

COMPARABLE OUTCOMES IN ROBOTIC AND LAPAROSCOPIC BARIATRIC SURGERY

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ABSTRACT

Background: Laparoscopic Roux-en-Y gastric bypass (RYGB) is a well-established surgical treatment for morbid obesity. Robotic-assisted RYGB has recently emerged as an alternative approach with potential advantages in reducing perioperative complications. This study aimed to compare outcomes of robotic versus laparoscopic RYGB in a teaching institution over a defined period.

Methods & Material: This prospective comparative study included 231 consecutive patients who underwent minimally invasive RYGB between January 2024 and June 2024. Patients were divided into two groups: robotic RYGB (n=121, 52.4%) and laparoscopic RYGB (n=110, 47.6%). Data were collected prospectively and analyzed for operative time, conversion rate, perioperative complications (Clavien-Dindo classification), reoperations, hospital stay, and weight loss outcomes.

Results: Operative time was significantly longer in the robotic group. However, robotic RYGB demonstrated a lower conversion rate and reduced overall postoperative complications compared to laparoscopic surgery. Anastomotic leak rates and early reoperations were also lower in the robotic group. Hospital stay was shorter in robotic cases. Mortality was comparable between both groups with one case in each cohort. While learning curve effects improved operative efficiency over time, no significant impact on overall morbidity or mortality was observed. Laparoscopic patients demonstrated slightly greater long-term BMI reduction compared to robotic patients.

Conclusions: Robotic RYGB is a safe and feasible alternative to laparoscopic RYGB, offering improved short-term perioperative outcomes, including lower conversion rates, fewer complications, and shorter hospital stay. However, laparoscopic surgery showed marginally better long-term weight loss outcomes. Further studies are required to define the optimal role of robotic bariatric surgery.

Keywords: Robotic, bariatric, Surgery

Introduction

Two decades after the introduction of laparoscopic Roux-en-Y gastric bypass (RYGB)¹ it is now widely regarded as the standard bariatric procedure particularly across most bariatric centers^{2,3}. Extensive

studies have demonstrated not only favorable perioperative results but also consistent and durable long-term weight reduction^{4,5}. Furthermore, RYGB has been shown to significantly improve or resolve many obesity-associated co-morbid conditions,

including diabetes, hypertension, and obstructive sleep apnea^{6,7}. Although the overall complication rate following laparoscopic RYGB remains relatively low, the incidence of gastrointestinal leaks has been reported to be as high as 5.2%⁸⁹. Such leaks are considered one of the most serious complications after RYGB, which is why

Identifying and addressing potential risk factors continues to be an area of active research to reduce this risk. At the same time, robotic technology has evolved to broaden the scope of minimally invasive surgical procedures. Since the early 2000s, robotic surgery has been shown to be both safe and feasible, even for technically demanding and complex operations¹⁰. In the field of bariatric surgery, robotic approaches have been successfully adopted, as evidenced by multiple institutional reports¹¹⁻¹⁵. In particular, outcomes of robotic RYGB have been encouraging, with some studies suggesting a potential decrease in anastomotic complications as demonstrated in recent systematic reviews¹⁶⁻¹⁸. Nevertheless, its adoption remains confined to a limited number of centers, likely due to the absence of large-scale comparative studies. The objective of our study was to present our long-term experience with robotic RYGB in a teaching hospital and to compare its outcomes with those of the laparoscopic technique.

Material and Methods

Study Design: A prospective comparative study was conducted.

Study Setting: Department of General Surgery, Jinnah Postgraduate Medical Centre (tertiary care hospital), Karachi, Pakistan.

Study Duration: January 2024 to June 2024.

Sample Size: The sample size was calculated with Open-EPI software using a 95% confidence interval and 5% margin of error, resulting in a final sample size of $n=231$.

Sampling Technique: Non-probability consecutive sampling.

Selection Criteria: There were no specific selection criteria for assigning patients to robotic or

laparoscopic groups. Exclusion criteria were identical for both cohorts and included contraindications to general anesthesia and the presence of a hostile abdomen.

In addition to it, all procedures were performed by experienced laparoscopic and robotic surgeons, each with extensive experience in advanced minimally invasive bariatric surgery. Patients were selected according to standard bariatric eligibility criteria and underwent a comprehensive preoperative evaluation, including upper gastrointestinal endoscopy, nutritional assessment, and multidisciplinary review involving surgical, medical, and psychiatric evaluation. Postoperative follow-up was systematically arranged through a dedicated bariatric care program and coordinated by a specialized research nurse in accordance with institutional and national follow-up protocols.

Surgical Technique: A standardized surgical technique was used in both groups with minor differences based on the approach. Moreover, Pneumo-peritoneum was established using the OPTIVIEW access technique. A small gastric pouch of approximately 20–30 mL was created using linear staplers. A standard RYGB was constructed with a 150-cm alimentary limb. In the robotic group, both gastrojejunal (GJ) and jejunojejunal (JJ) anastomoses were performed using a hand-sewn single-layer continuous technique with 2-0 Vicryl sutures, allowing precise intracorporeal suturing under enhanced 3D visualization. In the laparoscopic group, the gastrojejunal anastomosis was performed using either a circular stapled technique with a trans orally introduced anvil or a linear stapled technique in later cases. The jejunojejunal anastomosis was constructed using a linear stapler in all cases. At the end of each procedure, a routine air leak test was performed. Drain placement near the gastrojejunal anastomosis was left to the discretion of the operating surgeon.

Postoperative Management: During the initial phase of our experience, patients routinely underwent a postoperative liquid contrast study on postoperative day (POD) 2. If no abnormality was detected, a liquid diet was started on POD 3, followed by a puree diet on POD 4. Perioperative outcomes were compared between the two groups. Operative time was defined as

the interval from the initial skin incision to final skin closure. Conversion was considered when completion of the procedure required switching to a different surgical approach than initially intended.

Thirty-day morbidity and mortality were assessed, with complications classified according to the Clavien-Dindo grading system. For assessment of weight reduction, percentage BMI loss (%BMI loss) was calculated as the difference between preoperative BMI and follow up BMI, divided by the preoperative BMI. The percentage of excess BMI loss (%EBMIL) was calculated using the formula: $\%EBMIL = 100 - ((\text{follow-up BMI} - 25) / (\text{initial BMI} - 25) \times 100)$ Where a BMI of 25 was taken as the upper limit of normal.

Statistical Analysis: Parametric data were presented as mean \pm standard deviation (SD), while nonparametric data were expressed as median with range. All statistical analyses were performed using IBM SPSS statistics 30.x software. A confidence interval of 95% was applied, and a two-tailed p-value of ≤ 0.05 was considered statistically significant. Comparisons between the two groups were carried out using Fisher's exact test for categorical variables and Student's t-test for continuous variables.

Results: During the study period, a total of 231 patients underwent minimally invasive RYGB. Of these, 121 procedures (52.4%) were performed using a robotic approach, while 110 cases (47.6%) were completed laparoscopically. A slightly higher proportion of male patients was observed in the robotic group; however, this difference was not statistically significant. Patients in the laparoscopic group were marginally younger (mean age 41.9 vs. 43.2 years; $p=0.03$) and had a slightly higher preoperative BMI ($+0.6 \text{ kg/m}^2$; $p=0.05$). No significant differences were noted between the two groups in terms of American Society of Anesthesiologists (ASA) classification or associated comorbid conditions.

Peri-Operative Outcomes : The mean operative duration was longer in the robotic group, with an average increase of approximately 25 minutes compared to the laparoscopic approach ($p=0.001$). However, the conversion rate was lower in the robotic cohort (1.6% vs. 5.4%; $p=0.02$). In the robotic group, two conversions were recorded: one

due to stapler malfunction and another due to dense intra-abdominal adhesions. In contrast, six conversions occurred in the laparoscopic group, attributed to adhesions ($n=2$), enlarged left liver lobe ($n=1$), difficulty maintaining pneumoperitoneum ($n=1$), trocar-related injury ($n=1$), and technical issues including stapler failure ($n=1$). The rate of intraoperative complications was comparable between the groups. In the robotic cohort, two intraoperative events were noted: one stapler misfire and one gastric pouch perforation caused by a nasogastric tube, which was repaired robotically. In the laparoscopic group, four intraoperative complications were documented, including one esophageal injury (repaired intraoperatively), one duodenal injury during trocar insertion, one intraoperative leak detected on testing, and one case of severe bronchospasm during anesthesia induction.

Postoperative Morbidity: Overall postoperative complications were lower in the robotic group (12.4%) compared to the laparoscopic group (17.3%; $p=0.05$). In the robotic group, 15 complications were recorded, the majority being minor (Grades I-II, approximately 73%). Grade I ($n=4$): included anastomotic edema causing delayed diet progression, transient peripheral paresthesia, atelectasis, and minor wound complications. Grade II ($n=6$): included pulmonary embolism ($n=3$), deep venous thrombosis ($n=1$), bacteremia ($n=1$), and urinary tract infection ($n=1$). Grade III ($n=2$): required intervention, including one reoperation and one endoscopic hemostasis for bleeding. Grade IV ($n=3$): included respiratory failure and severe pulmonary complications requiring ICU admission. In the laparoscopic group, 19 complications were observed, with the majority classified as Grades I-II (~70%). Grade I ($n=7$): included wound infections, minor gastrojejunal leaks managed conservatively, atelectasis, bile leak following liver biopsy, and anastomotic edema delaying diet.

Grade II ($n=8$): included pulmonary embolism ($n=3$), deep venous thrombosis ($n=1$), gastrointestinal bleeding requiring transfusion ($n=2$), urinary tract infections ($n=2$), pneumonia ($n=1$), intra-abdominal abscess ($n=2$; requiring intravenous antibiotics), heparin-induced thrombocytopenia ($n=1$), acute pulmonary edema ($n=1$), and Clostridium difficile-associated diarrhea ($n=1$). A total of five Grade III

complications were identified in the laparoscopic group. Among these, two were Grade IIIa, including one duodenal leak following concomitant subtotal gastrectomy (managed with radiological drainage) and one pulmonary embolism requiring inferior vena cava filter placement. One bile leak following liver biopsy was also managed successfully with image-guided drainage. Additionally, three Grade IIIb complications required surgical re-intervention. Furthermore, three Grade IV complications were reported. One patient developed respiratory failure requiring intubation, while another required prolonged ventilatory support in the ICU. The remaining case (Grade IVb) involved a gastrointestinal leak.

Reoperations and Early Surgical Interventions: In addition, there were fewer early reoperations in the robotic group (approximately 1.7%) compared to the laparoscopic group (around 5.0%; $p=0.05$). In the robotic cohort, three re-interventions were required: one for staple line bleeding, one for an incarcerated port-site hernia, and one for a late gastrojejunal leak occurring on Post-operative day 13 following dietary indiscretion. Another patient underwent re-exploration due to a suspected infected hematoma. In contrast, the laparoscopic group required nine reoperations. The majority were related to anastomotic failure, including four jejuno-jejunal leaks, three gastrojejunal leaks, and one leak originating from the gastric remnant. One patient underwent negative exploration where no definitive intra-abdominal pathology was found. Additional reoperations included one incarcerated port-site hernia leading to gastrojejunal disruption due to increased intra-abdominal pressure, one cystic duct leak on postoperative day 1 requiring re-exploration, one large intra-abdominal hematoma requiring evacuation, and one case of mechanical obstruction due to kinking of the alimentary limb, which necessitated surgical correction and placement of a remnant gastrostomy.

Effect of Learning Curve: When the series was stratified chronologically into early and late phases, no significant differences were observed in overall complication, reoperation, or mortality rates between initial and later cases in either group. However, a marked reduction in operative time was noted with

experience, particularly in the robotic group, where operative duration decreased by nearly two hours between the first and last 100 cases ($p=0.0001$). Similarly, the difference in operative time between the most recent robotic and laparoscopic cases became minimal (approximately 18 minutes; $p=0.06$), suggesting convergence of performance with experience.

Effect on Body Mass Index: Maximum weight reduction was observed at approximately 24 months of follow-up. Interestingly, patients in the laparoscopic group demonstrated slightly greater BMI reduction, higher percent BMI loss, and higher excess BMI loss compared to the robotic group.

Discussion: More than a decade after the introduction of robotic bariatric surgery, its precise role in metabolic and bariatric procedures continues to evolve. Although its feasibility and safety have been well established for Roux-en-Y gastric bypass as well as other bariatric procedures including sleeve gastrectomy, gastric banding, and duodenal switch, its widespread adoption remains limited. Despite multiple encouraging reports, a segment of the surgical community continues to await stronger comparative evidence demonstrating clear superiority of robotic over conventional laparoscopic techniques. Nevertheless, recent systematic reviews suggest at least comparable, if not improved, postoperative outcomes with robotic assistance. Potential advantages of robotic surgery include a shorter learning curve, improved ergonomics, and potentially safer performance in technically complex scenarios such as super-obesity and revisional bariatric surgery. The present study represents one of the larger comparative series with extended follow-up, demonstrating that robotic RYGB is associated with reduced conversion rates, lower reoperation rates, and shorter hospital stay, although at the cost of longer operative time. These findings are consistent with most published literature. A particularly notable observation is the reduction in anastomotic leaks in the robotic group, supporting the hypothesis that hand-sewn robotic anastomosis may provide improved technical precision compared to laparoscopic stapled techniques.

However, an increased incidence of pulmonary embolism in the robotic group was also observed, potentially related to longer operative duration rather than surgical technique itself. Interestingly, despite these perioperative advantages, laparoscopic patients demonstrated slightly superior long-term weight loss outcomes, which may be influenced by differences in anastomotic calibration and limb measurement techniques. Overall, the learning curve appeared limited, with most improvements related to operative efficiency rather than complication reduction, suggesting that both techniques are reproducible in experienced hands. Finally, although robotic surgery offers several technical and perioperative benefits, its optimal indications remain under discussion. Current evidence supports its use in selected complex cases, but not yet as a universal replacement for standard laparoscopy. With a cumulative global experience exceeding 1,800 robotic RYGB procedures reported in the literature, the robotic approach can now be considered a safe, feasible, and valid alternative, particularly in technically demanding cases. As previously highlighted, revisional bariatric procedures—which are inherently complex—can be performed safely using robotic assistance¹⁹, with outcomes that are often superior to both open and conventional laparoscopic approaches²⁰. Similarly, super-obese patients represent another important indication, where robotic technology may offer advantages by reducing torque effects and facilitating dissection within deep and narrow operative fields²¹. However, concerns have been raised regarding the high cost of robotic systems²². In bariatric surgery, our previous cost analysis demonstrated a potential economic advantage of the robotic approach, mainly due to a reduction in postoperative complications²³ and fewer radiological investigations required during follow-up²¹. Comparable findings have also been reported by some institution²⁴. Conversely, other studies have reported increased overall costs associated with robotic surgery²²⁻²⁴. A recent systematic review and economic evaluation by²⁵ concluded that robotic RYGB is generally associated with higher expected costs compared to laparoscopic surgery. Therefore, further robust data are required to clearly define the economic impact of robotic bariatric surgery. Despite the strengths of this study, several limitations should be acknowledged. First, its non-randomized design

limits the level of evidence, as it represents a large prospective comparative cohort rather than a randomized controlled trial. The study spans different time periods and involves multiple surgeons; however, all procedures followed a standardized technique within a teaching institution. Overall, no major differences were observed across time periods except for operative time and hospital stay, likely reflecting the effect of the learning curve.

Conclusions: The present study represents one of the largest reported robotic bariatric series with extended follow-up. Our findings demonstrate that robotic Roux-en-Y gastric bypass is a safe, feasible, and effective alternative to conventional laparoscopy. Although associated with a longer operative time, the robotic approach was linked to improved short-term outcomes, including reduced conversion rates, fewer reoperations, and shorter hospital stay. However, long-term weight loss outcomes unexpectedly favored the laparoscopic group, prompting us to refine our surgical technique, particularly regarding alimentary limb measurement and calibration of the gastrojejunal anastomosis. Overall, robotic bariatric surgery appears to offer meaningful perioperative advantages, but further high-quality randomized and cost-effectiveness studies are required before it can be considered a universal standard approach.

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