The worldwide obesity epidemic has led to an increase in the number of bariatric procedures for treatment. Currently, the most commonly performed bariatric surgical operation in the United States is the laparoscopic sleeve gastrectomy (LSG). The risk of postoperative nausea and vomiting (PONV) is exceptionally high following the LSG: as much as 65%. Anesthesia providers should be mindful of this elevated risk and stay up to date on evidence-based techniques that help to mitigate the incidence of PONV related to this specific procedure. The purposes of this clinical review are to increase provider awareness of the PONV risk following LSG and to examine methods for improving PONV outcomes for this population.

Keywords: Bariatric surgery, laparoscopic sleeve gastrectomy, postoperative nausea and vomiting.

The World Health Organization notes that there are nearly 2 billion adults who are either overweight or obese worldwide. Current trends show an increase in the prevalence of obesity in almost every nation. The Centers for Disease Control and Prevention estimate that more than 93 million Americans, or about 40% of the population, are clinically obese. This widespread obesity has led to an increasing number of bariatric surgeries, which are procedures aimed at reducing obesity and its associated comorbidities. In the United States the estimated number of bariatric procedures performed rose from 158,000 in 2011 to 228,000 in 2017 (Figure 1). In 2017 the laparoscopic sleeve gastrectomy (LSG) accounted for nearly 60% of all bariatric surgeries.5

Although the LSG is safe and efficacious, postoperative nausea and vomiting (PONV) is abundantly common and problematic. Postoperative nausea and vomiting is more likely after LSG than after other bariatric procedures, with as many as 65% of patients experiencing PONV within the first 24 hours. Not only is PONV an unpleasant experience but also a multitude of complications can jeopardize the safety and welfare of patients. Among the more common problems are dehydration and electrolyte imbalances. During the vomiting event patients can experience aspiration, increased intracranial and intraocular pressures, wound dehiscence, and esophageal rupture. In addition, nausea and vomiting are the most common reasons for hospital readmission following bariatric surgery, and this leads to significant increases in healthcare expenditures.

As anesthesia providers, we aspire to provide safe care that extends well into the postoperative period without the occurrence of troublesome complications like PONV. Attaining these favorable results can be especially challenging after bariatric surgery. In people with morbid obesity, mask ventilation and intubation can be exceptionally difficult; hence, a thorough preoperative airway

Figure 1. Number of Bariatric Cases, 2011-2017
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assessment is critical.9,10 Airway and soft-tissue obstruction are likely, because the incidence of obstructive sleep apnea and obstructive sleep-related breathing disorders in bariatric surgery candidates can be as high as 70%.11 These patients commonly present with multiple chronic conditions such as diabetes, fatty liver, and hypertension. In addition, they are more likely to have underlying cardiovascular disease.12 These comorbidities, along with associated risks related to body habitus in patients who are morbidly obese, necessitate an abundance of vigilance. Also, the anesthesia provider must be mindful of the likelihood for postoperative issues such as PONV and be prepared to act in the event of their occurrence.

The purpose of this clinical review was twofold: first, to increase nurse anesthetists’ awareness of the increased incidence of PONV after LSG and second, to present evidence-based, alternative anesthetic approaches to decrease PONV in patients undergoing LSG. A literature search of the past 5 years was completed using the National Center for Biotechnology Information (NCBI) database. The search terms of surgery, bariatric, anesthesia, postoperative nausea, and/or postoperative vomiting yielded 30 articles. After discarding duplicates and examining reference lists of the selected articles, the authors reviewed 38 articles.

Laparoscopic Sleeve Gastrectomy

Since 1994, when Wittgrove and colleagues13 performed the first laparoscopic Roux-en-Y gastric bypass procedure, hundreds of thousands of minimally invasive bariatric operations have been conducted for the treatment of morbid obesity. Subsequently, other bariatric surgical options have been introduced, including the laparoscopic adjustable gastric band and the LSG.

Although the laparoscopic adjustable gastric band was popular a decade ago, the LSG has now become the most common bariatric procedure in the United States5 (Figure 2). The first LSG procedure was completed in 2000 by Ren et al.14 With the LSG, the stomach is downsized substantially to create a tubular structure that limits food consumption15 (Figure 3). Compared with other bariatric operations, the LSG is simple and cost-effective, and it eliminates the need for gastrointestinal tract disruption.16,17 In addition to a drastic reduction in excess body weight, the long-term effects of the LSG procedure include decreases in hemoglobin A1c levels in patients with diabetes, lower Framingham scores for cardiovascular risk, and reduced blood pressure in patients with hypertension.18,19

Despite its numerous beneficial attributes, the LSG results in an alarmingly high percentage of PONV compared with other forms of bariatric surgery.20 In fact, in one study PONV occurred in almost 60% of patients undergoing LSG compared with 19% in those undergoing laparoscopic Roux-en-Y gastric bypass.20

Risk Factors for Postoperative Nausea and Vomiting

Consideration of patient-related risk factors for PONV among those undergoing LSG is vital. These risks include age (primarily < 50 years), nonsmoking status, and a history of PONV or motion sickness.21 Perhaps the most influential patient-related risk factor is female gender; as many as 78% of female LSG recipients experience PONV within the first 24 hours after surgery compared with 26% of male patients.6,22

Scientists and investigators have studied PONV for decades, but its complex etiology and pathophysiology have been an elusive and puzzling paradox.7 It is important to remember that there are several neurotransmitters responsible for producing an emetogenic response. These
neurotransmitters include acetylcholine, serotonin, dopamine, histamine, and neurokinin-1. Fortunately, selected pharmacologic agents can be used to inhibit the action of these neurotransmitters and thereby reduce the stimuli that lead to nausea and vomiting.

Additionally, understanding the anatomical origins of nausea and vomiting may lead to a better understanding of why LSG recipients are vulnerable to PONV. There are 4 pathways to the nucleus tractus solitarii in the hindbrain that activate vomiting. These pathways include (1) the afferent vagal nerve fibers from the gastrointestinal tract itself, (2) vestibular stimulation, (3) the area postrema in the medulla oblongata, and (4) the forebrain. Because the LSG involves gastric manipulation and incisions through afferent branches of the vagus nerve, it is hypothesized that stimulation of those nerve fibers is responsible for increasing the incidence of PONV after LSG. This risk may be increased because the manipulation of the procedure causes the release of 5-hydroxytryptamine from enterochromaffin cells in the stomach.

In addition to the anatomical aspects and numerous patient-related risks, there are several critical anesthesia-related elements that are also responsible for PONV. Among those are the use of postoperative opioids, inhalational anesthetics, and nitrous oxide, which have all been linked to inducing nausea and vomiting in the postoperative period.

- **Opioids.** The perioperative and postoperative administration of opioids commonly used in anesthesia practice increases the likelihood of PONV. In one study of 10 patients receiving postoperative rescue opioid analgesics experienced PONV compared with 44% who did not receive opioids for postoperative pain control. In addition to PONV, opioids carry a multitude of other deleterious side effects, including delayed gastric motility, depressed respiration, airway obstruction, and drowsiness, further complicating the postoperative period for this high-risk group.

- **Inhalational Anesthetics.** Although opioids play a role in PONV, the use of inhalational anesthetics is also an important anesthesia-related risk factor. Patients undergoing total intravenous anesthesia (TIVA) experience significantly less postoperative severe nausea and retching compared with a classic inhalational balanced technique. Researchers compared the use of desflurane, a commonly used inhaled vapor, with an intravenous (IV)-only regimen consisting of propofol and dexmedetomidine for patients undergoing LSG. The TIVA group experienced a shorter duration in the postanesthesia care unit (PACU), thus indicating that the administration of a propofol-based TIVA was likely more beneficial in reducing PONV in the immediate postoperative period. In addition, there was a decreased need for rescue analgesia and ondansetron for PONV.

**Reducing Postoperative Nausea and Vomiting After Laparoscopic Sleeve Gastrectomy**

- **Opioid-Free Anesthesia and Adjunctive Therapies.** The relationship between opioid administration and PONV is apparent when opioid use is omitted. In fact, the rate of PONV was reduced by nearly 20% for patients receiving opioid-free anesthesia during laparoscopic bariatric surgery compared with a balanced anesthetic with triple-antiemetic therapy. Postoperative opioid administration is problematic, and these medications should be given judiciously.

For bariatric surgery, employing a nonopioid multimodal analgesic approach can be advantageous. Multimodal analgesia involves the administration of 2 or more analgesic medications with differing mechanisms of action to reduce opioid use, further minimizing the risk of PONV. Examples of these analgesics include acetaminophen, nonsteroidal anti-inflammatory drugs, N-methyl D-aspartate (NMDA) antagonists, α₂ agonists, and gabapentinoids.
Dexmedetomidine, an α₂ agonist, provides an opioid-sparing effect in patients undergoing laparoscopic bariatric surgery and decreases the risk of PONV and postoperative shivering.²⁸,²⁹ When dexmedetomidine is administered during the intraoperative period as an IV infusion, inhalational agent requirements are reduced by approximately 20%.³⁰,³¹ Reductions in propofol and fentanyl dosages are also observed when dexmedetomidine is a component of TIVA. Dexmedetomidine also decreases rescue analgesic needs in the PACU, further reducing the need for nausea-inducing opioids.³⁰

Another approach is an intraoperative lidocaine infusion, which produces a similar opioid-sparing effect to dexmedetomidine and is a cost-effective option.³² Systemic lidocaine provides analgesia, has anti-inflammatory properties, and promotes gastrointestinal tract motility, making it beneficial for this population.³³

Two other medications may also be helpful in decreasing PONV. Gabapentin plays a unique role as part of a multimodal regimen by decreasing opioid requirements and lowering the overall risk of PONV.³⁴ Gabapentin works by binding to calcium channels, preventing the release of excitatory neurotransmitters responsible for nociceptive pain. When taken orally before LSG, gabapentin delays the need for postoperative oxycodone and reduces the overall 12-hour opioid requirement.³⁵ Ketamine, an NMDA-receptor antagonist and μ-, δ-, and κ-opioid agonist, provides profound analgesia and is ideal for patients undergoing bariatric surgery because it promotes airway patency and respiratory drive in the postoperative period.³⁶

A commonly used analgesic, acetaminophen, is a beneficial adjunct. Acetaminophen is inexpensive, comes in both IV and oral formulations, and is beneficial for pain management.²⁴ Acetaminophen works centrally and peripherally to relieve pain with minimal side effects.²⁷ The IV formulation of acetaminophen should be used because of impaired gastric absorption following surgery and the possible intolerance to oral medications in the postoperative period.²⁷

Finally, neuromuscular blockade reversal with sugammadex demonstrates a mild reduction in PONV in the early postoperative period. In addition, less pain is experienced in the PACU compared with traditional neostigmine reversal.³⁷

Various forms of local and regional anesthesia have also been studied. Laparoscopic trocar site infiltration with bupivacaine provides a level of analgesia similar to epidural analgesia and is significantly superior to IV pain medications.³⁸ In a study comparing postoperative narcotic requirements between patients receiving a transversus abdominus plane (TAP) block with liposomal bupivacaine and a standard patient-controlled analgesia (PCA) regimen with IV analgesia, the TAP block group received significantly fewer narcotics postoperatively compared with the PCA group.³⁹ People in the PCA group were more likely to experience immediate postoperative nausea and subsequently required rescue antiemetic treatment. When possible, anesthesia providers should minimize the risk of PONV by using regional techniques.

- **Enhanced Recovery After Surgery Protocols.** Enhanced Recovery After Surgery (ERAS) protocols developed for bariatric surgery improve postoperative outcomes by decreasing opioid requirements following laparoscopic bariatric surgery, as well as reducing post-discharge emergency department visits.³⁰,⁴¹ The ERAS protocols incorporate evidence-based multimodal analgesia techniques to optimize patient outcomes. In one ERAS protocol study, patients were discharged from the hospital sooner, reported lower pain scores, and required fewer opioids compared with patients who did not use ERAS protocols.⁴⁰ As prospective evidence is introduced, the evolution of ERAS protocols may further enhance anesthesia care for patients undergoing LSG.

- **Antiemetic Therapy.** The 2014 consensus guidelines for PONV management provide detailed instruction on PONV prophylaxis according to the latest evidence-based data.²⁴ For this review, only literature about antiemetics that were specific to patients undergoing the LSG will be discussed.

The 5-hydroxytryptamine antagonist class includes ondansetron, one of the most popular and studied antiemetics. Ondansetron, 4 mg given IV, reduces PONV by 25% and is more effective at preventing vomiting than at preventing nausea.²⁴ The 5-hydroxytryptamine antagonist group works in the chemoreceptor trigger zone, located in the area postrema and are most effective when given at the end of the procedure.⁷

Aprepitant, a neurokinin-1 inhibitor, delays the onset and overall occurrence of vomiting following laparoscopic bariatric surgery.⁵² With a 40-hour half-life, the duration of action of aprepitant extends nearly 2 days into the postoperative period. Compared with ondansetron, aprepitant was as effective as ondansetron during the first 24 hours following surgery and more effective than ondansetron in the initial 24 to 48 hours, with minimal adverse effects.³²

Corticosteroids, most commonly dexamethasone, for PONV prophylaxis reduce the incidence of PONV by 25%.²¹ Controversy exists related to the use of any corticosteroid in patients with diabetes. This is due to the possibility of postoperative hyperglycemia, delayed wound healing, and infection.²⁴ Additional studies are needed to confirm whether the risks outweigh the benefits of corticosteroid use in patients undergoing LSG.

Butyrophenones, which include droperidol and haloperidol, are beneficial for PONV prophylaxis. Haloperidol, 0.5 to 2 mg, given either intramuscularly or IV, may reduce PONV without sedation or cardiac arrhythmias.²⁴ It is important to note that haloperidol is not approved by the US Food and Drug Administration for IV administration as an antiemetic agent.
Minimizing PONV following LSG is most successful when a multimodal approach with antiemetic medications is used rather than just a single drug. In one study a 63% reduction of PONV was seen when patients were given prophylactic triple antiemetic therapy using haloperidol, ondansetron, and dexamethasone vs ondansetron alone. Those 3 antiemetics also reduced postoperative morphine consumption nearly twofold compared with monotherapy with ondansetron.

**Conclusion**

Discovering the perfect approach for PONV prevention after LSG is an ambitious task that continues to present challenges for the anesthesia care team, and more research is needed to develop better protocols. Research has showed that outcomes are improved when opioids and inhalational agents are kept to a minimum. Although opioids are often a component in the treatment of acute surgical pain, adjunctive agents can decrease the total opioid dose as well as minimize undesirable side effects, which may be magnified by the multiple comorbidities associated with obesity.

As the LSG becomes a more attractive treatment option for weight loss, diabetes remission, blood pressure reduction, and improvement in overall cardiovascular health, anesthesia providers should be aware of the procedure’s emetogenic potential and stay up to date on strategies to improve care, outcomes, and patient satisfaction. Because of the relative newness of the LSG operation, questions remain about the direction anesthesia providers must take. Does the future of anesthesia for bariatric surgery focus on the use of opioid-free techniques and incorporate more regional techniques? Should independent PONV treatment recommendations be made specifically for LSG procedures? Until these questions are answered, anesthesia professionals should strive to increase their knowledge of the numerous PONV risks associated with LSG and incorporate evidence-based protocols into their routine.

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**AUTHORS**

Kerry L. Varner, MSNA, CRNA, is employed by Southeast Health in Dothan, Alabama. Email: kivarner@crimson.ua.edu.

Alice L. March, PhD, RN, FNP, CNE, is a professor at the University of Alabama’s Capstone College of Nursing in Tuscaloosa, Alabama. Email: almarch@ua.edu.

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