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Prospective Study

Postoperative nausea and vomiting after laparoscopic sleeve gastrectomy: A prospective cohort study

PONV after LSG

Guan-Yu Yang, Xiao-Fei Zhang, Xin Zhao, Huan Qu, Piao Zhou, Yan Wang, Shu-Min Tu, Zheng-Yuan Xia, Qin-Jun Chu

Abstract

BACKGROUND

Postoperative nausea and vomiting (PONV) remains a common and clinically important problem after laparoscopic sleeve gastrectomy (LSG), even with routine multimodal prophylaxis. Existing studies have often relied on retrospective designs or simple binary outcomes, which may not adequately reflect the full burden of postoperative symptoms.

AIM

To estimate the incidence and severity of PONV after LSG and to identify perioperative factors associated with its development.

METHODS

This prospective cohort study included consecutive adults undergoing elective LSG between March 2022 and December 2023. PONV was assessed using the validated Chinese version of the Index of Nausea, Vomiting, and Retching (INVR) at seven time points during the first 3 postoperative days. Demographic, clinical, and perioperative data were collected. Potential predictors were screened using least absolute shrinkage and selection operator regression and then entered into multivariable logistic regression models.

RESULTS

A total of 1054 patients were included in the final analysis. During the 3-day postoperative period, 804 patients experienced at least one episode of PONV, yielding an overall incidence of 76.3%. Nausea occurred in 73.7% of patients, vomiting in 50.3%, and retching in 35.0%. In multivariable analysis, intraoperative dexmedetomidine use was independently associated with a lower risk of PONV (odds ratio [OR] 0.50; 95% confidence interval [CI] 0.36–0.70; $P < 0.001$). Apfel scores of 3 (OR, 4.27; 95%CI, 1.33–13.55; $P = 0.013$) and 4 (OR, 4.93; 95%CI, 1.51–15.94; $P = 0.007$) were associated with an increased risk.

CONCLUSION

PONV remains highly prevalent after LSG despite guideline-based prophylaxis. Intraoperative dexmedetomidine was associated with a reduced risk of PONV, whereas higher Apfel scores predicted an increased risk. These findings may help refine antiemetic strategies for patients undergoing LSG.

Key Words: Postoperative nausea and vomiting; Laparoscopic sleeve gastrectomy; Dexmedetomidine; Apfel score; Index of Nausea, Vomiting, and Retching

Core Tip: In this prospective cohort study of 1054 patients undergoing LSG, PONV remained highly prevalent despite multimodal prophylaxis, affecting 76.3% of patients. Using the validated INVR, we found that intraoperative dexmedetomidine was associated with lower odds of PONV, whereas Apfel scores of 3–4 were associated with a substantially increased risk even with guideline-based prevention. These findings suggest a potential benefit of dexmedetomidine in this setting, although randomized controlled trials are needed to confirm causality. More effective antiemetic strategies, including additional pharmacological and non-pharmacological approaches, may be warranted for patients at high risk of PONV after LSG.

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INTRODUCTION

Laparoscopic sleeve gastrectomy (LSG) has become one of the most frequently performed procedures in metabolic and bariatric surgery worldwide [1]. Although perioperative management has improved considerably, postoperative nausea and vomiting (PONV) remains one of the most troublesome complications after LSG and may impair oral intake, delay mobilization, and prolong recovery [2-4].

The high incidence of PONV after LSG is likely multifactorial. Surgical manipulation of the stomach may stimulate vagal afferents and trigger the release of emetogenic mediators [5]. In addition, the reduced gastric volume and compliance after sleeve formation may increase intragastric pressure, contributing to gastric distension and reflux, both of which can promote nausea and vomiting [5,6]. These effects may be

particularly relevant in the early postoperative period, when patients are adapting to the physiological changes caused by surgery.

Although previous studies have shown that PONV is common after LSG, several limitations remain. Many were retrospective in design, enrolled relatively small samples, or used binary definitions that do not capture the full spectrum of postoperative symptoms [6-9]. Retching is often underrecognized, despite being highly distressing for patients. A more detailed and prospective assessment is therefore needed to better characterize the postoperative symptom burden in this population.

To address this gap, we conducted a prospective cohort study using the Chinese version of the Index of Nausea, Vomiting, and Retching (INVR), a validated instrument that allows graded assessment of postoperative symptoms [10,11]. By combining repeated symptom measurements with regression-based variable selection, we aimed to estimate the incidence and severity of PONV after LSG and to identify perioperative factors independently associated with its occurrence.

MATERIALS AND METHODS

Study design and participants

This study was approved by the Medical Ethics Committee of Zhengzhou Central Hospital Affiliated to Zhengzhou University (Approval No. 202207) on January 10, 2022, and was conducted in accordance with the Declaration of Helsinki. All patients provided written informed consent before enrollment. The study was reported in line with the STROBE statement for observational research.

We enrolled consecutive adults aged 18 years or older who were scheduled for elective LSG under general anesthesia and had an American Society of Anesthesiologists physical status of II or III. Recruitment was carried out between March 2022 and December 2023. Patients were not included if surgery was canceled on the day of operation, if they were transferred to the intensive care unit after surgery, if they underwent additional combined procedures, or if they had a mental or neurological condition that could interfere with outcome assessment. We also excluded

patients who declined participation, had missing key data, or were unable to complete follow-up assessments.

Data collection

Trained research staff collected demographic and clinical data from medical records and perioperative assessments. The variables recorded included sex, age, height, weight, body mass index, American Society of Anesthesiologists physical status, Apfel score, smoking history, previous PONV, history of motion sickness, and comorbidities such as hypertension and diabetes. Perioperative data encompassed intraoperative consumption of sufentanil and remifentanil, use of dexmedetomidine (yes/no), the number of prophylactic antiemetic types administered (1–4), duration of anesthesia, total volume of fluid administered, INVR scores, Quality of Recovery-15 (QoR-15) scores (preoperative and 24 and 48 hours postoperatively), postoperative complications (*e.g.*, dehydration, electrolyte imbalances, wound issues, staple line complications, intra-abdominal infection, respiratory infection, and reoperation), time to first flatus, and length of postoperative hospital stay.

Variable definitions

Dexmedetomidine use was defined as administration of a standardized loading dose of 0.5 μg/kg (no maintenance infusion), as documented in the anesthetic record. Smoking history was defined as any regular tobacco use documented in the medical record. PONV history and motion sickness history were self-reported during the preoperative interview, defined respectively as prior postoperative nausea/vomiting and prior travel-related dizziness, nausea, or vomiting.

Perioperative management

A standardized anesthetic protocol was followed. For patients receiving dexmedetomidine, a standardized loading dose of 0.5 μg/kg was administered intravenously over 10 minutes upon arrival in the operating room; no maintenance

infusion was given. The decision to administer dexmedetomidine was at the discretion of the attending anesthesiologist. General anesthesia was induced with intravenous sufentanil (0.3–0.5 μg/kg), propofol (1.5–2.5 mg/kg), and rocuronium (0.6–1.2 mg/kg). After endotracheal intubation, anesthesia was maintained with propofol (4–8 mg/kg/h), sevoflurane (1%–2%), and a continuous infusion of remifentanil (0.1–0.2 μg/kg/min), with intermittent boluses of rocuronium as needed. As a standard part of the analgesic regimen, all patients received a bilateral paravertebral block and standardized patient-controlled intravenous analgesia. The PCA solution contained sufentanil (100 μg), oxycodone (20 mg), and flurbiprofen axetil (300 mg), diluted with normal saline to a final volume of 100 mL. The pump was set to deliver a continuous background infusion of 1 mL/h, with a patient-activated bolus dose of 3.5 mL, a lockout interval of 5 minutes, and a maximum infusion rate of 10 mL/h.

At the end of surgery, neuromuscular blockade was routinely reversed with sugammadex (2 mg/kg) in all patients. After tracheal extubation, patients were transferred to the post-anesthesia care unit for further observation.

Antiemetic prophylaxis was given intravenously according to the patient's Apfel score[12]. Patients with a score of 0 received dexamethasone (4–8 mg). Those with scores of 1–2 were given dexamethasone (4–8 mg) together with tropisetron (5 mg). In patients with scores of 3–4, additional antiemetic agents were used at the anesthesiologist's discretion, including metoclopramide (10 mg) and/or droperidol (1 mg), in combination with dexamethasone and tropisetron.

For rescue treatment of PONV, intravenous fosaprepitant (150 mg) was administered when symptoms occurred within the first 6 postoperative hours. Beyond 6 hours, either ondansetron (4 mg) or fosaprepitant (150 mg) was used.

Assessment of PONV

The primary outcome was assessed using the validated Chinese version of the INVR[11]. The INVR is a multidimensional instrument that quantifies the severity of nausea, vomiting, and retching. It comprises eight items scored on a 5-point Likert scale

(0 = "not at all", 4 = "very severe and intolerable"). The total score ranges from 0 to 32, with higher scores indicating more severe symptoms.

Two trained research nurses administered the INVR to assess symptoms since the last assessment at seven predefined time points: 1 day before surgery, at 20: 00 on the day of surgery, and at 8: 00 and 20: 00 on postoperative days 1–3. For patients discharged before a scheduled assessment, the evaluation was completed *via* telephone follow-up.

Outcomes

The primary outcome was the incidence of PONV within the first 3 postoperative days. PONV was defined as a total INVR score > 0 at any of the seven postoperative assessments, consistent with the validated use of the INVR where any score > 0 indicates the presence of nausea, vomiting, or retching[10,11]. This definition follows the validated use of the INVR scale and is consistent with the binary framework (presence vs absence) commonly employed in clinical PONV research, although the INVR may detect milder symptoms than those captured in some traditional assessments[2-4,12].

Secondary outcomes included: (1) The incidence and severity of the individual symptom dimensions (nausea, vomiting, and retching); (2) The total and dimensional INVR scores across the assessment time points; (3) Identification of factors associated with PONV; and (4) Postoperative complications and other recovery metrics, including QoR-15 scores at 24 and 48 hours postoperatively, time to first flatus, and length of postoperative hospital stay.

Statistical analysis

As a prospective observational study employing consecutive sampling, a formal *a priori* sample size calculation was not performed. The study aimed to include all eligible patients during the enrollment period. The final cohort included 1054 patients, among whom 804 experienced PONV. For the multivariable logistic regression model, the events-per-variable ratio was approximately 89 for the nine variables entered into the

analysis, which was well above the commonly cited minimum of 10 events per variable[13]. This supported the stability of the model estimates and provided sufficient statistical power.

Continuous variables with a normal distribution were presented as mean ± SD, whereas those with a skewed distribution were expressed as median (interquartile range). Categorical variables were reported as numbers and percentages. The Kolmogorov-Smirnov test was used to assess normality.

To identify factors associated with PONV, LASSO regression was first employed for variable selection. All candidate variables listed in Table 1 were entered into the LASSO regression, with the penalty parameter (λ) selected *via* 10-fold cross-validation based on the minimum mean squared error criterion. Variables with non-zero coefficients at the optimal λ value were retained as potential predictors. Subsequently, multivariable binary logistic regression was performed, including the LASSO-selected variables. Multicollinearity was assessed using the variance inflation factor (VIF), with VIF < 5 considered acceptable. Odds ratios (OR) and 95% confidence intervals (CIs) were calculated.

Two sensitivity analyses were performed using alternative outcome definitions. The first analysis defined moderate-to-severe PONV as an INVR total score > 8, consistent with previous studies that used this threshold to identify clinically significant symptoms requiring intervention[14,15]. The second analysis defined vomiting only as a score > 0 on the vomiting dimension of the INVR at any of the seven postoperative assessments. The same LASSO regression variable selection process and multivariable logistic regression analyses were applied for these outcomes.

All statistical analyses were performed using R software version 4.5.1 (R Development Core Team, Vienna, Austria). A two-sided $P < 0.05$ was considered statistically significant.

RESULTS

Patient characteristics

During the study period, 1181 patients were screened, and 1054 were included in the final analysis (Figure 1). Among the 127 excluded patients, 5 (0.4% of those screened) were excluded due to missing data; given the negligible proportion, no formal imputation or missingness assessment was performed. The baseline and perioperative characteristics of the entire cohort, stratified by the occurrence of PONV, are summarized in Table 1.

Primary outcome

The cumulative incidence of PONV over the first 3 postoperative days, defined as any INVR score > 0 at any of the seven assessment timepoints, was 76.3% (804/1054). The incidence of moderate-to-severe PONV, defined as an INVR score > 8, was 34.3% (362/1054). Nausea was the most common symptom, occurring in 73.7% of patients, followed by vomiting in 50.3% and retching in 35.0%.

Secondary outcomes

The longitudinal changes in total and dimensional INVR scores are shown in Figure 2. Symptom severity reached its highest level on the morning of postoperative day 1 (POD 1a) and then gradually declined over time. Supplementary Tables 1–3 summarize the distribution of symptom grades at each assessment point and show the proportions of patients with mild, moderate, and severe symptoms. On POD 1a, severe nausea (grade III–IV) was reported by 16.9% of patients (178/1054), and severe vomiting (grade III–IV) by 5.9% (62/1054). The daily incidence of each symptom dimension is visualized in Figure 3.

Following variable selection using LASSO regression (LASSO coefficient paths and cross-validation plots are shown in Supplementary Figure 1A, B), nine candidate variables were identified and subsequently entered into the multivariable logistic regression analysis: Sex, height, Apfel score, hypertension, intraoperative sufentanil consumption, intraoperative use of dexmedetomidine, number of antiemetic types, duration of anesthesia, and preoperative INVR score. Multivariable logistic regression

analysis with PONV as the outcome was performed (Figure 4). Compared with patients having an Apfel score of 0, those with scores of 3 (OR, 4.27; 95%CI, 1.33–13.55; P = 0.013) and 4 (OR, 4.93; 95%CI, 1.51–15.94; P = 0.007) had significantly increased odds of PONV. Intraoperative use of dexmedetomidine was associated with significantly lower odds of PONV (OR, 0.50; 95%CI, 0.36–0.70; P < 0.001). All VIF values were below 5 (range: 1.01–1.92), indicating no significant multicollinearity among the predictors.

Sensitivity analyses using moderate-to-severe PONV (INVR > 8) and vomiting only as outcomes confirmed that dexmedetomidine was associated with a lower risk of PONV (OR, 0.69; 95%CI, 0.52–0.90; P = 0.006 for moderate-to-severe PONV; OR, 0.68; 95%CI, 0.52–0.88; P = 0.004 for vomiting only). Detailed results are presented in Supplementary Tables 4 and 5.

Outcomes

Postoperative recovery outcomes are summarized in Table 2. Among the 1054 patients, 8 postoperative complication events were documented: 3 cases of suspected intra-abdominal infection, 4 cases of respiratory infection, and 1 reoperation.

DISCUSSION

In this large prospective cohort study utilizing the INVR, we found that PONV remains a pervasive challenge after LSG, affecting more than three-quarters of patients despite routine multimodal prophylaxis. Nausea was the most prevalent symptom (73.7%), followed by vomiting (50.3%) and retching (35.0%). Notably, intraoperative use of dexmedetomidine was independently associated with a significantly lower risk of PONV, while Apfel scores of 3–4 were associated with a markedly increased risk.

Dexmedetomidine use was associated with lower odds of PONV in this LSG cohort, which is in line with its reported antiemetic effects. At the same time, the Apfel score remained a useful predictor of risk even when prophylaxis was adjusted according to baseline risk.

Several points may help explain why the incidence of PONV in our cohort was so high. First, the use of the INVR allowed us to capture the full range of postoperative symptoms, including retching, which is often missed in studies that rely on binary outcomes alone. Our definition of PONV (INVR score > 0) was based on the validated use of the scale[10,11] and was intended to avoid overlooking mild but clinically relevant symptoms that may still affect recovery. It also remained consistent with the conventional clinical definition of PONV[12]. We recognize, however, that this threshold may have increased the reported incidence by classifying even minimal symptoms as events. Second, symptom assessments were performed prospectively at seven time points over the first 3 postoperative days, which allowed us to record both early and later episodes. This approach likely yielded a higher cumulative incidence than studies with shorter follow-up. Third, patients undergoing bariatric surgery are known to carry a particularly high risk of PONV, with reported rates of 60% to 80% in previous studies[7,16-19]. Our findings therefore confirmed that PONV remains a persistent clinical problem in this population despite contemporary prophylactic regimens.

The association between dexmedetomidine and a lower risk of PONV was consistent with previous meta-analyses showing antiemetic benefit across different surgical settings, including bariatric surgery[20-23]. Several mechanisms may account for this effect. Dexmedetomidine has sedative and anxiolytic properties, reduces opioid requirements, and exerts sympatholytic effects, all of which may contribute to attenuation of emetic pathways[20-23].

We also observed a strong association between Apfel scores of 3 or 4 and a higher risk of PONV, even though patients in these categories had already received intensified prophylaxis with three or four antiemetic agents. This suggests that current risk-adapted protocols may not fully offset the underlying susceptibility of high-risk patients. From a clinical standpoint, the finding indicates that guideline-based prophylaxis does not eliminate the burden of PONV in this subgroup. Further refinement of antiemetic strategies may therefore be needed, potentially through the

addition of other pharmacological agents or the incorporation of non-pharmacological measures such as transcutaneous electrical acupoint stimulation[24,25].

Traditional risk factors such as female sex, prior PONV, and motion sickness history were not retained as independent predictors in the final model[26]. This may be because these variables were already captured within the Apfel score[27]. When the Apfel score itself is included in the analysis, the individual contributions become non-significant due to collinearity. Moreover, our institutional practice of adjusting prophylaxis according to the Apfel score may have mitigated the independent effect of these factors[12], as higher-risk patients received more aggressive antiemetic treatment. This interpretation is supported by the fact that the number of antiemetic types administered was also considered in the LASSO selection but did not remain significant in the final multivariable regression. This might reflect the effectiveness of risk-adapted prophylaxis in attenuating the impact of individual risk factors.

Sensitivity analyses using moderate-to-severe PONV (INVR > 8) and vomiting only as outcomes confirmed that dexmedetomidine was associated with a lower risk of PONV across different definitions. However, Apfel scores of 3–4 were not significantly associated with moderate-to-severe PONV, suggesting that the risk factors for clinically significant symptoms may differ from those for any PONV. The association between older age and lower risk of moderate-to-severe PONV is consistent with previous reports that age may be inversely associated with PONV severity[5].

Using the INVR, we captured each symptom dimension separately and found that most symptoms were mild to moderate, but a notable proportion of patients still experienced severe symptoms on the morning of POD 1a, including grade III–IV nausea in 16.9% of patients and grade III–IV vomiting in 5.9%. These episodes deserve attention in clinical practice because they are more likely to lead to complications such as dehydration and electrolyte imbalance[3,4].

QoR-15 scores also differed between patients with and without PONV. The median between-group difference was 9 points at 24 hours and 3 points at 48 hours after surgery. Given that the minimal clinically important difference for the QoR-15 is

approximately 6 points[28], the 24-hour difference suggests that PONV may have had a meaningful effect on early recovery. That said, QoR-15 was a secondary outcome in this study, and we did not perform formal comparisons across PONV severity groups. These findings should therefore be interpreted cautiously and confirmed in future work.

This study had several limitations. First, it was conducted at a single center, so the results may have been influenced by local practices in anesthesia, surgery, and perioperative care. This may limit the generalizability of the findings to other settings. Multicenter studies will be needed to verify whether the same associations are observed in different clinical environments, and external validation of the predictive model in independent cohorts will also be important. Second, although we used LASSO regression and multivariable adjustment, residual confounding remains a concern. We did not collect detailed preoperative anxiety scores or intraoperative pain control metrics, both of which could affect PONV risk. Other unmeasured factors, such as genetic susceptibility, may also have influenced the results. Third, the use of dexmedetomidine was non-randomized and determined according to the attending anesthesiologist's clinical judgment, which may introduce selection bias. Although we adjusted for a comprehensive set of perioperative variables, the possibility of residual confounding cannot be entirely excluded. Therefore, the observed protective effect of dexmedetomidine should be interpreted with caution, and future randomized controlled trials are warranted to confirm these findings. Fourth, the observational design precludes causal inference. Fifth, because prophylactic antiemetic regimens were administered according to the Apfel score, an inherent correlation exists between these two variables. This collinearity made it difficult to isolate the independent contribution of the Apfel score, since the score reflected not only baseline risk but also the intensity of prophylaxis administered. As a result, the positive association we observed between Apfel score and PONV risk may actually have been underestimated. Sixth, we also performed sensitivity analyses using moderate-to-severe PONV and vomiting-only outcomes to test the robustness of the findings, but we did not examine every possible symptom threshold in a systematic manner. Finally, patient-reported measures such as

the INVR remain vulnerable to recall bias. Even though symptoms were assessed prospectively at seven predefined time points over 3 days to shorten the recall window and reduce this problem, some degree of over-reporting or under-reporting could not be excluded. Mild symptoms may have been forgotten, whereas more severe episodes were probably easier to remember, which could have led to some overestimation of symptom severity. Future studies may benefit from real-time symptom recording, including electronic diaries or digital tracking tools, to further reduce this source of bias.

CONCLUSION

In this prospective cohort study, PONV remained common after LSG, affecting 76.3% of patients despite prophylaxis. Intraoperative dexmedetomidine was independently associated with lower odds of PONV, whereas Apfel scores of 3–4 were associated with a markedly higher risk even when prophylaxis was guided by baseline risk. These findings suggested that dexmedetomidine use may help reduce the risk of PONV in patients undergoing LSG, although causal inference cannot be drawn from this observational design. Randomized controlled trials will be needed to confirm a protective effect. The results also support the need for more effective antiemetic strategies in high-risk patients, including additional pharmacological and non-pharmacological approaches.