Robotic gastric bypass may lead to fewer complications compared with laparoscopy

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Abstract

Background Robotic technology leads to improved visualization and precision over laparoscopy but also higher cost of care. The benefits of this technology to patient outcomes are controversial. Our objective was to assess whether the application of robotic surgery to Roux-en-Y gastric bypass (RYGB) would lead to improved patient outcomes.

Methods A prospectively collected database at a bariatric center of excellence was reviewed for all RYGB procedures performed by one surgeon between 2007 and 2015. Procedures performed laparoscopically (transoral circular stapling technique) versus robotically (hand-sewn anastomosis) were compared; the transition in technique occurred in 2011. Patient demographics, baseline weight, BMI, operation duration, estimated blood loss (EBL), length of hospital stay (LOS), morbidity and mortality, and percent excess weight loss (%EWL) at 1-year follow-up were compared between groups. Morbidity up to 1-year postop was assessed using the Clavien–Dindo classification.

Results Of 246 patients, 125 underwent robotic and 121 laparoscopic RYGB. Patients in the robotic group were older and heavier but achieved similar %EWL to the laparoscopic group. The operative duration was longer but the mean patient LOS was shorter with the robotic approach. There were no leaks and no mortality. Based on the Clavien–Dindo classification, fewer overall and fewer severe complications occurred in the robotic compared with the laparoscopic approach.

Conclusion In our experience, the use of robotic technology for the creation of gastric bypass led to longer operative times, similar %EWL but decreased LOS and number and severity of complications compared with the laparoscopic approach. Since our findings may have been influenced by the type of anastomotic technique used with each approach they need confirmation by a controlled trial.

Keywords Roux-en-Y gastric bypass • Bariatric surgery • Robotic • Complications • Patient outcomes

Obesity has reached epidemic proportions in the United States. While the prevalence of obesity was below 15% [1] in 1990, currently it is estimated that about 37.5% of the American adult population suffers from obesity [2]. Obesity-associated comorbidities such as diabetes, sleep apnea, hypertension, cardiovascular disease, dyslipidemia, osteoarthritis, and even cancer [3] have been linked to more than 2.5 million deaths in the world annually [4]. Given that many of the obesity-associated comorbidities resolve with weight loss [5, 6] effective weight loss methods are in high demand.

While multiple approaches exist for weight loss [7], bariatric surgery leads to the most sustainable weight loss and comorbidity resolution in the long term [8]. The Roux-en-Y gastric bypass (RYGB) procedure is one of the most effective weight loss procedures and has stood the test of time [6, 8]. Since it was first introduced in 1967, the...
procedure has evolved from an open to a laparoscopic technique [8]. The advantages of the minimally invasive approach, such as faster patient recovery, decreased rate of incisional hernias [9] and its safety profile [10], have led to the procedure being performed laparoscopically in the vast majority of cases in the US currently. Nevertheless, the laparoscopic Roux-en-Y Gastric Bypass (LRYGB) is a very technically challenging procedure [11] with a significant associated learning curve that recently has been shown to continue even beyond 500 cases [12].

Robotic surgery was introduced in 2001 [8] to address the limitations of laparoscopic surgery [9]. The instrument tip articulation, magnified and three-dimensional visualization, avoidance of fulcrum, camera stability, and motion scaling address known challenges of the laparoscopic technique and may lead to increase procedural accuracy that may benefit patients [9, 10]. Further, robotic technology may allow for easier performance of procedures [10]. Indeed, robotic surgery has seen significant penetration in urology and gynecology and most recently also in general surgery [13]. Nevertheless, besides some promising reports also in bariatric surgery [14–17], the benefits of the technology to patient outcomes have been questioned especially given its increased cost [18, 19].

The purpose of this study was to explore further the potential benefits of robotic surgery in bariatric surgery and to compare patient outcomes between the robotic and laparoscopic RYGB techniques. We hypothesized that the robotic technique would lead to fewer postoperative complications compared with the laparoscopic technique.

Methods

Patients

After Institutional Review Board (IRB) approval was obtained, prospectively collected data from a bariatric surgery center of excellence were reviewed and patients who had undergone RYGB between 2007 and 2015 identified. Only primary procedures were considered in this analysis; revisional cases were excluded. To be considered for bariatric surgery, the patients had to have a BMI of 40 kg/m² or a BMI of 35 kg/m² with at least one comorbidity. All patients had preoperative risk stratification and the majority had to successfully complete a preoperative supervised 3–6 month weight loss program as mandated by their insurance. The variables that were collected for analysis were patient demographics, baseline BMI, operation duration, estimated blood loss (EBL), length of hospital stay (LOS), percent excess weight loss (%EWL) at 1-year postoperative, 30-day readmissions and reoperations, and surgery-related complications at 30 days and within 1 year after surgery. In addition, preoperative comorbidities (hypercholesterolemia, hypertension, joint pains, diabetes mellitus, obstructive sleep apnea, etc.) and their resolution was assessed during the follow-up period. Postoperative complications were classified according to the Clavien–Dindo classification system (Table 1). This classification was developed to allow for an objective, simple, reliable, and reproducible way of reporting negative events after surgery [20, 21]. Its goal is to eliminate subjective interpretation of serious adverse events (such as “minor” or “major complication”) and any tendency to down-grade complications, because it is based on data that are usually well documented and easily verified. As recommended by its developers, in patients who may have experienced more than one related complications we counted only the highest-grade (worst) complication [21]. The primary outcome was the rate of complications according to Clavien–Dindo during the one-year follow-up period.

Procedure details

One surgeon (DS) performed all procedures with the assistance of a minimally invasive surgery fellow or general surgery resident. The laparoscopic approach was utilized during the first half of the study period (October 2007–July 2011), while the robotic approach was used during the second half (August 2011–July 2015). The laparoscopic approach included a 5-trocar technique (three 12 mm and two 5 mm trocars) and a Nathanson liver retractor in the subxiphoid position. The RYGB was constructed with a stapled jejunoojejunostomy and a 25-mm circular-stapled gastrojejunostomy. For the first 15 cases, a transgastric circular-stapled technique was used, while for the remaining a transoral technique (OrVil™) was used. A 150-cm antecolic antegastric Roux limb was created in the majority of the cases and both mesenteric defects were closed with permanent suture. A retrocolic Roux was constructed in <5% of cases where the antecolic approach was not feasible due to excessive anastomotic tension.

The robotic technique also involved five trocars (three 8-mm robotic trocars, and two 12-mm trocars) and the Nathanson retractor. The jejunoojejunostomy was created using the linear stapler similar to the laparoscopic approach during the initial half of the robotic experience and then transitioned to stapled anastomosis and robotic sewn closure of the enterotomies. The gastrojejunostomy was created using a linear stapling technique for the first ten cases and then completely hand sewn using robotic assistance. An antegastric antecolic approach was used and both mesenteric defects were closed with permanent suture.
similar to the laparoscopic technique. A small number of retrocolic Roux’s were constructed using the same criteria as during the laparoscopic approach. An endoscopic leak test was performed in all cases (laparoscopic or robotic) and no drains were placed.

Postoperatively, patients were discharged home usually on day 1 or day 2 after they were tolerating an adequate amount of oral fluids, had adequate pain control and no other concerns existed. They were followed in the office at 2 and 6 weeks, 3, and 6 months and 1 year after surgery and yearly thereafter. The follow-up duration of each patient was recorded and the % lost to follow up at 1 year was calculated.

To assess the effect of the learning curve on patient outcomes, we compared outcomes between the first and second half of patients in each group (i.e., the first 62 vs. the last 63 patients in the robotic group and the first 60 vs. that last 61 for the laparoscopic group). We hypothesized that if a learning curve effect was present we would detect lower complication rate in the second half of patients in either group.

**Statistical analysis**

Descriptive statistics were used including means and standard deviations or medians and range for continuous and ordinary data, respectively, and percentages for categorical data. A Student’s t test was used to compare the means between the groups and a Chi-square test was used to compare categorical data including the primary outcome (% complications at one-year postoperative). SAS statistical software was used for the analysis (SAS Institute, Inc., Cary, North Carolina).

**Results**

Two-hundred and 46 patients underwent RYGB during the study period; 121 patients underwent the laparoscopic technique and 125 patients underwent the robotic technique. Three patients had their procedure performed laparoscopically during the robotic phase of the study period due to unavailability of the robot and have been included with the laparoscopic group. There were 206 females (84%) and 40 males (16%). The mean body mass index (BMI) of all the patients was 47.6 kg/m^2 (range 35.4–62 kg/m^2, SD 6.197). Characteristics of the patients in the two groups are shown in Table 2. The robotic surgery group was older and had a higher BMI.

In addition to undergoing RYGB surgery, 27 patients in the robotic group and 32 patients in the laparoscopic group also underwent hiatal hernia repairs (p = NS), while another 12 patients in the robotic group and seven patients in the laparoscopic group (p = NS) underwent a concomitant cholecystectomy.

Perioperative outcomes are shown in Table 3. The robotic procedures took longer but had a similar EBL with the laparoscopic procedures. One of the laparoscopic procedures had to be converted to open. The patient had an uneventful recovery. Other than this case, there were no notable intraoperative complications in any group. The mean hospital stay was 1.7 ± 0.74 for the robotic group and 2.1 ± 1.04 for the laparoscopic group, respectively (p < 0.001).

Patient follow-up was longer for the robotic group (14.1 ± 10.8 months vs. 10.3 ± 10.2 months for the laparoscopic group; p < 0.01). The percentage of patients who were lost to follow up at 1 year was lower for the
The mean percent excess weight loss at one-year follow-up was 84% in the robotic group and 77% in the laparoscopic group ($p = 0.01$). Comorbidity resolution was similar between the groups. Postoperative complications are shown in Table 4. Overall complications according to Clavien–Dindo classification were higher in the laparoscopic group compared with the robotic group during the one-year FU period.

Most major complications according to the Clavien–Dindo classification were upper endoscopies performed to rule out an ulcer or stricture due to patients experiencing dysphagia/odynophagia (Table 5). While more frequent in the laparoscopic group, the difference was not statistically significant. In addition, endoscopies with negative findings were also higher in the laparoscopic group (43 vs. 31%, respectively) but this difference was also not statistically significant. The only complication that reached statistical significance between groups was the need for laparoscopic cholecystectomy.

In regards to the effect of the learning curve, the laparoscopic group had 24 complications in the first half of...
patients and another 24 in the second half ($p = 0.99$); the robotic group had 19 complications in the first half and 13 in the second ($p = 0.18$).

**Discussion**

Our hypothesis that gastric bypass surgery performed robotically would lead to fewer postoperative complications compared to laparoscopy was supported by the findings of this study. We found that within the 1-year follow-up duration of this study the patients that underwent robotic RYGB had significantly fewer Clavien–Dindo grade 3 and 4 complications compared with laparoscopic RYGB. We also demonstrated that the robotic technique can be incorporated seamlessly into bariatric surgery practice without any appreciable negative impact on patient outcomes but adds to the length of the procedure.

The increased duration of the robotic technique compared to laparoscopy has been a universal finding across the literature [8, 16–19, 22–26]. Nevertheless, a number of factors can account for this increased procedural length when using the robotic technique: the most obvious is the type of anastomotic technique. In our comparative groups, the laparoscopic technique utilized a circular stapled anastomosis whereas the robotic technique used a two-layered hand-sewn technique. It is well known that the circular technique can be accomplished a lot faster than the hand-sewn technique [27]. By not including hand-sewn techniques in both our groups, it is therefore difficult to assign the longer duration of the procedure to the robotic technique rather than the stapled- vs. hand-sewn-type anastomosis. Another factor that has likely affected the findings of this study in regard to procedure duration is that all cases were performed at an academic center with fellow or resident participation. Despite the vast majority of participating trainees being seniors (PGY 4 or 5 residents and PGY 6 or 7 MIS/bariatric fellows), they were all novices in robotic surgery as their prior experience was either none or very limited. In contrast, their laparoscopic experience was extensive and their laparoscopic skill far superior to their robotic. As a result, the longer duration of the robotic cases might also be a reflection of the skill level of the trainees, as they regularly performed part of the procedure dependent on their skill level. Nevertheless, despite the longer duration of the robotic cases, which was on average almost 1 h, we did not observe a negative impact on patient outcomes.

In fact, we found fewer complications in the robotic patient group, especially for grades 3 and 4 on the Clavien–Dindo classification. It should be noted, however, that by using this classification we recorded as complications any procedures (grade 3) that occurred during the one-year follow-up period. All upper endoscopies, which were the most common procedures performed in our patients (13% in the robotic group and 19% in the laparoscopic), were counted as grade 3A complications whether they identified a problem (stricture or ulcer) or not. Further, we counted cholecystectomies as complications as well (grade 3B).

<table>
<thead>
<tr>
<th>Complication</th>
<th>Robotic gastric bypass (%)</th>
<th>Laparoscopic gastric bypass (%)</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGD</td>
<td>13</td>
<td>19</td>
<td>NS</td>
</tr>
<tr>
<td>Incisional hernia</td>
<td>6</td>
<td>4.1</td>
<td>NS</td>
</tr>
<tr>
<td>Cholecystectomies</td>
<td>5</td>
<td>12.4</td>
<td>0.03</td>
</tr>
<tr>
<td>Bowel obstructions</td>
<td>5</td>
<td>7</td>
<td>NS</td>
</tr>
<tr>
<td>Wound infections</td>
<td>1.6</td>
<td>5</td>
<td>NS</td>
</tr>
<tr>
<td>Anastomotic LEAKS</td>
<td>0</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>GJ Anastomotic ulcers</td>
<td>6.4</td>
<td>4.9</td>
<td>NS</td>
</tr>
<tr>
<td>GJ Anastomotic strictures</td>
<td>0.8</td>
<td>2.4</td>
<td>NS</td>
</tr>
<tr>
<td>Reoperations 30-days</td>
<td>0.8</td>
<td>6.6</td>
<td>0.01</td>
</tr>
<tr>
<td>Readmissions 30-days</td>
<td>5.6</td>
<td>8.2</td>
<td>NS</td>
</tr>
</tbody>
</table>

**Table 5** Breakdown of complications during 1-year follow-up period unless noted otherwise

Importantly, while most specific complications appeared to occur more frequently in the laparoscopic group, only laparoscopic cholecystectomies and 30 day reoperations were statistically significant. One might argue that this difference is not related to surgical technique but rather to the weight lost after the gastric bypass. Nonetheless, there were no differences in weight loss between the groups to explain this finding. Further, given that all patients received care by the same surgeon, it is unlikely that the criteria used for cholecystectomy differed between study periods. Indeed, there were no differences in the percentage of patients with gallstones, acute cholecystitis, or biliary dyskinesia between the groups. On the other hand, in patients with persistent postoperative nausea and vomiting with a negative EGD for anastomatic ulcers or stricture, and the absence of gallstones on ultrasound but findings of gallbladder dysfunction on HIDA scan, a cholecystectomy was offered for the duration of the study for diagnostic and potentially therapeutic purposes. This group of patients was
offered laparoscopic cholecystectomy sometimes as a last resort in the surgeon’s attempt to help relieve their symptoms. We hypothesize that the difference in the rate of cholecystectomy might be technique related; the laparoscopic RYGB group had a larger percentage of patients with early postoperative nausea and vomiting, also evidenced by the larger number of upper endoscopies performed in this group. In addition, more patients in this group had a negative EGD compared with the robotic group and four (50%) of the 30-day reoperations in this group were cholecystectomies. A potential reason behind this finding could be related to the gastrojejunal anastomotic technique. Our experience with the circular technique has been that it occasionally may lead to twisting at the gastrojejunal anastomosis that could potentially lead to more postoperative patient nausea and vomiting. Twisting at the anastomosis is rarely the case with the hand-sewn technique. Thus, this anecdotally observed difference in techniques with the resultant increased unexplained patient nausea and vomiting might have accounted for the observed differences in endoscopy and cholecystectomy rates between the groups. We realize that a laparoscopic hand-sewn technique might have led to similar differences to the circular-stapled technique but we are unable to make this comparison.

Available comparative studies in the literature have had mixed results with some demonstrating a lower complication rate with the robotic technique, [15–17, 24, 28] some higher, [25] and some no difference in outcomes [8, 22]. Nevertheless, a systematic review that analyzed outcomes of 25 studies including 5145 patients, showed that the robotic technique was associated with fewer anastomotic strictures, reoperations, and a decreased length of hospital stay compared with the standard laparoscopic procedures [17].

Our study has several limitations. It was a retrospective review of prospectively collected data, which introduces bias in its results. In addition, the two study groups occurred consecutively during different time periods; as a result, changes in practices over the years may have affected our findings. While no specific change in the postoperative protocol occurred during the study period, it is possible that the decrease in hospital stay in favor of the robotic technique may have been impacted by other factors such changing trends in the field or change in comfort of sending patients home sooner with increasing experience. Further, there was also only one surgeon who performed the operations limiting its generalizability. On the other hand, this ensured similar skill, decision-making, and postoperative patient care for all procedures of both study groups. It should also be noted that while the surgeon had completed fellowship training in laparoscopic bariatric surgery, he did not have training in robotic techniques prior to incorporating this technique in his practice other than the Intuitive led certification process [29]. This may have biased the results of this study against robotic surgery but no negative effects were observed on patient outcomes. The two groups also had differences at baseline as the robotic group was almost 3 years older and had an approximately 1.5 higher average BMI and follow-up was less complete in the laparoscopic group. These differences bias this study in favor of the laparoscopic technique, thus supporting the validity of our findings. Further, no cost analysis was completed for this study. Prior studies have suggested increased cost associated with the robotic approach [18, 19, 26]. A good quality analysis of the value of robotic gastric bypass is therefore needed and in our future plans. Finally, differences in anastomotic techniques (hand sewn vs. circular stapled) as discussed previously may have accounted for some of the differences detected in this study irrespective of the modality used (robotic vs. laparoscopic). On the other hand, the robotic technology allowed for the change in technique to occur. In the absence of robotic assistance, it is unlikely that the surgeon’s technique would have changed from circular to laparoscopic suturing.

Despite the limitations of this study, we believe that our findings add support to the integration of robotic technology into RYGB surgery. The potential advantages of the robotic technique we identified could also have been affected by differences in anastomotic technique such as circular versus hand sewn and suggest the need for a high-quality randomized controlled trial that will compare the outcomes and cost of the same two techniques to delineate the value of robotics in bariatric surgery.

In conclusion, the use of robotic technology for the creation of gastric bypass in a single surgeon experience led to longer operative times, similar %EWL, decreased LOS, and fewer complications compared with the laparoscopic approach. Since our findings may have been influenced by the type of anastomotic technique used with each approach they need confirmation by a controlled trial.

Compliance with ethical standards

Disclosures Drs. Dimitrios Stefanidis and Timothy Kuwada, and Savannah B. Bailey and Connie Simms have no conflicts of interest or financial ties to disclose. Dr Keith Gersin is paid consultant for GI Dynamics, WL Gore, and on the speaker’s bureau for Mallinckrodt.

References