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SURGICAL ENDOSCOPY
and Other Interventional Techniques

The learning curve for laparoscopic Roux-en-Y gastric bypass is 100 cases

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Abstract
Background: The purpose of this study was to determine the effect of operative experience on perioperative outcomes for laparoscopic Roux-en-Y gastric bypass (LGB).
Methods: Between July 1997 and September 2001, 750 patients underwent LGB for the treatment of morbid obesity at our center. We evaluated the perioperative outcomes of the first 150 consecutive patients to determine if a learning curve effect could be demonstrated. The patients were divided into three groups (1, 2, and 3) of 50 consecutive patients, and outcomes for each group were compared.
Results: The patients in group 3 had a larger body mass index (BMI), were more likely to have had prior abdominal surgery, and were more likely to have secondary operations at the time of LGB. Operating time decreased from a mean of 311 min in group 11 to 237 min in group 3, and technical complications were reduced by 50% after an experience of 100 cases.
Conclusions: Operative time and technically related complications decreased with operative experience even though heavier patients and higher-risk patients were more predominant in the latter part of our experience. LGB is a technically challenging operation with a long learning curve. To minimize morbidity related to the learning curve, strategies for developing training programs must address these challenges.

Key words: Bariatric surgery — Complications — Learning curve — Laparoscopic skills — Obesity

Laparoscopic Roux-en-Y gastric bypass (LGB) has been shown to significantly reduce the perioperative morbidity and recovery time associated with the open approach while maintaining excellent weight loss [1, 4, 5, 9, 13]. Improved outcomes as well as patient demand have driven surgeons to adopt the laparoscopic approach. LGB is technically very challenging because it requires skills not needed to perform of other advanced laparoscopic procedures. Relatively steep learning curves have been demonstrated with the introduction of most new laparoscopic procedures, including cholecystectomy, inguinal hernia, Nissen fundoplication, splenectomy, and colectomy.

The purpose of this study was to evaluate perioperative outcomes in our early experience with LGB at the University of Pittsburgh to determine if patient outcomes improved with experience and at what level of experience operative complication rates and operating time reached levels comparable to open gastric bypass surgery. This information will be helpful in developing strategies for training programs aimed at reducing morbidity related to the learning curve for LGB.

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Materials and methods

We evaluated the perioperative outcomes of the first 150 consecutive patients who underwent LGB at the University of Pittsburgh beginning in July 1997 to determine if a learning curve effect could be demonstrated. Patients were divided into three groups (1, 2, and 3) of 50 consecutive patients, and outcomes for each group were compared. We chose to evaluate the first 150 cases because at this time the operations were primarily performed by 2 attending surgeons who assisted each other. After the 150 cases, surgical residents and minimally invasive surgery fellows began assisting and performing the operations. We specifically evaluated operative time, conversion rates, estimated blood loss (EBL), operative complications, and length of hospitalization (LOS).

Since many patients had secondary procedures, such as laparoscopic cholecystectomy, that might affect their outcomes, these secondary procedures were compared among the groups. To risk-stratify the patients for group comparison, we also evaluated demographics, mean body mass index (BMI), American Society of Anesthesiologists (ASA) classification, and history of prior surgery for all patients. We defined the endpoint of the learning curve as the point at which technical complications became comparable to open gastric bypass and not necessarily as the point at which stabilization of complication rates occurred.

Table 1. Patient demographics and risk stratification

Group	Mean age (yr)	% male	% BMI > 55	% prior surgery	Mean ASA	% extra surgery
1 (1–50)	44	24	18	62	2.56	30
2 (51–100)	45	28	24	50	2.67	46
3 (101–150)	44	12	24[a]	68	2.70	54[a]

BMI, body mass index; ASA, American Society of Anesthesia risk classification
[a] $p < 0.05$ for group 3 vs group 1

Table 2. Perioperative outcomes

Group	OR time (min)	Conversion (*n*, %)	EBL (ml)	Intraoperative complications (*n*)	Operative complications (*n*)	LOS (days)
1 (1–50)	311	1 (2 %)	98	2	21	2.7
2 (51–100)	227	0	80	0	15	2.5
3 (101–150)	237[a]	1 (2 %)	169	2	11[a]	3.6

OR, operating room; EBL, estimated blood loss; LOS, length of hospital stay
[a] $p < 0.05$ for group 3 vs group 1

Gastric bypass technique

The operative technique has already been described in a previous publication from our group [9]. Briefly, it consists of a laparoscopic approach with two 11/12-mm ports and four 5-mm ports. The technique includes the creation of an isolated 15-ml gastric pouch and a retrocolic, retrogastric Roux-en-Y gastrojejunostomy. In our first 150 patients, the gastrojejunostomy was created primarily using a circular stapler technique. We later changed to a linear stapler technique. The Roux limb was 150 cm in patients with BMI ≥50 and 75 cm in patients with BMI ≤50. All operations included endoscopy at the conclusion of the procedure to check for leaks.

Statistical analysis

For statistical correlations, we carried out by used the Wilcoxon signed rank test and chi-square analysis.

Results

From July 1997 to September 2001, 750 patients underwent LGB for the treatment of morbid obesity at our center. The first 150 cases were performed by the same two surgeons (P.S., S.I.). Table 1 shows the patient demographics and risk stratification for the three groups. Group 3 group 1 tended to have a greater percenage of patients than group 1 with a high BMI (>55) ($p < 0.05$) and a higher mean ASA risk. Previous abdominal surgery was common in all three groups, but group 3 had the highest percentage of patients with one or more previous operations (Table 2) Cholecystectomy, Cesarean section, and hysterectomy were the most common procedures in all groups. Secondary procedures performed concomitantly with LGB are shown in Table 3. Group 3 patients had the highest rate of secondary procedures. Laparoscopic cholecystectomy, lysis of adhesions, and liver biopsy were the most common secondary operations.

Perioperative outcomes for the three groups are shown in Table 4. Group 3 had a significantly shorter operating time and a lower complication rate than group 1 ($p < 0.05$). There was no significant difference in conversion rates, EBL, or LOS blood loss, or length of stay among the groups. Table 5 shows the specific technical complications encountered in each group. There was a steady decrease in wound infections and leakage rates with increasing experience.

Discussion

With the introduction of laparoscopic cholecystectomy in the late 1980's the concept of a learning curve for laparoscopic operations was introduced. The concept arose after the identification of a higher rate of operative complications among to surgeons who were still learning the laparoscopic technique. Common bile duct injuries were among the most notorious complications attributed to the chole learning curve for laparoscopic cholecystectomy [3, 6, 10]. As new laparoscopic procedures have been developed over the last 10–12 years, a significant learning curve for each procedure has been established. Investigators have generally shown that after a certain volume of experience, these technical complications tend to decrease to more acceptable levels. For laparoscopic inguinal hernia, Voitk showed that ≥50 cases were required to reduce complications to a steady level [11]. Cusick and Waldhausen found that laparoscopic splenectomy complications dropped after an experience of 20 cases [2]. Watson, et al. and studied the learning curve for laparoscopic fundoplication and found that complication, reoperation, and conversion rates were all higher in the first 50 cases performed by the overall group and in the first 20 cases performed by each individual surgeon [12]. In that study, the compli-

Table 3. Prior abdominal surgery

	Group 1 (1–50)	Group 2 (51–100)	Group 3 (101–150)
1 Prior operation	31	25	34
> 1 Prior operation	12	15	21
Open cholecystectomy	5	8	6
Laparoscopic choletecystectomy	5	2	1
BTL	5	2	9
Abdominoplasty	4	1	0
C-section	11	6	8
Appendectomy	5	8	6
Hysterectomy	2	6	10
Hernia	2	0	4
Prior bariatric surgery	0	0	1 (VBG)
Miscellaneous	4	4	7
Total	43	37	51

Table 4. Secondary operations

	Group 1 (1–50)	Group 2 (51–100)	Group 3 (101–150)
Pts with >1 operation	15	23	27
Lysis of adhesions	5	7	9
Liver biopsy	2	5	8
Laparoscopic cholecystectomy	6	10	10
Umbilical hernia repair	7	4	3
Endoscopic polypectomy	0	0	1
Laparoscopic gastrostomy tube	0	3	3
Laparoscopic splenectomy	0	0	1
Laparoscopic PEH	0	0	2
Total	20	29	37

Table 5. Specific technical complications

	Group 1 (1–50)	Group 2 (51–100)	Group 3 (101–150)
Wound infectons	10	7	2
GJ leak	5 (4 contained)	2 (1 contained)	0
Bleeding	2	0	4
GJ stricture	2	4	4
SBO	0	2	1
Stapler malfunction	1	0	0
Esophogeal mucosal tear	1	0	0
Total	21	15	11

cation rates were even higher in the initial first 20 cases, and the first five individual cases. However, adverse outcomes were less likely for surgeons who began fundoplication later in their overall experience, when experienced supervision could be provided. Another study suggested that gastroesophageal perforations during laparoscopic fundoplication were the equivalent of bile duct injury during laparoscopic cholecystectomy, since most of the perforations occurred early in the surgeons experience [8]. Laparoscopic colectomy, arguably more difficult than laparoscopic fundoplication, has been associated with a steep learning curve as well. Lauter and Froines showed a significant drop in complications after an experience of 50 cases [7].

LGB is certainly one of the more technically challenging laparoscopic procedures performed today. Both the size of the obese patient and the complexity of these reconstructive procedures create the major technical barriers. Surgeons must perform such complex tasks as gastric pouch creation, Roux limb creation, two anastomoses, and closure of mesenteric defects (to avoid internal hernia formation). Advanced skills such as laparoscopic suturing, stapling, and dissection techniques must be mastered. Patient factors such as massive obesity (BMI > 60), severe hepatomegaly, prior abdominal surgery, and reoperative bariatric surgery may increase the degree of difficulty by several magnitudes.

In this study, we found that overall operating time and complications were significantly lower in group 3 after an experience of 100 cases. Major factors that may adversely affect operating time and complication rates include patient size, operative risk (ASA classification), history of prior abdominal surgery, and the performance of secondary procedures. As our experience increased, we liberalized our selection criteria to include more of these higher-risk patients. Yet even the degree of difficulty steadily increased, we continued to observe a reduction in operating time and operative complications. The operating time of 237 min (3–4 h) after 100 cases may seem high compared to open surgery. This time included total anesthesia time as well as time to complete additional procedures. For example, laparoscopic cholecystectomy typically increases operating time by 45–60 min. We have seen our operative time (after an experience of 750 cases) continue to decrease to a range of 1–2 h for the vast majority of patients.

The most notable complications that decreased with experience included wound infections and anastomatic leaks. Wound infections almost always occurred at the site of insertion of the EEA stapler. After we instituted preoperative bowel preparation, wound infections decreased significantly. After the first 200 cases, we switched to a linear stapler technique that obviated the need to pull the contaminated EEA stapler through the wound; since that time, wound infections have been very rare. The anastomatic leaks were largely contained leaks, and only one of our cases required operative correction. In group 3, no leaks occurred, and we have seen our leak rate stabilize at 1–2%. Since leaks are associated with potentially high morbidity and mortality, the learning curve for performing the two anastomoses may be the most important one of the entire operation.

Operative blood loss and hospital length of stay was slightly higher in group 3 ($p > 0.05$). The increase in these parameters is most readily explained by an increase in patient complexity related to BMI, increased ASA class, prior surgery, and secondary procedures that was observed in the later experience. Conversion rates also did not seem to change with experience, remaining at a reasonably low 0–2% throughout our learning experience. We attribute this low, stable rate to our willingness to accept longer operating times in our early experience rather than converting to an open procedure when progress was slow on the more challenging cases.

A recent review of open gastric bypass series showed acceptable operative complications rates in the 10–25% range for major and minor complications [9]. Specifically, wound infections were in the 5–15% range, leak rates 1–5%, anastomatic strictures 5–15%, bleeding 3–8%, and bowel obstruction 2–5%. In our study, these rates or better were achieved in group 3 after an experience of 100 cases.

Other studies of LGB have shown similar trends in improved perioperative outcomes and operating times with experience. Higa et al. reported a steady decrease in operating time that seemed to stabilize at ≤ 2 h after an experience of 100 cases [13]. Wittgrove et al. reported a steady decrease in operative complications and operative time when they evaluated their experience in 500 consecutive cases [5].

Conclusion

In summary, this study indicates that LGB is associated with a significant learning curve that is perhaps more pronounced than many other advanced laparoscopic procedures. In our experience, complications rates and operating times approached the levels reported for open gastric bypass after an experience of 100 cases. It is our belief that a large volume of experience is necessary to learn the intricacies of this operation, as well as to be exposed to a variety of patient-specific challenges such as body size, adhesions, large liver, and anatomic variation. The acquisition of advanced laparoscopic skills is essential for the safe and effective performance of LGB. Surgeons who do not have the benefit of experience with at least some of the other advanced laparoscopic procedures will be at a significant disadvantage. Furthermore, surgeons not experienced in the perioperative management of the bariatric patient may be equally vulnerable. For some surgeons, certainly <100 cases will be sufficient, especially if they already have significant laparoscopic skills and some experience in bariatric surgery. For surgeons entering laparoscopic bariatric surgery, either fellowship training or extended mentoring by an experienced surgeon is the optimal strategy to reduce patient morbidity related to the learning curve.

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