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# Staple Line Treatment and Bleeding After Laparoscopic Sleeve Gastrectomy

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## ABSTRACT

**Background and Objectives:** Staple line treatment during laparoscopic sleeve gastrectomy (LSG) remains a controversial issue among bariatric surgeons. The objective of this study was to compare rates of postoperative bleeding (POB) among various methods of staple line reinforcement.

**Methods:** The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program 2015 dataset was queried for patients undergoing an LSG. Patients were stratified by staple line treatment groups—no treatment (NT), suture oversewing (OVERSEW), buttressing by a commercial product (BUTTRESS), and both buttress and oversew (COMBINATION). The primary outcome was POB. Multivariable logistic regression was used to compare POB rates among the treatment groups.

**Results:** In the 98,142 LSG patients meeting selection criteria, 623 (0.63%) patients had POB and 181 (0.18%) required reoperation. POB occurred in 0.80% for the NT group, 0.68% for the OVERSEW group, 0.57% for the BUTTRESS group, and 0.55% for the COMBINATION group. On multivariable analyses, all treatment groups were less likely to have POB compared with the NT group—OVERSEW (odds ratio [OR] 0.73, 95% confidence interval [CI] 0.54–0.98), BUTTRESS (OR 0.70, 95% CI 0.57–0.84), and COMBINATION (OR 0.66, 95% CI 0.50–0.89) (all $P < .01$). Subset analysis revealed no difference between BUTTRESS and OVERSEW (OR 0.95, 95% CI 0.71–1.26, $P = .71$).

**Conclusions:** Relative to an NT staple line, the use of OVERSEW or BUTTRESS can decrease the rates of POB by up to 30%. The use of these techniques should be strongly considered by the bariatric surgeon.

**Key Words:** Bariatric surgery, Complications, Outcomes, Quality.

## INTRODUCTION

Laparoscopic sleeve gastrectomy (LSG) is the most commonly performed bariatric procedure in the United States, favored for its excess weight loss, resolution of comorbidities, and low complication rate.[1] Serious complications associated with LSG include postoperative leaks and hemorrhage from the staple line. The reported incidence of staple line hemorrhage is up to 3%.[2] The median additional cost per bleed is approximately $5261 (range $1879-$49,350), with the majority attributable to prolonged hospital stay.[3]

Staple line reinforcement (SLR)—using biologic or synthetic buttressing or by oversewing the staple line—is used as a strategy to decrease the incidence of both leaks and hemorrhage. However, the effectiveness of these methods in reducing the incidence of hemorrhage POB is not well defined.[4,5] Although various studies have assessed the impact of these techniques on the safety of LSG, the results have been controversial. Using a large multicenter dataset, this study aims to determine the incidence, consequences, and factors associated with POB after LSG. We also aim to compare the risk-adjusted rates of POB among the various accepted methods of SLR.

## METHODS

We selected all patients undergoing an LSG from the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP), participant user file (PUF) dataset for admission year 2015. The MBSAQIP is a

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The hospitals participating in the MBSAQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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Informed consent: Dr. Kligman declares that written informed consent was obtained from the patient for publication of this study/report and any accompanying images.

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joint venture by the American College of Surgeons and the American Society for Metabolic and Bariatric Surgery to achieve a national standard for bariatric surgery. Part of the accreditation status ensures collection of high-quality clinical and outcome data. The MBSAQIP PUF is a Health Insurance Portability and Accountability Act compliant data file containing information from all participating centers across the country for research purposes.[6] The 2015 PUF contains demographic, clinical, operative, and outcome information from more than 160,000 patients from more than 742 centers across the United States. The dataset does not contain any identifying information for patients, surgeons, or facilities, and secondary data analysis was exempt from review by the Institutional Review Board at the University of Maryland School of Medicine.

Patients undergoing an LSG were identified by a *Current Procedural Terminology* (CPT) procedure code of 43775. We excluded patients at extremes of ages (age $<$ 10 y and $>$ 80 y). Demographic information included age, ethnicity, and sex. Biometric measurements included weight and body mass index (BMI). Preoperative clinical information included comorbid conditions, medication use, and history of certain illnesses and procedures. Intraoperative variables included concurrent procedures, length of operation, assistant's level of training, size of bougie used, conversion to open procedure, use of robotic technology, and method of staple line treatment. Staple line treatment included no treatment (NT), suture oversewing (OVERSEW), buttressing by a commercial product (BUTTRESS), and both buttress and oversew (COMBINATION).

The primary outcome variable was POB, defined as the need for a blood transfusion within 72 h of operation or any unplanned procedure (including reoperation, unplanned endoscopy, and interventional radiology) performed for the purposes of "bleeding." We chose this definition of POB to detect only those with clinically significant bleeding events. Patients who had POB who did not require any intervention (transfusion or procedure) were not captured in the database and are not included in the outcome analysis. Other outcome variables included postoperative length of hospital stay (LOS), in-hospital mortality, 30-d mortality, 30-d complications, discharge to facility, and readmission within 30 d.

We calculated and tabulated means and standard deviations (SDs) for continuous variables and frequency with proportions for categorical ones. To determine factors associated with POB, we performed bivariate analysis using the $\chi^2$ test and Student's *t* test when appropriate. All variables that were significant on bivariate analysis ($P <$ .05), and those that were clinically relevant were selected for the multivariable model. Multivariable logistic regression was used to determine the independent effect of staple line treatment on POB. The NT group was compared with each of the other 3 treatment groups (OVERSEW, BUTTRESS, and COMBINATION). Separate multivariable models were used to compare the effect of OVERSEW alone versus BUTTRESS alone, OVERSEW versus COMBINATION, and BUTTRESS versus COMBINATION. Bonferroni corrections were applied. The Hosmer-Lemeshow Goodness of Fit was used to test for model fit.[7] All analyses were performed using STATA Version 13 (Stata Corp, College Station, TX, USA).

## RESULTS

A total of 98,142 patients undergoing LSG were selected for analysis. The mean age was 44.5 y (SD ± 12 y), and 79% of the population were women; 73.5% were reported to be of white ethnicity. The mean BMI was 45.1 kg/m$^2$ (SD 8.3). Comorbid conditions were expectedly frequent, with the most common being hypertension requiring medication (48%) followed by gastroesophageal reflux disease requiring medication (29%), diabetes mellitus (23%), and hyperlipidemia (23%). The mean operative time was 78 min (SD ± 39) with 50% of operations performed between 52 and 94 min. Most used a bougie size less than 38Fr (55%). A midlevel provider was the assistant in 37% of operations, and a resident was present in 17%. No staple line treatment was used in 23% of patients, while OVERSEW alone as used in 10%, BUTTRESS in 54%, and COMBINATION in 13% (**Table 1**).

A total of 623 (0.63%) patients had POB. Management of POB included reoperation in 181 (29.1%) patients and unplanned endoscopy in 34 (5.5%) patients. Patients with POB received a mean of 2.6 U of blood (range 1 to 12 U). The incidence of POB was 0.80% for the NT group, 0.68% for the OVERSEW group, 0.57% for the BUTTRESS group, and 0.55% for the COMBINATION group. **Table 2** depicts outcomes for patients with POB versus for patients without POB. Patients with POB had a significantly longer median LOS (3 vs 2 d), were more likely to suffer a 30-d complication (13.8% vs 1.3%), were more likely to be discharged to a facility rather than to home (4.01% vs 0.47%), and had higher mortality (1.12% vs 0.08%) (all *P*-values $<$ .001).

On bivariate analysis, several preoperative and operative factors were associated with POB (Table 1). Multivariable analysis (**Table 3**) revealed factors associated with an

**Table 1.**
Demographic and Clinical Characteristics of Patients Who Sustained a Postoperative Bleeding Event Versus Those Who Did Not, From the MBSAQIP

| A: Demographics<br>Variable | Categories | No POB<br>(n = 97,519) | POB<br>(n = 623) | Total<br>(N = 98,142) | *P* Value |
|---|---|---|---|---|---|
| Age (years) | <30 | 10,800 (11.1) | 28 (4.5) | 10,828 (11.0) | <.001 |
| | 30–39 | 24,451 (25.1) | 121 (19.4) | 24,572 (25.0) | |
| | 40–49 | 28,480 (29.2) | 180 (28.9) | 28,660 (29.2) | |
| | 50–59 | 22,170 (22.7) | 165 (26.5) | 22,335 (22.8) | |
| | ≥60 | 11,609 (11.9) | 129 (20.7) | 11,738 (12.0) | |
| | Missing | 9 (0.0) | 0 (0) | 9 (0.0) | |
| Sex | Male | 20,459 (21.0) | 155 (24.9) | 20,614 (21.0) | .017 |
| | Female | 77,060 (79.0) | 468 (75.1) | 77,528 (79.0) | |
| Race | American Indian | 342 (0.4) | 1 (0.2) | 343 (0.4) | .245 |
| | Asian | 450 (0.5) | 4 (0.6) | 454 (0.5) | |
| | Black or African American | 17,556 (18.0) | 116 (18.6) | 17,672 (18.0) | |
| | Native Hawaiian | 204 (0.2) | 0 (0.0) | 204 (0.2) | |
| | White | 71,685 (73.5) | 469 (75.3) | 72,154 (73.5) | |
| | Missing | 7,282 (7.5) | 33 (5.3) | 7,315 (7.5) | |
| Hispanic ethnicity | Yes | 11,773 (12.1) | 70 (11.2) | 11,843 (12.1) | .619 |
| | No | 75,568 (77.5) | 493 (79.1) | 76,061 (77.5) | |
| | Missing | 10,178 (10.5) | 60 (9.6) | 10,238 (10.4) | |
| BMI category ($kg/m^2$) | <35 | 4,073 (4.2) | 31 (5.0) | 4,104 (4.2) | .308 |
| | 35–40 | 22,668 (23.3) | 167 (26.8) | 22,835 (23.4) | |
| | 40–50 | 48,989 (50.2) | 292 (46.87) | 49,281 (50.2) | |
| | 50–70 | 19,706 (20.2) | 124 (19.90) | 19,830 (20.2) | |
| | >70 | 1,363 (1.4) | 6 (0.96) | 1,369 (1.4) | |
| | Missing | 719 (0.7) | 3 (0.48) | 722 (0.7) | |
| **B: Preoperative Factors** | | | | | |
| GERD requiring medication | Yes | 28,111 (28.8) | 240 (38.5) | 28,351 (28.9) | <.001 |
| | No | 69,408 (71.2) | 383 (61.5) | 69,791 (71.1) | |
| Limited ambulation | Yes | 1,753 (1.8) | 24 (3.6) | 1,777 (1.8) | <.001 |
| | No | 95,766 (98.2) | 599 (96.2) | 96,365 (98.2) | |
| History of myocardial infarction | Yes | 1,162 (1.2) | 12 (1.9) | 1,1174 (1.2) | .093 |
| | No | 96,357 (98.8) | 611 (98.1) | 96,968 (98.8) | |
| History of cardiac surgery | Yes | 1,097 (1.1) | 24 (3.9) | 1,121 (1.1) | <.001 |
| | No | 96,422 (98.9) | 599 (96.2) | 97,021 (98.9) | |
| Previous PCI/PTCA | Yes | 1,861 (1.9) | 26 (4.2) | 1,887 (1.9) | <.001 |
| | No | 95,658 (98.1) | 597 (95.8) | 96,255 (98.1) | |

*Continued*

**Table 1.**
Demographic and Clinical Characteristics of Patients Who Sustained a Postoperative Bleeding Event Versus Those Who Did Not, From the MBSAQIP

| Variable | Categories | No POB (n = 97,519) | POB (n = 623) | Total (N = 98,142) | *P* Value |
|---|---|---|---|---|---|
| Preoperative hypertension requiring medication | Yes | 46,362 (47.5) | 391 (62.8) | 46,753 (47.6) | <0.001 |
| | No | 51,157 (52.5) | 232 (37.2) | 51,389 (52.4) | |
| Number of hypertension medications | 0 | 219 (0.2) | 0 (0.00) | 219 (0.2) | <.001 |
| | 1 | 21,413 (22.0) | 142 (22.8) | 21,555 (22.0) | |
| | 2 | 15,772 (16.2) | 148 (23.8) | 15,920 (16.2) | |
| | 3+ | 60,115 (61.6) | 333 (53.5) | 60,448 (61.6) | |
| Preoperative therapeutic anticoagulation | Yes | 2,098 (2.2) | 56 (9.0) | 2,154 (97.8) | <.001 |
| | No | 95,421 (97.9) | 567 (91.0) | 95,988 (97.8) | |
| Preoperative hyperlipidemia | Yes | 22,449 (23.0) | 217 (34.8) | 22,666 (23.1) | <.001 |
| | No | 75,070 (77.0) | 406 (65.2) | 75,476 (76.9) | |
| Preoperative deep venous thrombosis | Yes | 1,466 (1.5) | 18 (2.9) | 1,484 (1.5) | .005 |
| | No | 96,053 (98.5) | 605 (97.1) | 96,658 (98.5) | |
| Preoperative venous stasis | Yes | 876 (0.9) | 10 (1.6) | 886 (0.9) | .063 |
| | No | 96,643 (99.1) | 613 (98.4) | 97,256 (99.1) | |
| Preoperative dialysis | Yes | 303 (0.3) | 5 (0.8) | 308 (0.3) | .029 |
| | No | 97,216 (99.7) | 618 (99.2) | 97,834 (99.7) | |
| Preoperative renal insufficiency | Yes | 615 (0.6) | 18 (2.9) | 633 (0.6) | <.001 |
| | No | 96,904 (99.4) | 605 (97.1) | 97,509 (99.4) | |
| Previous surgery (obesity-related or foregut surgery) | Yes | 6,376 (6.5) | 47 (7.5) | 6,423 (6.5) | .312 |
| | No | 91,143 (93.5) | 576 (92.4) | 91,719 (93.5) | |
| Diabetes mellitus | Yes | 22,167 (22.7) | 207 (33.2) | 22,374 (22.8) | <.001 |
| | No | 75,352 (77.3) | 416 (66.8) | 75,768 (77.2) | |
| Smoked within 1 year | Yes | 8,584 (8.8) | 60 (9.6) | 8,644 (8.8) | .467 |
| | No | 88,935 (91.2) | 563 (90.4) | 89,498 (91.2) | |
| Presurgical functional status | Independent | 96,553 (99.0) | 611 (98.1) | 97,164 (99.0) | .055 |
| | Partially dependent | 588 (0.6) | 8 (1.3) | 596 (0.6) | |
| | Totally dependent | 378 (0.4) | 4 (0.6) | 382 (0.4) | |
| History of COPD | Yes | 1,575 (1.6) | 25 (4.0) | 1,600 (1.6) | <.001 |
| | No | 95,944 (98.4) | 598 (96.0) | 96,542 (98.4) | |
| Oxygen dependence | Yes | 597 (0.6) | 12 (1.9) | 609 (0.6) | <.001 |
| | No | 96,922 (99.4) | 611 (98.1) | 97,533 (99.4) | |
| History of pulmonary embolism (posttreatment) | Yes | 1,044 (1.1) | 16 (2.6) | 1,060 (1.1) | <.001 |
| | No | 96,475 (98.9) | 607 (97.4) | 97,082 (98.9) | |
| Preoperative obstructive sleep apnea requiring CPAP/BiPAP | Yes | 33,680 (34.5) | 275 (44.1) | 33,955 (34.6) | <.001 |
| | No | 63,839 (65.5) | 348 (66.9) | 64,187 (65.4) | |
| Preoperative steroid/immuno-suppressant use for a chronic condition | Yes | 1,591 (1.6) | 16 (2.6) | 1,607 (1.6) | .066 |
| | No | 95,928 (98.4) | 607 (97.4) | 96,535 (98.4) | |

*Continued*

**Table 1.**
Demographic and Clinical Characteristics of Patients Who Sustained a Postoperative Bleeding Event Versus Those Who Did Not, From the MBSAQIP

| Variable | Categories | No POB (n = 97,519) | POB (n = 623) | Total (N = 98,142) | *P* Value |
|---|---|---|---|---|---|
| Preoperative IVC filter | Yes | 899 (0.9) | 8 (1.3) | 907 (0.9) | .346 |
| | No | 96,620 (99.1) | 615 (98.7) | 97,235 (99.0) | |
| ASA classification principle operative procedure | I No disturbance | 528 (0.5) | 3 (0.5) | 531 (0.5) | <.001 |
| | II Mild disturbance | 25,336 (26.0) | 124 (19.9) | 25,460 (25.9) | |
| | III Severe disturbance | 68,099 (69.8) | 437 (70.1) | 68,536 (69.8) | |
| | IV Life threatening | 3,259 (3.3) | 57 (9.2) | 3,316 (3.4) | |
| | V Moribund | 4 (0.0) | 1 (0.2) | 5 (0.0) | |
| | None assigned | 293 (0.3) | 1 (0.2) | 294 (0.3) | |
| Preoperative hematocrit | <21 | 138 (0.1) | 1 (0.2) | 139 (0.1) | <.001 |
| | 21–30 | 237 (0.2) | 13 (2.1) | 250 (0.3) | |
| | 30–36 | 6,209 (6.4) | 68 (10.9) | 6,277 (6.4) | |
| | 36–45 | 70,495 (72.3) | 407 (65.3) | 70,902 (72.2) | |
| | >45 | 11,324 (11.6) | 81 (13.0) | 11,405 (11.6) | |
| | Unknown | 9,116 (9.4) | 53 (8.5) | 9,169 (9.3) | |
| Preoperative albumin less than 3 mg/dL | Yes | 374 (0.4) | 6 (1.0) | 380 (0.4) | .020 |
| | No | 97,145 (99.6) | 617 (99.0) | 97,762 (99.6) | |
| **C: Intraoperative Variables** | | | | | |
| Robotic approach | Yes | 5,843 (6.0) | 33 (5.3) | 5,876 (6.0) | .466 |
| | No | 91,676 (94.0) | 590 (94.7) | 92,266 (94.0) | |
| Approach converted to open | Yes | 57 (0.1) | 9 (1.4) | 66 (0.1) | <.001 |
| | No | 97,462 (99.9) | 614 (98.6) | 98,076 (99.9) | |
| Reoperation revision/conversion | Yes | 5,544 (5.7) | 42 (6.7) | 5,586 (5.7) | .257 |
| | No | 91,975 (94.3) | 581 (93.3) | 92,556 (94.3) | |
| Drain placed at time of operation | Yes | 19,748 (20.3) | 163 (26.2) | 19,911 (20.3) | <.001 |
| | No | 77,771 (79.8) | 460 (73.8) | 78,231 (79.7) | |
| Swallow study performed day of or day after procedure | Yes, routine | 41,846 (42.9) | 243 (39.0) | 42,089 (42.9) | .001 |
| | Yes, selective | 1,359 (1.4) | 19 (3.1) | 1,378 (1.4) | |
| | No | 54,314 (55.7) | 361 (58.0) | 54,675 (55.7) | |
| Concurrent procedure | None | 65,191 (66.9) | 406 (65.2) | 65,597 (66.8) | .006 |
| | Liver biopsy | 5,902 (6.1) | 57 (9.2) | 5,959 (6.1) | |
| | Hiatal hernia repair | 22,209 (22.8) | 125 (20.1) | 22,334 (22.8) | |
| | Cholecystectomy | 1,353 (1.4) | 12 (1.9) | 1,365 (1.4) | |
| | Band removal | 2,864 (2.9) | 23 (3.7) | 2,887 (2.9) | |

*Continued*

**Table 1.**
Demographic and Clinical Characteristics of Patients Who Sustained a Postoperative Bleeding Event Versus Those Who Did Not, From the MBSAQIP

| Variable | Categories | No POB (n = 97,519) | POB (n = 623) | Total (N = 98,142) | *P* Value |
|---|---|---|---|---|---|
| Assistant level | Resident | 16,472 (16.9) | 121 (19.4) | 16,593 (16.9) | .233 |
| | Fellow | 7,578 (7.8) | 59 (9.5) | 7,637 (7.8) | |
| | PA/NP/RNF | 35,725 (36.6) | 222 (35.6) | 35,947 (36.6) | |
| | Attending | 16,135 (16.6) | 98 (15.7) | 16,233 (16.5) | |
| | Attending non-bariatric | 6,157 (6.3) | 33 (5.3) | 6,190 (6.3) | |
| | None | 15,452 (15.9) | 90 (14.5) | 15,542 (15.8) | |
| Bougie size | < 38Fr | 54,066 (55.4) | 341 (54.7) | 54,407 (55.4) | .302 |
| | ≥ 38Fr | 39,212 (40.2) | 247 (39.7) | 39,459 (40.2) | |
| | Missing | 4,241 (4.4) | 35 (5.6) | 4,276 (4.4) | |
| Staple line treatment | No treatment | 22,420 (23.0) | 181 (29.1) | 22,601 (23.0) | .005 |
| | Oversew alone | 9,864 (10.1) | 68 (10.9) | 9,932 (10.1) | |
| | Buttress | 52,654 (54.0) | 304 (48.8) | 52,958 (54.0) | |
| | Combination of buttress and oversew | 12,576 (12.9) | 70 (11.2) | 12,646 (12.9) | |

ASA, American Society of Aanesthesiology; BiPAP, bilevel positive airway pressure; BMI, body mass index; COPD, chronic obstructive pulmonary disease; CPAP, continuous positive airway pressure; GERD, gastroesophageal reflux disease; IVC, inferior vena cava; NP, nurse practitioner; PA, physician assistant; PCI, percutaneous coronary intervention; POB, postoperative bleeding; PTCA, percutaneous transluminal coronary angioplasty; RNF, Registered Nurse First Assistant.

Values given as n (%).

increased likelihood of POB included higher age (OR 2.02, 95% CI 1.27–3.21 for age > 60 y vs < 30 y), gastroesophageal reflux disease requiring medication (OR 1.23, 95% CI 1.04–1.47), hypertension (OR 1.33, 95% CI 1.10–1.62), history of renal failure (OR 2.10, 95% CI 1.20–3.68), preoperative therapeutic anticoagulation (OR 3.20, 95% CI 2.26–4.55), undergoing a liver biopsy (OR 1.41, 95% CI 1.05, 1.89), conversion to open (OR 17.7, 95% CI 8.00–39.1), and placement of a drain (OR 1.36, 95% CI 1.12–1.65). However, higher weight (OR 0.98, 95% CI 0.96–0.99 for every 10-kg increase) and higher preoperative hematocrit (OR 0.15, 95% CI 0.08–0.28 for hematocrit of > 45% vs < 30%) were both associated with a decreased likelihood of POB.

Staple line treatment was an independent factor associated with POB. OVERSEW (OR 0.73, 95% CI 0.54–0.98), BUTTRESS (OR 0.70, 95% CI 0.57–0.84), and COMBINATION (OR 0.66, 95% CI 0.50–0.89) were significantly protective against bleeding compared with an untreated staple line. In separate multivariable models when staple line treatments were compared, no difference was found for OVERSEW versus BUTTRESS (OR 0.95, 95% CI 0.71–1.26), OVERSEW versus COMBINATION (OR 0.91, 95% CI 0.63–1.32), or BUTTRESS versus COMBINATION (OR 0.96, 95% CI 0.73–1.26) (**Figure 1**).

## DISCUSSION

The impact of SLR on POB is controversial. Several previous studies demonstrated that SLR reduces the incidence of POB but provided conflicting evidence with regard to the optimal technique. In a similar analysis of an older version of MBSAQIP, Berger et al found that buttressing resulted in lower bleed rates compared with no SLR.[8] Patients who underwent buttressing with or without oversewing of the staple line had significantly lower bleeding rates than did those patients with no reinforcement (0.67% vs 1.00%). In their analysis, they found that the bleeding rate with just oversewing was higher than that of buttress alone or buttress plus oversewing.[8] Musella et al found that using fibrin sealant significantly reduced the rate of POB after LSG compared with no reinforcement.[9] In a multicenter study of 1162 LSG patients, D'Ugo et al also found a

**Table 2.**
Bivariate Comparison of Outcomes for Patients Who Sustained a Postoperative Bleed After Laparoscopic Sleeve Gastrectomy Versus Those Who Did Not, From the MBSAQIP

| Outcome | No POB (n = 97,519) n (%) | POB (n = 623) n (%) | Total (N = 98,142) n (%) | *P* Value |
|---|---|---|---|---|
| Length of stay: 0–1 days | 46,939 (48.2) | 35 (5.7) | 46,974 (47.9) | <.001 |
| 2 days | 40,957 (42.0) | 79 (12.7) | 41,036 (41.9) | |
| 3–7 days | 8,971 (9.21) | 467 (75.3) | 9,438 (9.63) | |
| >7 days | 560 (0.57) | 39 (6.29) | 599 (0.61) | |
| Length of stay, median (IQR) | 2 (1–2) | 3 (3–3) | 2 (1–2) | <.001* |
| Discharged to facility | 455 (0.47) | 25 (4.01) | 480 (0.49) | <.001 |
| In-hospital mortality | 19 (0.02) | 7 (1.12) | 26 (0.03) | <.001 |
| 30-day postsurgery mortality | 81 (0.08) | 7 (1.12) | 88 (0.09) | <.001 |
| Unplanned readmission within 30 days | 431 (0.44) | 135 (21.67) | 566 (0.58) | <.001 |
| Acute renal failure requiring hemodialysis | 54 (0.06) | 12 (1.93) | 66 (0.07) | <.001 |
| Intraoperative or postoperative cardiac arrest requiring CPR | 26 (0.03) | 12 (1.93) | 38 (0.04) | <.001 |
| Intraoperative or postoperative cerebrovascular incident | 9 (0.01) | 3 (0.48) | 12 (0.01) | <.001 |
| Postoperative deep incisional SSI | 27 (0.03) | 1 (0.16) | 28 (0.03) | .050 |
| Postoperative superficial SSIs | 239 (0.25) | 5 (0.80) | 244 (0.25) | <.001 |
| Postoperative organ space SSIs | 174 (0.18) | 14 (2.25) | 188 (0.19) | >.001 |
| Wound disruption | 20 (0.02) | 4 (0.64) | 24 (0.02) | <.001 |
| Postoperative ventilator requirement > 48 hours | 51 (0.05) | 14 (2.25) | 65 (0.07) | <.001 |
| Intraoperative or postoperative myocardial infarction | 27 (0.03) | 3 (0.48) | 30 (0.03) | <.001 |
| Pulmonary embolism | 87 (0.09) | 5 (0.80) | 92 (0.09) | <.001 |
| Progressive renal insufficiency (not requiring hemodialysis) | 62 (0.06) | 11 (1.77) | 73 (0.07) | <.001 |
| Postoperative sepsis (if occurred) | 76 (0.08) | 12 (1.93) | 88 | <.001 |
| Postoperative septic shock | 31 (0.03) | 8 (1.28) | 39 (0.04) | <.001 |
| Unplanned intubation | 99 (0.10) | 25 (4.01) | 124 (0.13) | <.001 |
| Postoperative UTI | 271 (0.28) | 5 (0.80) | 276 (0.28) | .048 |
| Postoperative venous thrombosis requiring treatment | 170 (0.17) | 7 (1.12) | 177 (0.18) | <.001 |
| Postoperative pneumonia | 129 (0.13) | 8 (1.28) | 137 (0.14) | <.001 |
| Any complication | 1,264 (1.30) | 86 (13.8) | 1,350 (1.38) | <.001 |

Length of stay variables are postoperative length of stay. CPR, cardiopulmonary resuscitation; IQR, interquartile range; MBSAQIP, Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program; SSI, surgical site infection; UTI, urinary tract infection.

* Wilcoxon rank sum test.

**Table 3.**
Factors Associated With Bleeding From Multivariable Logistic Regression Analysis

| Variable | Categories | Odds Ratio | 95% CI | *P* Value |
|---|---|---|---|---|
| Staple line treatment | No treatment | 1.00 | – | – |
| | Oversew alone | 0.73 | 0.54–0.98 | .040 |
| | Buttress | 0.70 | 0.57–0.84 | <.001 |
| | Combination | 0.66 | 0.50–0.89 | <.001 |
| Age (years) | <30 | 1.00 | – | – |
| | 30–39 | 1.64 | 1.06–2.52 | .025 |
| | 40–49 | 1.82 | 1.19–2.78 | .006 |
| | 50–59 | 1.81 | 1.17–2.81 | .008 |
| | >60 | 2.02 | 1.27–3.21 | .003 |
| Weight | Every 10-kg increase | 0.98 | 0.96–0.99 | .009 |
| Preoperative hematocrit level | <30 | 1.00 | – | – |
| | 30–36 | 0.22 | 0.11–0.42 | <.001 |
| | 36–45 | 0.13 | 0.07–0.24 | <.001 |
| | >45 | 0.15 | 0.08–0.28 | <.001 |
| GERD requiring medications | Yes | 1.23 | 1.04–1.47 | .018 |
| HTN requiring medications | Yes | 1.33 | 1.10–1.62 | .004 |
| History of renal insufficiency | Yes | 2.10 | 1.20–3.68 | .009 |
| Preoperative therapeutic anticoagulation | Yes | 3.20 | 2.26–4.55 | <.001 |
| Liver biopsy | Yes | 1.41 | 1.05–1.89 | .022 |
| Converted to open | Yes | 17.7 | 8.00–39.1 | <.001 |
| Drain placed | Yes | 1.36 | 1.12–1.65 | .002 |

CI, confidence interval; GERD, gastroesophageal reflux disease; HTN, hypertension.

Model additionally adjusted for sex, revisional surgery, functional status, preoperative percutaneous cardiac intervention, prior cardiac surgery, history of deep vein thrombosis or pulmonary embolism, prior foregut surgery, history of hyperlipidemia, diabetes, history of chronic obstructive pulmonary disease, oxygen dependency, robotic approach, assistant level of training, preoperative albumin level, leak testing, and other concurrent procedures.

lower rate of POB in patients who received SLR with either oversewing, bovine pericardium, synthetic polyester, glycolide/trimethylene copolymer, or thrombin matrix.[10] They found no difference between the various techniques used. However, other studies have found no benefit with SLR to prevent POB after LSG. Carandina et al found that in comparison with the non-SLR group, performing SLR with either fibrin glue coverage or oversewing with imbricating absorbable or barbed running suture did not change the rate of POB.[11] A large meta-analysis of 7 randomized controlled trials found no significant difference in bleeding when performing staple line oversewing during LSG.[12] Most of the studies showing no benefit for staple line treatment have smaller sample sizes and may be lacking in power to demonstrate a difference.

There may be a role for selective versus routine use of SLR. In our study, we found that patients with hypertension, a history of renal insufficiency, and the use of preoperative therapeutic anticoagulation are associated with higher odds of developing POB; these may be considered high-risk patients. We were unable to perform stratified analysis of staple line treatment in high- and low-risk patients alone due to lack of power; however, this should be considered in the future as more data are accrued. A previous study by Janik et al found that protective factors for hemorrhagic complications after LSG were no history of obstructive sleep apnea (OSA) and no history of hypertension. They also found that a low level of surgeon expertise and no SLR were associated with a higher risk of POB.[13] De Angelis et al, in a 4-year review of a high-volume center, similarly found that patients with POB

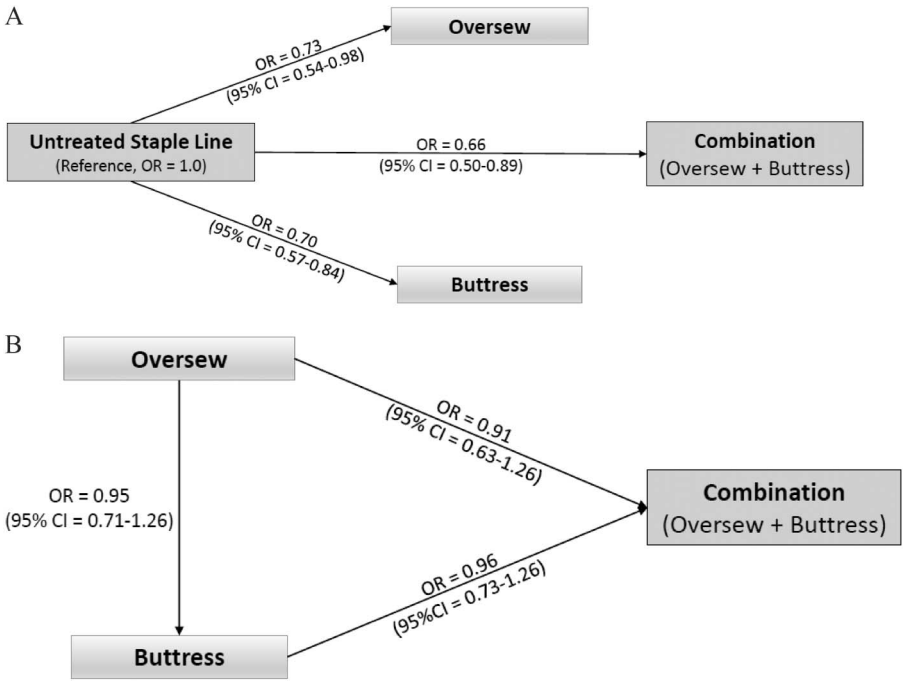


**Figure 1.** Multivariable comparison of various staple line treatment methods and postoperative bleeding. **A.** Comparison of postoperative bleeding between untreated staple lines and the various staple line reinforcement techniques. (adjusted odds ratios and 95% confidence intervals provided.) **B.** Comparison of postoperative bleeding between oversew and buttress techniques of staple line reinforcement. (Adjusted odds ratios and 95% confidence intervals provided.)

were more likely to have hypertension and to be taking anticoagulation medications.[14] We found, somewhat comparably, that hypertension is associated with a 33% increased risk of post-LSG bleeding. Janik et al surmised that because both hypertension and OSA are associated with peripheral vascular resistance and atherosclerosis, these conditions can lead to vascular remodeling, which may change the vascular histology and increase stiffness of the small vessels. In turn, the staple firing or ligation by the energy device may have been altered as a result.[13] Choosing to perform SLR in high-risk patients, such as patients with hypertension or OSA or who are taking anticoagulation therapy, may be the most beneficial route, rather than performing SLR routinely on all patients. Future cost-effectiveness studies should focus on high-risk individuals.

Reinforcing the staple line can require extra operative time, cost, and expertise. Carandina et al found that SLR significantly increased mean total operative time by up to about 27 min; however, it did not increase LOS.[11] A meta-analysis found that, overall, there was no significant difference in operative time between SLR and the no-reinforcement group; however, when stratified, there was found to be a longer operative time for the oversewing group compared with no reinforcement.[15] In a study done in Italy, Gentileschi et al found that oversewing the staple line, buttressing the transsection with a polyglycolide acid and trimethylne carbonate, or staple line roofing with gelatin fibrin matrix also increased the cost of the operation by up to 580 euros per patient. Also, mean operating room times increased by up to 14 min with the addition of SLR.[16] However, the costs of leaks and POBare quite significant[3] and may easily offset the cost of extra time taken to reinforce the staple line.[17]

There are several limitations to this study. Because this is a retrospective analysis of prospectively collected data, our analysis is limited to the information provided in the dataset and is subject to errors in data collection and coding inherent to large database studies. It is important to remember that our analysis captures only clinically significant bleeding events and not all postoperative bleeds. In our definition of POB, we only include those bleeding events that led to a blood transfusion or an interventional procedure. It is very possible that there are still several patients who had POB that was not clinically significant to require transfusions or procedure. Also, surgeons have varying thresholds to intervene on POB. It is impossible to capture and account for these variations in our analysis. There is no clear variable for postoperative

"leaks" in the dataset, and this was not assessed. However, assessing postoperative leaks was also not in the scope of this report, which focuses on postoperative bleeds. Another limitation is that all SLR by buttressing is lumped into one category; no information is available about the product used, so product-related effects cannot be ascertained. Similarly, the particular techniques used to oversew are also unknown. In addition, individual information on facilities and surgeons is not provided in the MBSAQIP PUF, so we are unable to adjust for clustering by facility or provider.

In conclusion, POB, occurring in 0.6% of patients after LSG, can be significantly reduced by addressing the staple line. We found that either suture oversewing or buttressing the staple line with a commercial product is effective at maintaining hemostasis. More research must be done to determine the underlying reasons for postoperative staple line bleeding and whether SLR should be performed only in a selection of high-risk patients. Because POB after LSG is associated with remarkably worse outcomes, these reinforcement techniques should be strongly considered by the bariatric surgeon.

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