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Implementation of a Safe Cost Reduction Strategy for Laparoscopic Sleeve Gastrectomy

Scott Z. Mu, MD, MHS, Moamena El-Matbouly, MD, Hector M. Lopez, MD, MHA, Alan A. Saber, MD, MS, FACS, FASMBS, ABOM, ABS-FPD MBS

ABSTRACT

Background: We conducted a quality improvement initiative aimed at reducing operating room disposable supply costs during sleeve gastrectomy.

Methods: We implemented a cost reduction strategy for all sleeve gastrectomy operations at a single center which involved switching from ECHELON+ stapler with routine use staple line buttressing to a single-fire stapler (Titan SGS) to standardize the amount of staple reloads and afterwards, switching to the easyEndoLite stapler with shorter staple heights and selective use of staple line reinforcements and clip appliers.

Results: We included 638 cases of primary laparoscopic sleeve gastrectomy performed from January 2020 to June 2024. There were no significant differences in the total operating room supply costs after switching to a single-fire stapler, but after switching to a less costly stapler and selectively using staple line reinforcements and clip appliers, we demonstrated a cost savings of $1,283 (95% confidence interval [CI]: $1,216 to $1,351) per case ($P <$ .001), without any differences in length of stay or 30-day weight loss or risk of reoperation or readmission.

Conclusion: During sleeve gastrectomy, surgeons should consider adopting operating room cost-reduction strategies such as selective use of clip appliers, judicious usage of staple line reinforcement material, and choosing less costly stapler devices.

Key Words: Cost reduction, Intraoperative cost, Quality improvement, Sleeve gastrectomy, Surgical staplers.

Department of General Surgery, Rutgers New Jersey Medical School, Newark, New Jersey, USA. (Dr. Mu)

Division of Bariatric and Metabolic Surgery, Newark Beth Israel Medical Center, Newark, New Jersey, USA. (Drs. El-Matbouly, Lopez, and Saber)

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Address correspondence to: Dr. Saber, Division of Bariatric and Metabolic Surgery, Newark Beth Israel Medical Center, 201 Lyons Avenue, Newark, NJ 07112, USA. Telephone: 973-926-7402, E-mail: saber6231@gmail.com.

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INTRODUCTION

With over 160,000 cases performed in 2022, laparoscopic sleeve gastrectomy is the most commonly performed bariatric and metabolic procedure in the United States, accounting for nearly 60% of all such procedures.[1] The clinical outcomes after sleeve gastrectomy are well-studied and have demonstrated ongoing improvement as techniques, devices, and surgeon experience continue to evolve.[2] However, there have only been a few studies on the impact of procedural variations on cost in bariatric surgery.

In recent years, healthcare organizations and governing bodies have become increasingly aware of the financial and environmental costs of surgery and as such, numerous quality improvement projects across multiple surgical specialties have been implemented, aimed at reducing waste, and thereby, overall cost.[3–5] Intraoperative interventions for waste reduction centers around eliminating the use of redundant, underused, and single-use instruments.[3]

Optimizing the sleeve gastrectomy procedure from a cost perspective is especially timely and salient given continually decreasing reimbursement, with Centers for Medicare and Medicaid Services (CMS) facility reimbursement reduced by 32.8% between 2010 and 2022.[6] Single-use instruments such as endoscopic staplers and clip appliers are ubiquitously used during sleeve gastrectomy and represent avenues for cost-reduction. Additional cost-reducing measures that have been previously reported include switching to a lower cost stapler and omitting staple line reinforcement.[7–10]

Thus, we conducted a quality improvement initiative at our high-volume bariatric and metabolic surgery program aimed at reducing operating room disposable supply costs during laparoscopic sleeve gastrectomy. We wanted to measure the difference in intraoperative supply cost after instrument optimization and to assess any potential changes in complication rates.

METHODS

Study Design

This study was performed at a Metabolic and Bariatric Surgery Accreditation And Quality Improving Program (MBSAQIP) accredited medical center using cases from January 2020 to June 2024. Patient data was retrieved from our institutional bariatric surgery registry, which includes all patients who have undergone laparoscopic sleeve gastrectomy as a primary bariatric procedure. The institutional registry contains information collected by reviewing patients' electronic health records, including preoperative assessments, anesthesia evaluations, program notes for bariatric surgery, and diagnostic/radiographic studies. The registry data includes patient characteristics, comorbidities, details of the bariatric procedure, and follow-up. All the information was entered into the registry by a trained database manager who was not involved in the clinical care of patients.

Operative Technique

Laparoscopic sleeve gastrectomy technique was consistent during the study period. After Hasson entry at the umbilicus, a liver retractor, 2 5-mm trocars, and a single 12-mm trocar were placed. The omental and short gastric division was accomplished with the LigaSure Maryland jaw laparoscopic sealer/divider (Medtronic, Minneapolis, MN). The stomach was tubularized using staple loads from 4 cm proximal to the pylorus to the esophagogastric angle along a 40 Fr orogastric tube. Afterwards, Tisseel fibrin sealant was applied to the staple line (Baxter, Deerfield, IL). Prior to the implementation of the cost reduction strategy, the preferred surgical stapler was the ECHELON+ stapler (Ethicon, Raritan, NJ), with staple reloads with closed staple height of 1.8, 2.0, or 2.3 mm and staple line reinforcement using Peri-Strips (Baxter). Additionally, a laparoscopic clip applier LIGAMAX5 (Ethicon, Raritan) was opened for each case for clipping of bleeding vessels or staple lines.

Quality Improvement

We used the Plan, Do, Study, Act (PDSA) framework to guide our cost reduction quality initiative. The first cycle of PDSA involved analyzing baseline operating room supply costs to identify potential areas of optimization and was considered the baseline comparator group. In the second cycle of the cost reduction strategy, which began in March 2022, we switched to a single-fire stapler Titan SGS stapler (Standard Bariatrics, Cincinnati, OH) to reduce variability due to varying numbers of staple reloads. The third cycle of the cost reduction strategy involved several disposable supply minimization changes, including preferential use of reloads with staple heights of 1.5 or 1.0 mm, selective use of staple line reinforcements and clip appliers, and switching to a less costly multiple fire stapler (easyEndoLite stapler, Ezisurg Medical, Shanghai, China).

We tabulated the number of staplers reloads, staple line reinforcements and clip appliers used, and calculated the operating room disposable supply cost using billing data provided by the information technology division of our department and linked this to the electronic health record for all patients in the study cohort. An itemized list of costs incurred in the perioperative period was generated for each patient in the study. All implausible values were manually checked against the senior surgeon's written case records and video recordings of the operations.

Statistical Analysis

We used a multivariable linear regression model to estimate the independent association of disposable operating room supply cost with quality improvement cycle, adjusting for the following patient characteristics and comorbidities: age, smoking history, American Society of Anesthesiologists (ASA) class, history of diabetes, gastroesophageal reflux disease (GERD), pulmonary embolism, myocardial infarction, cardiac surgery, previous percutaneous coronary intervention, hypertension, venous thrombosis, dialysis, renal insufficiency, and immunosuppression. Lastly, we compared clinical outcomes between the three cycles including operating room duration, length of stay, weight loss at 1 month, and the 30-day risks of emergency department visits, Lastly, we compared clinical outcomes of operating room duration, length of stay, weight loss at 1 month, and the 30-day risks of any emergency department visit, reoperation or readmission between the 3 cycles and performed a complete case analysis using multivariable linear and logistic regression, adjusting for the previously stated patient characteristics and comorbidities reoperations and readmissions.

This retrospective study was approved by our institutional review board, protocol number 2024.04. This report followed the SQUIRE 2.0 publication guidelines for quality improvement interventions.[11] All statistical analyses were performed in the R language and environment for statistical programming, version 4.4.1.[12]

Lastly, we compared clinical outcomes of operating room duration, length of stay, weight loss at 1 month, and the 30-day risks of any emergency department visit, reoperation or readmission between the 3 cycles and performed a complete case analysis using multivariable linear and logistic regression, adjusting for the previously stated patient characteristics and comorbidities.

Table 1.
Clinical Characteristics

	Cycle 1 N = 320	Cycle 2 N = 107	Cycle 3 N = 211	*P*-Value
Age, years	38 (30, 47)	35 (29, 45)	36 (28, 43)	.12
Height, cm	165 (160, 170)	165 (160, 170)	163 (157, 170)	.10
Weight, kg	120 (108, 137)	122 (105, 142)	112 (103, 133)	.001
Body mass index	44 (40, 49)	44 (40, 49)	42 (38, 47)	.004
Female sex	277 (87%)	91 (85%)	182 (86%)	>.9
ASA Class				.2
II	52 (16%)	26 (24%)	33 (16%)	
III	266 (83%)	81 (76%)	178 (84%)	
IV	2 (0.6%)	0 (0%)	0 (0%)	
Ethnicity				<.001
Not Hispanic or Latino	174 (80%)	33 (85%)	95 (64%)	
Hispanic or Latino	43 (20%)	6 (15%)	54 (36%)	
Unknown	103	68	62	
Diabetes				.5
No	258 (81%)	81 (76%)	173 (82%)	
Noninsulin dependent	50 (16%)	23 (21%)	34 (16%)	
Insulin-dependent	12 (3.8%)	3 (2.8%)	4 (1.9%)	
Gastroesophageal reflux disease (GERD)	71 (22%)	26 (24%)	37 (18%)	.3
Hypertension	98 (31%)	29 (27%)	59 (28%)	.7
Hyperlipidemia	61 (19%)	24 (22%)	39 (18%)	.7
Myocardial infarction	6 (1.9%)	1 (0.9%)	3 (1.4%)	>.9
Cardiac surgery	12 (3.8%)	3 (2.8%)	2 (0.9%)	.13
Previous percutaneous coronary intervention	7 (2.2%)	1 (0.9%)	2 (0.9%)	.6
Smoking	80 (25%)	28 (26%)	48 (23%)	.8
Chronic obstructive pulmonary disease (COPD)	17 (5.3%)	4 (3.7%)	1 (0.5%)	.004
Supplemental oxygen	5 (1.6%)	2 (1.9%)	3 (1.4%)	>.9
Pulmonary embolism	9 (2.8%)	1 (0.9%)	2 (0.9%)	.3
Venous thrombosis	11 (3.4%)	1 (0.9%)	6 (2.8%)	.5
Obstructive sleep apnea	52 (16%)	15 (14%)	28 (13%)	.6
Limited ambulation	23 (7.2%)	6 (5.6%)	6 (2.8%)	.10
Renal insufficiency	6 (1.9%)	1 (0.9%)	6 (2.8%)	.5
Steroids or immunosuppression	15 (4.7%)	3 (2.8%)	9 (4.3%)	.8
Anticoagulant medication	36 (11%)	15 (14%)	8 (3.8%)	.003

RESULTS

In the baseline cycle, which included cases from January 2020 to June 203, 320 cases were performed with the ECHELON+ stapler. In cycle 2, 107 cases were performed using a single-fire stapler from March 2022 to February 2023, and in the final cycle, 211 cases were performed from December 2022 to June 2024.

The baseline clinical characteristics of patients grouped by study cycle are provided in **Table 1**. The patients were predominately female (86%), with median age of 37 and body mass index (BMI) of 43. Most clinical characteristics were not statistically different between stapler groups, but for the final cycle, there were fewer patients with history of chronic obstructive pulmonary disease (COPD) and anticoagulant use.

Table 2.
Stapler Costs

	Cycle 1: Baseline N = 320	**Cycle 2: Single-Fire Stapler** N = 107	**Cycle 3: Disposable Supply Minimization** N = 211	*P*-Value
Stapler body	$335	$1,800	$200	<.001
Cost per stapler reload	$137	$0	$100	<.001
Stapler reloads used				<.001
1	0 (0%)	107 (100%)	0 (0%)	
4	2 (0.6%)	0 (0%)	14 (6.6%)	
5	67 (21%)	0 (0%)	106 (50%)	
6	129 (40%)	0 (0%)	68 (32%)	
7	119 (37%)	0 (0%)	19 (9.0%)	
8	2 (0.6%)	0 (0%)	3 (1.4%)	
9	1 (0.3%)	0 (0%)	1 (0.5%)	
Stapler reload cost	$845 (822, 959)	$0 (0, 0)	$550 (500, 600)	<.001
Staple line reinforcements used				<.001
0	26 (8.1%)	67 (63%)	105 (50%)	
1	0 (0%)	5 (4.7%)	8 (3.8%)	
2	2 (0.6%)	35 (33%)	1 (0.5%)	
3	3 (0.9%)	0 (0%)	4 (1.9%)	
4	14 (4.4%)	0 (0%)	4 (1.9%)	
5	68 (21%)	0 (0%)	47 (22%)	
6	119 (37%)	0 (0%)	32 (15%)	
7	84 (26%)	0 (0%)	9 (4.3%)	
8	4 (1.3%)	0 (0%)	0 (0%)	
9	0 (0%)	0 (0%)	1 (0.5%)	
Staple line reinforcement cost	$774 (711, 995)	$100 (0, 284)	$362 (0, 711)	<.001
Clip appliers used				<.001
0	0 (0%)	0 (0%)	168 (80%)	
1	178 (56%)	62 (58%)	35 (17%)	
2	139 (43%)	45 (42%)	8 (3.8%)	
3	3 (0.9%)	0 (0%)	0 (0%)	
Clip applier cost	$519 (357, 714)	$507 (357, 714)	$86 (0, 0)	<.001
Total operating room cost	$4,341 (4,234, 4,513)	$4,274 (4,025, 4,382)	$3,065 (2,568, 3,521)	<.001

Table 2 details the number of staples reloads, staple line reinforcements, clip appliers used and the total associated costs, grouped by quality improvement cycle. For the baseline cycle, the most commonly recorded number of reloads was 6, which was decreased to 1 in the second cycle (single-fire stapler). In the second cycle, staple line reinforcement use was decreased to 37% from 92% in the previous cycle but the number of clip appliers used was similar. **Table 3** displays the total operating room supply cost adjusted for patient age and medical comorbidities. There were no statistically significant differences between the total operating room costs between the first and second cycles (cost difference: −$59, 95% confidence interval [CI] [−$143 to $26], $P = .20$), as the increased cost of the stapler body ($1,800) offset the cost savings due to decreased staple line reinforcement.

In the third study cycle, there was significantly less use of staple line reinforcements, clip appliers, as well as decreased costs associated with the stapler body and reloads. Only 20% of cases required a clip applier, and in 50% of cases, staple line reinforcement was not used. Compared to the first cycle, the adjusted overall operating room supply costs were significantly decreased (cost difference: −$1,283, 95% CI [−$1,351 to −$1,216], $P < .001$).

Figure 1 displays the detailed cost breakdown by cycle, showing that the cost reduction associated with the final

Table 3.
Multivariable Linear Regression Model for Operating Room Disposable Supply Cost

	Cost Difference	95% CI	*P*-Value
Cycle			
Cycle 1: Baseline	—	—	
Cycle 2: Single-fire stapler	−59	−143, 26	.2
Cycle 3: Disposable supply minimization	−1,283	−1,351, −1,216	<.001
Age, year	0.02	−3.0, 3.1	>.9
Diabetes			
No	—	—	
Noninsulin dependent	45	−39, 128	.3
Insulin-dependent	120	−64, 303	.2
Smoking	−6.7	−77, 64	.9
GERD	−71	−147, 5.2	.068
Anticoagulation	19	−98, 135	.7
Pulmonary embolism	−47	−309, 215	.7
Myocardial infarction	125	−163, 412	.4
Cardiac surgery	−214	−443, 16	.068
Previous PCI	−93	−383, 198	.5
Hypertension	−68	−143, 7.8	.079
Venous thrombosis	153	−62, 367	.2
Dialysis	83	−372, 537	.7
Renal insufficiency	68	−204, 340	.6
Steroids or immunosuppression	−104	−275, 67	.2
ASA Class			
II	—	—	
III	93	13, 173	.023
IV	507	−43, 1,058	.071

Abbreviations: CI, confidence interval, NA

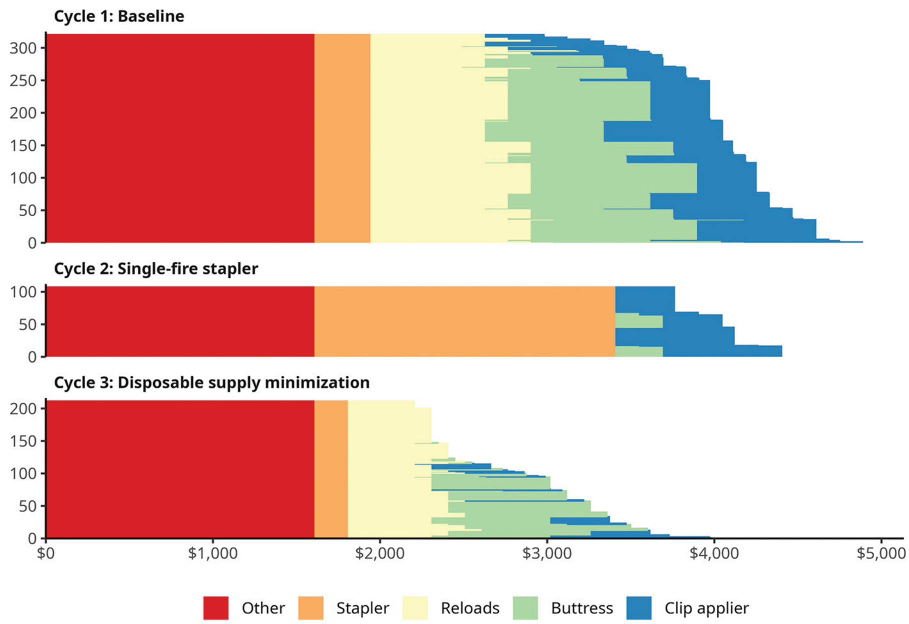

Figure 1. Detailed cost breakdown by stapler.

cycle was due to decreased staple reload costs, staple line reinforcements, and number of clip appliers used.

The total cost of operating room disposable supplies over the study period, showing a decrease in cost that only occurred after the implementation of multiple disposable supply minimization strategies.

Table 3 displays results of a multivariable linear regression model for operating room disposable supply cost. Compared to the baseline cycle, the final cycle was associated with a statistically significant decrease in $1,283 (95% CI [$1,216 to $1,351]) per case ($P < .001$).

Table 4 and **Table 5** display results of selected clinical outcomes. Operative duration was not statistically significantly different between cycles 1 and 2, but the final disposable supply minimization cycle group was associated with a 11-minute reduction in operating room time (95% CI [7 to 14]) compared to baseline. Postoperative weight information was available for 98% of patients in cycle 1, 100% of patients in cycle 2, and 91% of patients in cycle 3. There were no statistically significant differences in the average postoperative length of stay, mean weight loss in kilograms at 1 month, or in the 30-day risk of emergency department visits, reoperation, or readmission between all 3 study cycles.

After adjusting for patient characteristics and comorbidities, there were no statistically significant differences in the average postoperative length of stay or mean weight loss in kilograms at 1 month (Supplemental Table 1).

Table 4.
Univariable Logistic Regression Model for 30-Day ED Visits, Readmission, and Reoperation

	Cycle 1: Baseline N = 320	Cycle 2: Single-Fire Stapler N = 107	Cycle 3: Disposable Supply Minimization N = 211	*P*-Value
Operating room duration (minutes)	66 (54, 83)	67 (56, 81)	57 (48, 70)	<.001
Length of stay (day)	1 (1, 1)	1 (1, 1)	1 (1, 1)	.2
Weight loss at 1 month (kg)	10.9 (8.2, 13.6)	10.0 (7.7, 13.2)	10.4 (8.6, 12.7)	.4
ED visit	48 (15%)	14 (13%)	18 (8.5%)	.087
Reoperation	2 (0.6%)	1 (0.9%)	0 (0%)	.4
Readmission	3 (0.9%)	1 (0.9%)	0 (0%)	.4

Table 5.
Univariable Linear Regression Model for Selected 30-Day Outcomes

Outcome	Beta	95% CI	*P*-Value
Length of stay (day)			
Cycle 1	—	—	
Cycle 2	0.02	−0.03, 0.07	.4
Cycle 3	−0.02	−0.06, 0.01	.2
Weight loss at 1 month (kg)			
Cycle 1	—	—	
Cycle 2	−0.66	−2.0, 0.71	.3
Cycle 3	−0.27	−1.4, 0.85	.6
Percent excess body weight loss at 1 month			
Cycle 1	—	—	
Cycle 2	−1.6%	−4.9%, 1.8%	.4
Cycle 3	3.1%	0.31%, 5.8%	.029
Operating room duration (minutes)			
Cycle 1	—	—	
Cycle 2	−0.27	−5.0, 4.5	>.9
Cycle 3	−11	−14, −6.8	<.001

Abbreviation: CI, confidence interval.

There were too few reoperation or readmission events to provide stable regression estimates for comparison. Compared to the baseline cycle, there was higher percent excess weight loss at 30 days (3% difference, 95% CI [0% to 6%], $P = .026$) in cycle 3, lower adjusted odds of any 30-day emergency department visit (odds ratio [OR] 0.48, 95% CI [0.26 to 0.86], $P = .016$), and shorter operative duration (–10 minutes, 95% CI [–14 to –6], $P < .001$).

DISCUSSION

In this study conducted over 4 years at a single high-volume bariatric and metabolic surgery center, an operating room cost-reduction strategy focused on reducing the number of stapler reloads, reinforcements and clip appliers was successful in reducing the total operating room costs by an average of $1,283, without any increase in complications or decreased quality metrics.

The strengths of this study included a rigorous data collection design that leveraged the pre-existing MBSAQIP institutional registry, and consistency of the surgical technique and patient population. To our knowledge, this is the first study of costs associated with laparoscopic sleeve gastrectomy with detailed counts of the number of staple loads and reinforcements used. This level of granular detail allowed us to identify the exact contributions to cost reduction when comparing operations performed with 3 different staplers.

Staple line bleeding is a significant concern in bariatric surgery. In our study, we noted an increased use of clip appliers when the Titan SGS and ECHELON ENDOPATH staplers were used. However, by only selectively opening the clip applier, we were able to avoid its use in 50% of cases. Additionally, by selecting a staple reload with shorter compression height, we were able to reduce the intraoperative risk of staple line bleeding without the need for reinforcement material.

Because this quality improvement intervention focused on consciously reducing the number of intraoperative supplies used, its effect on operating room cost was a directly measured effect. Its effects on postoperative outcomes were indirect and could have been affected by confounders such as differences in routine postoperative care or and increased staff experience with this procedure. However, it was reassuring to find that with over 200 cases of sleeve gastrectomies performed with easyEndoLite stapler, there were no measured increases in complication rates.

There are only a few clinical studies directly comparing cost outcomes of different stapling platforms.[7–9,13,14] A previous comparative study of easyEndoLite use in minimally invasive lung cancer resection demonstrated that the EasyEndo stapler was associated with a 15.4% lower cost compared to ECHELON FLEX.[15] In a separate retrospective study, switching from a multiple firing stapler to the Titan SGS stapler as associated with an average cost-savings of $317.10 per case.[16] Additonal rigorous inquiry into the clinical and differences associated with variations in device choice and surgical technique in sleeve gastrectomy is clearly needed.

Our study has several limitations. First, the retrospective nature of data collection and analysis of this study. There were differences in baseline characteristics between the 3 groups, including weight, BMI, ethnicity, and comorbidities such as COPD and anticoagulant medication use. These were accounted for in the multivariable regression analysis for operating room cost, but there may have been residual confounding. Additionally, we were unable to account for inflation, institutional and regional differences in procurement policies and negotiated prices, and we did not account for other in-hospital costs, or any other medical expenditures after the initial operation. In addition, we did not analyze post sleeve gastrectomy GERD, a common complication after sleeve gastrectomy that may vary according to the type of surgical stapler.[17] Finally, this study is a single surgeon experience; although this ensure no variation in the operative technique, however: multicenter or multisurgeon validation would be desirable.

Future directions of inquiry should extend this cost reduction strategy towards other procedures, scaled across entire health enterprises, but raise the challenge of decreasing individual center and surgeon flexibility with regards to equipment and supply choice. Finding a balance between cost savings while mitigating surgeon inertia or potential complications due to the learning curve with new instruments and devices will likely be an ongoing and dynamic challenge.

CONCLUSIONS

Operating room cost-reduction methods such as selective use of staple line reinforcement, clip appliers and choosing less costly stapler devices may be effective cost-reduction strategies for laparoscopic sleeve gastrectomy. In our study, the application of multiple intraoperative strategies was associated with comparable safety and decreased cost. Additional studies should seek to understand the scalability and long-term durability of such association, and their application for other procedures.

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Appendix

Supplemental Table 1
Additional Analysis of Clinical Outcomes by Study Cycle, Using the Same Adjustment Variables as the Main Outcome of Cost

Outcome	Outcome Available (Sample Size)	Difference/Odds Ratio	95% CI	*P*-Value
Operative duration (minutes)	635			
Cycle 1: Baseline		—	—	
Cycle 2: Single-fire stapler		0	−4, 5	.9
Cycle 3: Disposable supply minimization		−10	−14, −6	<.001
Length of stay (days)	638			
Cycle 1: Baseline		—	—	
Cycle 2: Single-fire stapler		0	0, 0	.5
Cycle 3: Disposable supply minimization		0	0, 0	.14
30-day postoperative weight loss (kg)	610			
Cycle 1: Baseline		—	—	
Cycle 2: Single-fire stapler		−1	−2, 1	.4
Cycle 3: Disposable supply minimization		0	−1, 1	.6
Excess weight loss (%)	610			
Cycle 1: Baseline		—	—	
Cycle 2: Single-fire stapler		−2%	−5%, 1%	.3
Cycle 3: Disposable supply minimization		3%	0%, 6%	.026
ED visits	638			
Cycle 1: Baseline		—	—	
Cycle 2: Single-fire stapler		0.91	0.45, 1.75	.8
Cycle 3: Disposable supply minimization		0.48	0.26, 0.86	.016