A New and Simplified Technique for Laparoscopic Gastric Bypass in a Residency Training Program

Decreased Resource Utilization and Enhanced Training

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Background: Laparoscopic gastric bypass (LGB) is an advanced complex procedure. Teaching programs must balance resident training and participation with resource utilization, patient safety, and outcomes. We prospectively studied a new simplified LGB technique (S-LGB) in a residency training program.

Design: Prospective observational study.

Setting: Academic bariatric program.

Patients: All patients undergoing S-LGB during 17 months.

Interventions: Clinical data collection and surgeon survey.

Main Outcome Measures: Resource utilization, patient outcomes, and resident/staff satisfaction.

Results: There were 140 S-LGB operations performed by 4 staff members, all with postgraduate year 2 through 5 residents. There were no major intraoperative complications and no anastomotic leaks or deaths. Mean operative time for cases with no concurrent procedures was 91 minutes, with no intraoperative transfusions and 1 conversion to an open procedure. Compared with our standard technique, operative times with simple S-LGB decreased by an average of 56% for all staff (range, 45%-60%; P < .01). Lower postgraduate year level increased operative times with the standard technique but not with S-LGB. The anastomotic stricture rate decreased from 10.0% to 3.6% (P = .02). The mean excess body weight lost at 3, 6, and 12 months was 42%, 55%, and 87%, respectively. All staff surgeons preferred the S-LGB technique for technical difficulty, speed, safety, and ability to teach residents. Residents scored the S-LGB significantly better than our standard technique for difficulty, learning curve, and overall satisfaction (all P < .05).

Conclusion: Introduction of S-LGB has resulted in excellent outcomes and significant reductions in resource utilization while enhancing opportunities for resident teaching and full participation.

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LAPAROSCOPY HAS NOW BECOME the preferred modality for performing a variety of bariatric surgical procedures. Although all of these require advanced laparoscopic skills, the laparoscopic gastric bypass (LGB) is the most difficult to learn and master. Previous studies have identified a steep learning curve characterized by longer operative times and increased complication rates during the early experience.1-7 Methods that have been proposed to eliminate or decrease this have included mentorship programs, formal courses, simulator training, and the establishment of minimally invasive/bariatric fellowship programs.6-11 However, even after mastery of this procedure there remains a considerable risk of major morbidity or mortality.12 Bariatric surgery represents an increasingly important component of training programs for surgical residents and postgraduate fellows. With the already demonstrated steep learning curve for even staff physicians, academic centers often struggle between optimizing patient safety and outcomes and the mandate to train surgical residents in advanced laparoscopic techniques. In many centers this has limited the ability of surgical trainees to perform or even to serve as first assistant in these procedures.13

The reported surgical techniques for LGB vary widely and are typically based on surgeon training, personal preference, and available equipment. In centers (such as ours) where residents are expected to actively assist with or perform LGB, the choice of technique must safely accommodate the varying levels of knowl-
edge and skill of the participating resident. This frequently results in some adverse effects, such as prolonged operative times, blood loss, or technical mistakes. The purpose of this study was to prospectively collect and report our experience with a new and simplified technique for LGB introduced in our active academic bariatric practice. Our objectives were to analyze the short- and longer-term outcomes with this new procedure in terms of patient safety and outcomes, resource utilization, and weight loss. In addition, we sought to quantify the perceptions and opinions of the staff and resident surgeons performing this new technique.

METHODS

This study was conducted at Madigan Army Medical Center, a military tertiary referral center and Accreditation Council for Graduate Medical Education–approved general surgery resident training program. A key component of the resident training program is a high-volume bariatric surgery service staffed by 7 attending surgeons. The service operates under the mandate from the program director that surgical residents should actively participate in all cases and operate in the primary surgeon position whenever possible.

STANDARD LGB TECHNIQUE

The 6 attending surgeons who perform LGB adopted a standard surgical technique in 2003. This technique used a 25-mm circular stapler to perform the antecolic, antegastric gastrojejunostomy. The stapler anvil was introduced through the abdominal wall and placed into the pouch via a greater curve gastrotomy. The pouch was then created, followed by the gastrojejunostomy. A 40-cm biliopancreatic limb was measured and transected by linear stapler, and a 100- to 150-cm Roux limb was created. A side-to-side stapled jejuno-jejunostomy was then performed and the mesenteric defect was closed with interrupted or running suture.

SIMPLIFIED LGB TECHNIQUE

In May 2008 one of us (M.J.M.) developed and introduced a new simplified technique for performing LGB (S-LGB). This was done by eliminating the circular stapler and converting to a totally stapled linear gastrojejunostomy, creating the anastomosis before pouch formation, and simplifying the jejuno-jejunostomy and mesenteric defect closure. The S-LGB technique was subsequently adopted by the other 3 staff surgeons performing LGB during the study period. All cases were performed with the resident in the operating surgeon position (patient right) and the staff surgeon in the first assistant position (patient left).

For the S-LGB, 6 trocars are inserted in a diamond pattern as shown in Figure 1. The inferior border of the pouch is formed by a single firing of a 60-mm linear stapler (Figure 2A). A gastrotomy is then made at the inferior left corner of the pouch (Figure 2B). A traction suture is placed for traction during anastomosis.

The jejunal and ileal limbs are then divided with linear staplers and the mesenteric defect is closed with interrupted or running suture.
the linear stapler (Figure 3D), resulting in a 1.5- to 2-cm-diameter anastomosis. A 34F bougie is passed transorally through the anastomosis. The pouch is now completed by serial vertical firings of the linear stapler. Before the first vertical staple load is fired, the staple line from the common enterotomy closure is grasped and retracted laterally, thus including it in the excluded remnant and not the gastric pouch (Figure 4).

Two silk sutures or self-securing distal anastomosis devices (U-Clips; Medtronic Inc, Minneapolis, Minnesota) are placed to reinforce the anterior wall of the gastrojejunostomy. The Roux limb is run for 100 to 150 cm and a triple-stapled technique, as described by Madan and Frantzides, is used to create the jejunojejunostomy. A 90-mm-long side-to-side anastomosis is created with 2 firings of the 45-mm linear stapler (1 proximally, 1 distally). The edges of the common enterotomy are then grasped, elevated, and closed with a linear stapler (Figure 5A). The mesenteric defect is closed with a running silk suture that is secured at either end with clips rather than a knot (Figure 5B). A leak test is then performed and a 10-mm Jackson-Pratt drain is placed overlying the gastrojejunostomy.

STUDY METHODS AND DEFINITIONS

A prospective observational study was performed from May 1, 2008, through December 31, 2009. All patients undergoing a primary LGB using this simplified technique were included. Patients undergoing an open procedure or conversion of a prior bariatric procedure were excluded. Data were collected and maintained by the principal investigator (M.J.M.) on a computer spreadsheet. All noted complications were discussed and clarified with the responsible surgeons. Follow-up was performed per our protocol, with postoperative visits at 1, 3, 6, 9, and 12 months. All hospital readmissions for any reason during the study period were noted and included for analysis.

Each S-LGB procedure was further classified as simple or complex to clarify the data regarding operative times. Simple procedures were those that involved only the gastric bypass. A complex procedure was any defined surgical procedure that was performed in addition to the LGB, such as cholecystectomy. The recorded operative times for the complex cases were the total time required for all procedures. For comparison, our operating room database was queried for all standard LGB procedures performed by the same 4 staff surgeons from 2006 through 2008. Only simple cases with no additional concurrent procedures were included in the conventional LGB group. Data collected included the operative time, blood loss, and postgraduate year (PGY) of the resident.

To quantify the opinions of the staff and resident surgeons, an anonymous questionnaire was distributed to all involved staff surgeons and to all residents who had performed both the standard and the S-LGB technique. Respondents ranked the 2 procedures side by side on a numeric scale of 1 (lowest) to 10 (highest) for technical difficulty, learning curve, ability of resident to perform the case, ability to teach the procedure, risk of complications, reproducibility, and overall satisfaction.

Descriptive statistics including mean (SD), median (range), or percentiles were used for summary data. Univariate analyses were performed with the 2-tailed unpaired t test and Fisher
exact test. Survey results were compared by the Mann-Whitney test. Significance was set at $P < 0.05$. All analyses were performed by means of SPSS version 14.0 (SPSS Inc, Chicago, Illinois). The local institutional review board approved both the prospective (S-LGB) and retrospective (standard technique) components of this study.

### RESULTS

A total of 140 S-LGB procedures were performed, all with PGY-2 through PGY-5 residents. The median follow-up was 8 months (range, 1-20 months), with all patients having at least 30-day data available. The demographics of the patient population are given in Table 1. More than half of the patients had a history of previous abdominal surgery. There was no attempt at selection of patients with favorable factors (ie, low body mass index, no previous surgery), and this was a consecutive sample with the only exclusion criteria as described in the “Study Methods and Definitions” subsection.

There were no major intraoperative complications or deaths. There were 11 (7.9%) minor intraoperative complications, including 2 bowel serosal tears, 7 enterotomies, and 2 complications of the gastrojejunostomy requiring immediate revision. Only 1 case (0.7%) required conversion to laparotomy for revision of an ischemic area of the gastric pouch. The mean (SD) estimated blood loss was 40 (40) mL, with no patient requiring an intraoperative blood transfusion. Concurrent procedures were performed in 53 patients (37.9%), most commonly cholecystectomy and hernia repairs.

The mean (SD) operative time for the S-LGB was 116 (50) minutes. Operative time for those undergoing simple S-LGB was 91 (27) minutes and for complex cases was 156 (54) minutes. Among the simple S-LGB cases (n=87), 51 (58.6%) were completed in less than 90 minutes and 74 (85.1%) in less than 2 hours. For comparison, a sample of the last 180 cases treated with the standard LGB technique by the same 4 surgeons was identified. Operative times for both simple and complex S-LGB were significantly shorter than with the previously used standard technique (mean, 209 [76] minutes; $P < 0.001$ for both). Figure 6A demonstrates the reduction in operative times with the S-LGB technique for all cases and for the subset of simple cases. Figure 6B demonstrates the same significant improvements in operative time for resident surgeons by PGY.

No anastomotic leaks were identified among the study population. Seven patients (5.0%) experienced complications during their hospital stay, including pneumonia (1 patient), pancreatitis (1), respiratory depression (1), uri-
nary retention (1), and self-limited bleeding requiring transfusion (2). One patient required a return to the operating room on postoperative day 1 and was found to have a small enterotomy (grasper injury) that was repaired laparoscopically. This compares favorably with the 15% incidence of postoperative complications with the standard technique, including 5 patients requiring early reoperation for leak or obstruction. The mean postoperative length of stay was 2.4 days (range, 1-9 days), with no patients requiring an intensive care unit stay or prolonged hospitalization. The only major postdischarge complication occurred in 1 patient who returned 2 weeks after surgery with a small-bowel obstruction and femoral deep venous thrombosis. She underwent laparotomy with lysis of adhesions and recovered well. The incidence of symptomatic stricture was 3.6% (5 cases) with the S-LGB vs 10.0% (18 cases) with the standard technique ($P = .02$), and marginal ulcers were diagnosed in 2 (1.4%) of the S-LGB group vs 9 (5.0%) of the standard group ($P = .12$). All strictures among the S-LGB group patients were fully resolved after 1 to 2 endoscopic balloon dilations.

The observed postoperative weight loss was excellent, with a decrease in mean (SD) body mass index (calculated as weight in kilograms divided by height in meters squared) from 42.8 (5.3) preoperatively to 26.6 (3.3) at 1-year follow-up. Figure 7 shows the weight loss during the first year with the number of patients at each follow-up point. On average, patients had lost 42% of their excess body weight at 3 months ($n=128$), 55% at 6 months ($n=90$), and 87% at 1 year ($n=31$). The maximum patient body mass index at 1 year was 32.

The results of the staff (4 surgeons) and resident (12 residents; 6 PGY-5, 3 PGY-4, 1 PGY-3, and 2 PGY-2) surveys demonstrated nearly unanimous preference for the S-LGB technique over the standard technique (Figure 8).

Laparoscopic gastric bypass has become the most commonly performed bariatric surgical procedure in the United States. It is widely accepted as the current criterion standard on the basis of its proven safety, efficacy, and durability. However, it is also among the most technically demanding and demanding advanced laparoscopic procedures in the abdomen. Several series have identified a learning curve of between 50 and 150 cases for a staff surgeon to attain proficiency in this proce-

### Table 1. Demographics of Study and Control Populations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Simplified LGB (n=140)</th>
<th>Standard LGBa (n=180)</th>
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<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>44 (13)</td>
<td>42 (15)</td>
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<tr>
<td>Sex, No. (%)</td>
<td></td>
<td></td>
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<tr>
<td>Male</td>
<td>13 (9.3)</td>
<td>18 (10.0)</td>
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<tr>
<td>Female</td>
<td>127 (90.7)</td>
<td>162 (90.0)</td>
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<tr>
<td>Preoperative BMI, mean (SD)</td>
<td>43 (5)</td>
<td>45 (7)</td>
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<tr>
<td>Superobese (BMI &gt;50), No. (%)</td>
<td>16 (11.4)</td>
<td>25 (13.9)</td>
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<tr>
<td>Previous abdominal surgery, No. (%)</td>
<td>94 (67.1)</td>
<td>107 (59.4)</td>
</tr>
<tr>
<td>Open</td>
<td>61 (43.6)</td>
<td>73 (40.6)</td>
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<tr>
<td>Laparoscopic</td>
<td>48 (34.3)</td>
<td>59 (32.8)</td>
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Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); LGB, laparoscopic gastric bypass.

a $P$ not significant for all comparisons.
b Some patients had more than 1 previous operation.
eral surgery. Laparoscopic bariatric surgery provides an outstanding opportunity for both observers and performers to learn advanced laparoscopic tasks. However, it also represents a risk to patient safety and outcomes with the known technical difficulty and learning curve for LGB even among fully trained staff surgeons. In an analysis of 281 LGB procedures at an academic institution, DeMaria et al gave the opinion that residents lack the technical ability to perform LGB or even to serve as first assistant. An additional concern is the impact of resident participation on the learning curve or patient outcomes.

Both open and laparoscopic bariatric surgery have become a critical component of resident training in general surgery. Laparoscopic bariatric surgery provides an outstanding opportunity for both observers and performers to learn advanced laparoscopic tasks. However, it also represents a risk to patient safety and outcomes with the known technical difficulty and learning curve for LGB even among fully trained staff surgeons. In an analysis of 281 LGB procedures at an academic institution, DeMaria et al gave the opinion that residents lack the technical ability to perform LGB or even to serve as first assistant. An additional concern is the impact of resident participation on costs and resource utilization. Resident participation has been found to significantly increase operative times and costs but has not been found to increase patient morbidity.

There are currently several described techniques for performing LGB. They are typically classified by the method used for the gastrojejunoanastomosis: circular stapled, linear stapled, hand-sewn, or combination stapled and hand-sewn. The preferred technique for an individual surgeon or group is commonly chosen on the basis of personal preference, training experience and familiarity, available supplies, and cost. However, there are several additional factors that must be considered when choosing the optimal technique when surgical residents are active participants. These include technical difficulty, ability to teach the procedure, opportunity for resident participation, reproducibility, and ease of managing technical imperfections or complications.

Our data demonstrate that we were able to reduce an inherent complex operation into reproducible, logical steps that could be taught by experienced attending surgeons to practically any level of resident. We believe that the S-LGB technique offers a number of significant improvements and advantages over our previously used circular stapled technique (Table 2). We found that the application and use of articulating linear staplers during LGB was much easier for residents to grasp than the use

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**Table 2. Real and Perceived Advantages of the Simplified LGB Technique Compared With Our Previous Standard LGB Technique**

<table>
<thead>
<tr>
<th>Advantage</th>
<th>S-LGB</th>
<th>Standard LGB</th>
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<tbody>
<tr>
<td>Elimination of cost associated with circular staplers</td>
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<tr>
<td>Elimination of need to enlarge and dilate 1 incision for circular stapler introduction</td>
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<tr>
<td>Decreased patient complaints about pain and cosmesis</td>
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<td>Decreased wound infections at this site</td>
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<td>No persistent air leak during procedure from dilated fascial opening</td>
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<tr>
<td>Elimination of need to perform fascial closure of dilated fascial opening</td>
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<tr>
<td>No requirement for transoral anvil passage or additional gastrotomy for transgastric passage</td>
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<tr>
<td>Gastrojejunostomy performed before gastric pouch is completed</td>
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<tr>
<td>Ample room for additional manipulation or even complete revision</td>
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<tr>
<td>Easy to elevate and oppose edges of common enterotomy for stapled closure</td>
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<tr>
<td>No risk of anastomotic torsion due to slippage around anvil or circular stapler</td>
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<tr>
<td>No division of small-bowel mesentery required</td>
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<tr>
<td>Decreased bleeding events and risk</td>
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<tr>
<td>Decreased chance of compromising blood supply to end of Roux limb</td>
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<tr>
<td>Maintains bilipancreatic limb in upper abdominal field</td>
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<tr>
<td>For easier anastomosis</td>
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<tr>
<td>Maintains mesenteric defect in more visible and accessible position for closure</td>
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<tr>
<td>Smaller mesenteric defect to close; possible decreased internal hernia risk</td>
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<tr>
<td>Common enterotomy closure is on excluded remnant rather than gastric pouch</td>
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<tr>
<td>Triple-stapled jejun jejunoanastomosty technique decreases risk of inadvertent stenosis</td>
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<tr>
<td>Opportunity for resident to suture but anastomoses do not rely on intracorporeal suturing skill</td>
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<tr>
<td>Use of clips to secure mesenteric closure suture avoids difficult area of intracorporeal knot tying</td>
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<tr>
<td>Eliminates requirement to resect and remove proximal segment of Roux limb (&quot;candy cane&quot;)</td>
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<tr>
<td>Shorter operative times with less staff and resident fatigue or distraction</td>
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<tr>
<td>Shorter times for patient under general anesthesia and with abdominal insufflation</td>
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Abbreviation: LGB, laparoscopic gastric bypass.
of the circular stapler or advanced suturing techniques. We also found a decrease in the incidence of anastomotic strictures with the S-LGB technique. Our low S-LGB stricture incidence of 3.6% is in agreement with multiple previous studies comparing the linear with the circular stapled technique.\textsuperscript{23-26} The short- and mid-term outcomes of the patients who underwent S-LGB have been excellent, with short hospital stays, minimal complications, and postoperative weight loss that compares favorably with reported standards.

One of our most striking findings was the significant decrease in operative times that was achieved with the S-LGB. We found a 45% reduction in operative time even when including the cases in which additional concurrent procedures were performed. For those undergoing S-LGB only, the reduction was 56%. Our mean operative times with this technique compare favorably with those in most reports in the literature of this procedure being performed by fully trained bariatric surgeons. DeMaria et al\textsuperscript{13} reported mean times of 234 minutes for S-LGB. We found a 45% reduction in operative times that was achieved with the S-LGB only, the reduction was 56%. Our mean operative time of 116 minutes in their early LGB experience and 162 minutes in the later phase. Another series comparing times of different anastomotic techniques reported 285 minutes for hand-sewn, 215 minutes for circular stapled, and 204 minutes for linear stapled techniques. Even among the patients in the S-LGB group undergoing concurrent procedures, the mean operative time of 116 minutes was significantly shorter than reported times for LGB in most series.\textsuperscript{27} In addition, the short operative times in this series were achieved with full resident participation. This compares favorably with previous reports that have found increased operative times for LGB when residents assist (191 minutes)\textsuperscript{28} or perform (150-250 minutes) the surgery.\textsuperscript{29}

Our surveys showed that both resident and attending surgeons believed subjectively that the S-LGB technique reduced the difficulty of the operation and was overall a more satisfying technique than our previous standard technique. All residents and staff surgeons who completed the survey and who perform or plan to perform LGB selected the S-LGB technique as their preferred method. Although further study is needed to clarify the longer-term outcomes and durability of this technique, our results support the adoption of the S-LGB technique as safe, effective, and beneficial for performing LGB and training residents in minimally invasive surgery.

This study does have several limitations that should be noted. This was a relatively small sample with few data on outcomes beyond the first postoperative year and a median follow-up of only 8 months. The data for the comparison group of standard LGB procedures was obtained retrospectively and thus is subject to limitations in available data and incomplete or erroneous records. Although there was overlap in the periods during which the standard and simplified techniques were performed, the majority of the standard gastric bypasses were performed at an earlier time and not concurrently. The routine postoperative surveillance program we use for the first year may be more intense than many other programs and could affect the early outcomes and weight loss demonstrated. We do not have postoperative weight loss data for the standard technique group for comparison. Another possible source of confounding is that all the S-LGB procedures were done later in the surgeon's experience than the standard procedures. However, all procedures were performed by experienced surgeons who were past their learning curve. In addition, our results are strengthened by the fact that we compared outcomes from an established and practiced procedure (standard LGB) with those of a newly introduced and unfamiliar one (S-LGB).

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Analysis and interpretation of data: Martin, Eggebroten, and Beekley.
Drafting of the manuscript: Martin and Eggebroten.
Critical revision of the manuscript for important intellectual content: Martin, Eckert, Eggebroten, and Beekley.
Statistical analysis: Martin and Eckert.
Administrative, technical, and material support: Eckert, Eggebroten, and Beekley.
Study supervision: Eggebroten and Beekley.

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REFERENCES

Simplifying Surgical Technique

Good for the Goose and the Gander

Martin et al should be commended for developing a technique that simplifies one of the most advanced laparoscopic procedures performed in general surgery, that is, the laparoscopic Roux-en-Y gastric bypass. By simplifying the technique, they have not only made it so that residents can easily perform it but they have also shortened the operative time for the patient and reduced the operating room utilization cost for their institution. It seems that this is a perfect scenario.

In the past couple of decades, we have seen similar patterns in other aspects of general surgery in which simplified techniques also reduce operating time, with improved outcomes. Residents today have the luxury of applying a variety of technologies to simplify surgical technique: staplers, vessel-sealing systems, and biological glues, to name a few. As a result, we are graduating surgeons with limited experience in performing basic surgical techniques, such as hand-sewn bowel anastomosis, vessel ligation, and control of bleeding. These techniques are not necessarily of historical consequence, rather they are basic tools that we need when technology is not available or malfunctions.

As a laparoscopic surgeon, I am by definition a technophile. This is not my peeve. What concerns me is that we are graduating surgeons without the appropriate breadth of core surgical techniques. We are all aware that most residents today graduate having never performed or even seen an open cholecystectomy. In many institutions, the open appendectomy has also become a rarity. First- and second-year residents commonly perform these procedures, the open appendectomy has also become a rarity. At the same time, they are at risk of losing the advanced technical skills required to safely perform these procedures, such as laparoscopic suturing and intracorporeal knot-tying.

No one has found a good solution to this problem. We certainly do not want to encourage the performance of more open cholecystectomies, because these patients are put at a disadvantage. So, is it appropriate to demand that more advanced laparoscopic procedures be performed with hand-sewn techniques, for example, as opposed to staplers—even if it may imply a longer operation or less resident involvement, with no immediate benefit to the patient? The answer is not yet clear to me.

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