGB laparoscopic cholecystectomy most likely returned to the office for follow-up and so were operated on again by the original surgeon. **Table 2B** details what the reoperations were.

There is no standardized technique for LRYGB. In a recent survey of 215 surgeons performing RYGB,[11] variations were reported in construction of the pouch, GJ, JJ, and Roux limb. Variable practices were also reported with respect to closure of mesenteric defects, sizing the gastric pouch, reinforcing the gastric pouch (use of banded by-

**Table 5.**
Complications Before and After Modifications

| Complication | Modification | Before | After | Start and End Date | *P* |
|---|---|---|---|---|---|
| Bleeding from the GJ | Circumferential sutures to the GJ | 3/211 (1.4) | 3/906 (0.3) | 09/2002 | 0.05 |
| Early stricture | Circumferential sutures to the GJ | 6/211 (2.8) | 12/906 (1.3) | 09/2002 | 0.11 |
| Internal hernia | Medial rotation of the Roux limb and interrupted closure of mesenteric defects | 2/280 (0.7) | 5/183 (2.7) | 01/2003-present | 0.08 |
| | Running closure of mesenteric defects | 7/463 (1.5) | 17/558 (3.0) | 07/2003 to present | 0.11 |
| | Closure of the base of Petersen's space | 24/1021 (2.4) | 1/96 (1.0) | 2007 to present | 0.41 |
| Wound infection | Insertion of a Penrose drain in the left upper quadrant | 27/830 (3.3) | 2/287 (0.7) | 2005 to present | 0.02 |

Data are the patients with the complication/total patient sample (percentage). GJ = gastrojejunostomy.

pass), and testing the integrity of the GJ during and after surgery.

Some studies reported the effect of surgical technique on clinical outcome of LRYGB. Results from the Michigan Bariatric Surgery Collaborative[12] indicate that use of a circular stapler in creation of the GJ is associated with higher rates of postoperative bleeding and wound infection. In contrast, the linear stapler and hand-sewn GJ techniques lead to reduced rates of postoperative bleeding. According to Giordano et al,[13] the stricture rate is lower with the use of a linear stapler. In this series, the stricture rate declined after the technique was modified by placing circumferential absorbable sutures. Small series comparing techniques for creating the GJ have not identified differences in the rates of leakage or hemorrhage, but staple line reinforcement has been shown to reduce intraoperative bleeding,[12] division of the stomach has been shown to reduce instances of gastrogastric fistula formation,[14] and lengthening the Roux limb from 75 to 150 cm increases the percentage of weight loss by approximately 14%, without apparent metabolic sequelae.[15]

Internal hernias after LRYGB occur at 3 sites: the transverse mesocolon window, Petersen's space, and the mesenteric defect at the JJ. Internal hernia occurs more frequently with the laparoscopic approach because there are fewer adhesions. Some surgeons advocate routine closure of all mesenteric defects,[10] whereas others have adopted a selective approach to closure without a recorded increase in internal hernia.[16] Similarly, there is no consensus as to whether the placement of the Roux limb should be antecolic or retrocolic. While the incidence of Petersen's hernia decreased in our series, the internal hernia rate did not. Oversewing the staple line, use of fibrin sealants, and the application of buttressing material have all been evaluated in the literature as possible options for minimizing postoperative leaks. However, there is no evidence that supports oversewing staple lines to prevent leaks.[17] The leak rate remained low in this series, but after the first leak, sutures were placed around the GJ.

Tejirian et al[18] reported the experience of 4 surgeons with 1096 gastric bypass procedures over a 5-year period. They, too, modified their technique as their experience progressed and reported an overall complication rate of 7%. Early reoperations were required in 2% and they reported no surgery-related deaths and no strictures. Han et al[19] reported outcomes in 835 LRYGB operations performed by 4 surgeons. The initial 143 had retrocolic, retrogastric positioning of the Roux limb, and the mesenteric defects were closed. The surgeons then changed to an antecolic, antegastric approach without closure of the defects and reported no incidence of internal hernia. Shikora et al[4] described their results in 750 patients undergoing LGRYB without evolution of technique throughout the study period. They noted a progressive decrease in operating time with experience (212 minutes in the initial 100 patients to 132 minutes for all cases after the first 100 cases), hospital stay, and blood loss. Their overall mortality rate was 0.3%, and the complication rate was 15%.

Lim et al[20] cited the incidence of bleeding and stricture formation as between 0.8% and 4.4% and 8% and 19%, respectively. In our series, the incidence of bleeding from

**Table 6.**
Complications in Selected Gastric Bypass Series

| Author | Date | N | Internal Hernia | Stricture | Marginal Ulcer | Wound Infection | Bleeding |
|---|---|---|---|---|---|---|---|
| Obeid et al. (21) | 2012 | 172 | 19 | 11 | 13 | | |
| Suter et al. (22) | 2011 | 379 | 9 | 6.6 | 1 | | |
| Higa et al. (23) | 2011 | 242 | 16 | 4.9 | | | |
| Finks et al. (12) | 2011 | 9904 | | | | 3.2 | 2.3 grade I<br>0.5 grade II |
| Tejirian et al. (18) | 2008 | 1096 | | 0 | 1.3 | | 4.4 |
| Carrodeguas et al. (24) | 2006 | 1291 | | 7.3 | | | |
| Higa et al. (10) | 2003 | 2000 | 3.1 | | | | |
| Podnos et al. (25) | 2003 | 3464 | | 4.73 | | 2.98 | |
| Present study | 2014 | 1117 | 2.3 | 1.7 | 0.9 | 2.7 | 1.5 |

Data are percentage of total patient sample (N).

the GJ decreased from 1.4% to 0.3% after the GJ was circumferentially sutured. The early stricture rate also improved (2.8%–1.4%) after this modification. The rate of conversion to an open approach was also low: 0.45%, compared with 1.7%[20] quoted in the literature. We report lower rates of internal hernia with progressive modifications of the technique, with the incidence being 1.0% since the current technique has been used. The initially increased rate of internal hernia with both interrupted and running closure of mesenteric defects can be attributed to incomplete closure of the defect. It can be technically difficult to get to the base of the mesentery, and gaps may occur in a running suture that is not cinched tightly. The suture can also tear out of the closure in the postoperative period. The incidence of wound infections has improved significantly since the initiation of the practice of inserting a Penrose drain in the left upper quadrant ($P = .02$). Although the insertion of the Penrose drain was the single surgical modification to achieve a statistically significant decrease in complication rates, a clear trend in improved complications can be seen with all the surgical modifications described (**Table 5**). **Table 6** summarizes complication rates after LRYGB in selected series.

## CONCLUSIONS

After a learning curve for LRYGP of 100 cases, continual improvement in efficiency and complication rates can be expected as experience progresses and surgical technique evolves. Frequent examination of a database of patient outcomes will alert surgeons to re-examine aspects of the surgical technique and modify them as necessary.

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