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ORIGINAL ARTICLE

Study of penehyclidine for the prevention of postoperative nausea and vomiting following laparoscopic sleeve gastrectomy under general anesthesia: a randomized, prospective, double-blind trial

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Abstract

Purpose To investigate the efficacy of penehyclidine (PHC) for preventing postoperative nausea and vomiting (PONV) after laparoscopic sleeve gastrectomy (LSG) under general anesthesia.

Materials and methods In this prospective study, 219 patients who were scheduled to undergo LSG were randomly assigned to three cohorts: the control cohort (received normal saline), the infusion cohort (administered 0.25 mg of PHC intravenously followed by an additional 0.25 mg through an intravenous analgesia pump for 48 h after LSG), and the bolus cohort (received a single intravenous dose of 0.5 mg of PHC). The study outcomes included the incidence of PONV within the first 48 h postoperatively, the severity and intensity of PONV, side effects and postoperative recovery outcomes. Univariate and multivariate logistic analyses were performed to identify independent risk factors associated with PONV.

Results Compared with the control cohort, both the infusion and bolus cohorts presented considerably lower incidences of PONV (61.64% vs. 12.33% vs. 38.36%, $P < 0.05$), as well as significantly decreased PONV severities ($P < 0.05$) and intensities ($P < 0.05$). There were no significant differences in side effects and postoperative recovery outcomes among the three cohorts, with the exception of dry mouthand the administration of rescue antiemetic therapy ($P < 0.05$). Additionally, the Apfel risk score and PHC intervention were identified as independent risk factors associated with PONV incidence following LSG ($P < 0.05$).

Results PHC effectively prevented PONV occurrence and reduced its severity in LSG patients without decreasing postoperative recovery outcomes, particularly in the infusion cohort.

Keywords Penehyclidine (PHC) · Postoperative nausea and vomiting (PONV) · Laparoscopic sleeve gastrectomy (LSG) · General anesthesia · Randomized trial

Introduction

Obesity is characterized by a body mass index (BMI) of 30 or higher and excessive accumulation of body fat [1]. It has become a serious global health problem and cause of economic burden and is closely associated with a wide range of diseases [2–4], including fatty liver disease, cardiovascular disorders, diabetes, osteoarthritis, and sleep apnea, as well as an increased risk of cancer. Although lifestyle modifications such as dietary changes and increased physical activity and pharmacological interventions are crucial, their effectiveness in achieving substantial weight loss is often restricted [5, 6].

According to numerous studies, bariatric surgery has been deemed a successful intervention for patients with metabolic disease seeking long-term weight management [7]. Laparoscopic sleeve gastrectomy (LSG) has become as the preferred surgical option because of its safety, association with a reduced risk of complications, and favorable results [8, 9]. However, postoperative nausea and vomiting (PONV) frequently occurs after LSG, posing risks such as electrolyte imbalances, aspiration pneumonia, and in severe

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cases, cardia mucosa rupture or anastomotic leakage [10]. These complications not only substantially affect patients' well-being but also increase the total health care cost. Therefore, enhancing strategies to manage PONV following LSG is crucial from a clinical perspective.

The prominent role of the M1 and M3 muscarinic acetylcholine receptors in the pathogenic development of PONV is widely recognized [11]. Owing to its strong affinity for the M1 and M3 receptors and its more than 10-h half-life [12], penehyclidine (PHC) is considered a promising anticholinergic agent for the prevention of PONV in patients undergoing laparoscopic procedures [13, 14]. However, the notable lack of randomized and prospective studies on the effectiveness of PHC in preventing PONV, especially in LSG patients, represents a significant gap in the literature. Furthermore, the ongoing debate surrounding the identification of risk factors linked to PONV following LSG further complicates the understanding of its occurrence. The aim of our study was to investigate the effectiveness and safety outcomes of PHC for preventing PONV in patients undergoing LSG through a randomized, prospective, double-blind trial.

Materials and methods

Ethical approval and study design

This prospective, double-blind, randomized clinical trial conducted at a single center was approved by the Ethics Committee of the Affiliated Changzhou NO. 2 People's Hospital of Nanjing Medical University (Approval number: 2022-YLJSA084). The trial protocol was registered on the Chinese Clinical Trial Registry (ChiCTR2300069082) and adhered to the principles outlined in the Declaration of Helsinki. Before enrollment, the patients and their family members were briefed on the potential benefits (such as PONV prevention and PONV intensity relief) and several side effects (dry mouth, dizziness, emergence agitation, facial flushing, urinary retention, tachycardia, hypotension, and fever) of the study procedures, and either the patient or their authorized family member signed the consent form. Notably, rescue antiemetic therapy will be administered to patients experiencing severe PONV following LSG. The reporting of this trial followed the guidelines established by the Consolidated Standards of Reporting Trials (CONSORT).

Patient selection and randomization method

Between January 2023 and December 2023, obese individuals aged 18 to 60 years with a BMI exceeding 27.5 kg/m^2 who were scheduled for LSG under general anesthesia were enrolled in the study. The exclusion criteria were as follows: 1) secondary obesity induced by medication or endocrine factors; 2) preoperative ASA grade ≥ IV, severe renal or hepatic dysfunction; 3) allergy to PHC or other anticholinergic drugs; 4) history of gastrointestinal or mental disorders; 5) pregnant or lactating or experiencing acute or chronic nausea and/or vomiting; 6) received antiemetics within 12 h before LSG; and 7) uncompliant, unable to follow preoperative instructions or adhere to postoperative rehabilitation guidance.

The eligible participants were randomly allocated at a 1:1:1 ratio to the control cohort, infusion cohort, or bolus cohort using computer-generated randomization. The random allocation sequence was concealed in opaque envelopes to guarantee unbiased assignment. To maintain blinding, participants, caregivers, and investigators were unaware of the specific treatment allocations. The anesthesiologists who were responsible for administering the anesthetics were informed about the cohort assignments for safety purposes but were not involved in postoperative evaluations or data collection. Importantly, the intervention cohort comprised both the bolus and infusion cohorts.

Anesthesia protocol

Before undergoing LSG, patients followed standard fasting protocols for approximately 6 to 8 h and their electrocardiogram (ECG), noninvasive blood pressure (BP), oxygen saturation (SpO_2), heart rate (HR), end-tidal CO_2 ($_{ET}CO_2$), and bispectral index (BIS) were continuously monitored. All the patients in all three groups underwent identical anesthesia induction procedures, with the only variation being the intervention. After adequate preoxygenation, midazolam (0.2 mg/kg), sufentanil (0.5 μg/kg), etomidate (0.3 mg/kg), rocuronium (0.8 mg/kg), and prophylactic dexamethasone (10 mg) were intravenously administered.

During LSG, a tracheal catheter was inserted to aid breathing, and the mechanical ventilation parameters were adjusted as follows: a tidal volume (VT) of 6–8 mL/kg, a respiratory rate (RR) of 12–16 breaths/min, an airway pressure below 30 mmHg, and an $_{ET}CO_2$ level at 34–45 mmHg. Anesthesia was maintained with 1 μg/kg/h of dexmedetomidine, 1% of sevoflurane, 4–6 μg/kg/h of remifentanil, and 2–5 mg/kg/h of propofol. Additionally, the bispectral index (BIS) value was maintained between 40 and 60 by adjusting the concentration of sevoflurane and the infusion rate of intravenous anesthesia maintenance drugs. Throughout the procedure, factors such as BP, HR, anesthesia depth, and surgical requirements were continuously monitored and adjusted to ensure appropriate levels.

In this study, the anesthesia intervention involved the administration of PHC to patients in different cohorts. The Bolus cohort received a single intravenous infusion of 0.5 mg of PHC at the start of anesthesia induction, and a dose of saline was added to the intravenous analgesia pump. The infusion cohort initially received an intravenous infusion of 0.25 mg of PHC at the onset of anesthesia induction, followed by a continuous infusion of 0.25 mg of PHC at a fixed rate of 2.0 mL/h through a postoperative intravenous analgesia pump for 48 h. Thus, both the bolus cohort and infusion cohort received a total of 0.5 mg of PHC. Conversely, the patients in the control cohort were given an equal volume of saline, and a dose of saline was added to the intravenous analgesia pump. The intravenous analgesia pump, which was prepared with sufentanil (0.8–1 μg/kg), oxycodone (30 mg), and dexmedetomidine (0.1 mg) and diluted with 100 ml of normal saline, was used to administer postoperative analgesics at a continuous infusion rate of 2 ml/h for 48 h.

LSG procedure

The start of LSG was marked by the dissection of the gastric omentum tissue to mobilize the stomach fundus and greater curvature. Then, the gastric volume was reduced by removing 75–80% of the stomach volume under the guidance of a 29-French endoscope. The area marked for resection was approximately 4–6 cm from the pylorus, extending to approximately 1 cm from the angle of His. The gastric pump was sutured intermittently, and the stomach was excised through the navel incision. After confirming that there were no leaks or bleeding along the gastric incision line, the incision was closed sequentially.

Data collection and study outcomes

The clinical baseline data obtained for the study included various parameters, such as age, sex, weight, height, BMI, hypertension status, diabetes mellitus status, ASA grade, smoking history, preoperative history of motion sickness (MS) or PONV, Apfel risk score, and duration of the LSG procedure. The incidence of PONV following LSG was evaluated by an impartial anesthesiologist who was unaware of the anesthesia protocols. The primary outcome was the incidence of PONV, which was defined as the occurrence of nausea, vomiting, retching, or a combination of these symptoms within 48 h after LSG.

The secondary outcomes were as follows: (1) PONV severity: categorized into Grade 0 (no nausea or vomiting), Grade 1 (mild nausea or a single vomiting episode), Grade 2 (moderate nausea or severe nausea, vomiting more than twice, or necessitating one rescue antiemetic), and Grade 3 (severe nausea or vomiting more than two times or requiring more than one rescue antiemetic medication) at 0–12 h, 12–24 h, and 24–48 h after LSG. (2) PONV intensity: assessed using an 11-point numerical rating scale within 48 h following LSG, with 0 indicating no PONV and 10 representing the most severe case of PONV [15].

Nine potential side effects were monitored within 48 h immediately following LSG, including dry mouth, dizziness, emergence agitation (Richmond AgitationSedation Scale ≥ 2; score ranges from –5 to + 4, and 0 indicates alert and calm), facial flushing, urinary retention, tachycardia (Defined as heart rate > 100 beat min^{-1} or an increase of $> 30\%$ from baseline, and required therapeutic interventions), fever (body temperatue $> 37°$), the administration of rescue antiemetic therapy. Furthermore, postoperative surgery recovery outcomes, the time to extubation and duration of stay in the postanesthesia care unit (PACU), were systematically documented.

Statistical analysis

The statistical analysis was performed using R software (version 4.3.0). Count data are presented as percentages (%), and continuous data that was normally distributed according to the Kolmogorov–Smirnov test are expressed as the mean ± standard deviation (SD), and nonnormally distributed data are expressed as the median ($P_{25} \sim P_{75}$). Continuous variables across different cohorts were compared using an analysis of variance or *Kruskal–Wallis* test, whereas categorical data were analyzed using the chi−square test or Fisher's exact test. Sequential univariate and multivariate logistic regression analyses were performed to identify the independent risk factors associated with PONV following LSG. A P value < 0.05 indicated statistical significance.

Results

Patient enrollment and baseline characteristics

During the recruitment period of this study, 234 patients who were initially chosen were scheduled to undergo LSG at our hospital. However, 12 participants were excluded, either for not meeting the inclusion criteria (n = 9) or declining to participate (n = 3). Additionally, 3 participants refused to participate in the follow-up procedures. As a result, 219 patients were ultimately included in the study and were randomly and evenly distributed into the control cohort (n = 73), infusion cohort (n = 73), and bolus cohort (n = 73).

Baseline clinical characteristics and surgical variables

The baseline characteristics, including age, sex, weight, height, BMI, hypertension status, diabetes mellitus status,

ASA grade, preoperative history (smoking, MS or PONV), Apfel risk score, and duration of the LSG procedure were comparable among all three cohorts, as outlined in Table 1.

Comparison of study outcomes

As presented in Table 2, the incidence of PONV following LSG was significantly lower in the intervention cohort than in the control cohort (25.34% vs. 61.64%, $P < 0.05$). Furthermore, compared with the bolus cohort, the infusion cohort displayed a significant decrease in the incidence of PONV (12.33% vs. 38.36%, $P < 0.001$). Noteworthy differences in the severity of PONV were noted between the intervention and control cohorts < 12 h, 12–24 h, and 24–48 h after LSG ($P < 0.05$). Additionally, the severity of PONV was lower in the infusion cohort than in the Bolus cohort < 12 h, 12–24 h and 24–48 h after LSG. Moreover, the PONV intensity was 2.36 ± 1.19 in the control cohort and 1.64 ± 0.95 in the intervention cohort ($P < 0.05$), whereas the PONV intensity was lower in the infusion cohort than in the bolus cohort (1.52 ± 0.88 vs. 1.75 ± 1.01, $P > 0.05$).

Side effects and postoperative recovery outcome

The prevalence of dry mouth was significantly higher in both the infusion cohort and the bolus cohort compared to the control cohort (63.01% vs. 52.05% vs. 20.55%, $P < 0.001$). Furthermore, the need for rescue antiemetic therapy in the control cohort was importantly higher than PHC intervention cohort (80.82% vs. 6.85% vs. 10.96%, $P < 0.001$). However, there were no significant differences among the three cohorts ($P > 0.05$) regarding other side effects, such as dizziness, emergence agitation, facial flushing, urinary retention, tachycardia, hypotension, and fever. Additionally, no significant differences were observed among the three cohorts in time to extubation, and duration of PICU stay ($P > 0.05$), as demonstrated in Table 3.

Univariate and multivariate logistic regression analyses

The Apfel risk score, duration of LSG, and PHC were identified as risk variables associated with PONV after LSG ($P < 0.05$). Following multivariate analyses, the independent risk factors remaining significantly associated with PONV after LSG were the Apfel risk score (OR = 2.81, 95% CI: 0.98–7.99, $P = 0.036$) and PHC (OR = 0.22, 95% CI: 0.09–0.52, $P < 0.001$), as illustrated in Table 4.

Table 1 Baseline Clinical Characteristics and Surgical Variables

Variables	All participants (n = 219)	Control cohort (n = 73)	Infusion cohort (n = 73)	Bolus cohort (n = 73)	*P* value
Age (Years)	32.15 ± 7.86	33.47 ± 8.65	30.71 ± 7.42	32.27 ± 7.28	0.105
Gender (n, %)					0.858
Male	65 (29.68)	20 (27.40)	22 (30.14)	23 (31.51)	
Female	154 (70.32)	53 (72.60)	51 (69.86)	50 (68.49)	
Weight (kg)	107.17 ± 22.20	107.02 ± 23.51	105.40 ± 19.45	109.09 ± 23.56	0.605
Height (m)	1.68 ± 0.07	1.67 ± 0.07	1.68 ± 0.07	1.68 ± 0.07	0.506
BMI (kg/m^2)	37.99 ± 6.42	38.21 ± 6.63	37.16 ± 5.63	38.61 ± 6.91	0.371
ASA grade (n, %)					0.365
II	182 (83.11)	62 (84.93)	63 (86.30)	57 (78.08)	
III	37 (16.89)	11 (15.07)	10 (13.70)	16 (21.92)	
Hypertension (n, %)	27 (12.33)	6 (8.22)	10 (13.70)	6 (8.22)	0.521
Diabetes mellitus (n, %)	23 (10.55)	7 (9.72)	10 (13.70)	6 (8.22)	0.538
Smoking history (n, %)	41 (18.72)	11 (15.07)	16 (21.92)	14 (19.18)	0.565
History of MS / PONV (n, %)	45 (20.55)	18 (24.66)	17 (23.29)	10 (13.70)	0.203
Apfel risk socre (n, %)					0.487
1	31 (14.16)	9 (12.33)	11 (15.07)	11 (15.07)	
2	142 (64.84)	48 (65.75)	42 (57.53)	52 (71.23)	
3	40 (18.26)	14 (19.18)	18 (24.66)	8 (10.96)	
4	6 (2.74)	2 (2.74)	2 (2.74)	2 (2.74)	
LSG time (minutes)	123.54 ± 37.79	119.32 ± 36.76	131.85 ± 40.36	119.45 ± 35.20	0.070

Table 2 Comparison of study outcomes among different cohorts

Variables		Control cohort (n = 73)	Intervention Cohort (n = 146)	P_1 value	Infusion cohort (n = 73)	Bolus Cohort (n = 73)	P_2 value
PONV Severity < 12 h, n (%)	0	28 (38.36)	109 (74.66)	< .001	64 (87.67)	45 (61.64)	< .001
	1	4 (5.48)	11 (7.53)		3 (4.11)	8 (10.96)	
	2	27 (36.99)	23 (15.75)		4 (5.48)	19 (26.03)	
	3	14 (19.18)	3 (2.05)		2 (2.74)	1 (1.37)	
PONV Severity 12-24 h, n (%)	0	29 (39.73)	115 (78.77)	< .001	67 (91.78)	48 (65.75)	< .001
	1	27 (36.99)	24 (16.44)		3 (4.11)	21 (28.77)	
	2	16 (21.92)	6 (4.11)		2 (2.74)	4 (5.48)	
	3	1 (1.37)	1 (0.68)		1 (1.37)	0 (0.00)	
PONV Severity 24-48 h, n (%)	0	47 (64.38)	133 (91.10)	< .001	69 (94.52)	60 (82.19)	0.036
	1	24 (32.88)	11 (7.53)		2 (2.74)	9 (12.32)	
	2	2 (2.74)	1 (0.68)		1 (1.37)	3 (4.11)	
	3	0 (0.00)	1 (0.68)		1 (1.37)	1 (1.37)	
PONV incidence		45 (61.64)	37 (25.34)	< .001	9 (12.33)	28 (38.36)	< .001
PONV intensity		2.36 ± 1.19	1.64 ± 0.95	< .001	1.52 ± 0.88	1.75 ± 1.01	0.141

P_1 control *vs.* intervention; P_2 infusion *vs.* bolus

Table 3 Comparison of side effects and postoperative recovery among different cohorts

	Control cohort (n = 73)	Infusion cohort (n = 73)	Bolus Cohort (n = 73)	*P* value
Dry mouth	15 (20.55)	46 (63.01)	38 (52.05)	< 0.001
Dizziness	8 (10.96)	10 (13.70)	8 (10.96)	0.840
Emergence agitation	12 (16.44)	15 (20.55)	14 (19.17)	0.811
Facial flushing	1 (1.37)	1 (1.37)	2 (2.74)	0.775
Urinary retention	1 (1.37)	1 (1.37)	0 (0.00)	0.604
Tachycardia	2 (1.37)	3 (4.11)	4 (5.48)	0.706
Hypotension	3 (4.11)	2 (2.74)	2 (2.74)	0.863
Fever	39 (53.42)	33 (45.21)	38 (52.05)	0.568
Time to extubation (min)	20.12 ± 9.34	21.33 ± 10.12	19.68 ± 9.09	0.632
PICU stay duration (min)	59.76 ± 28.98	61.37 ± 29.46	60.76 ± 25.04	0.738
Rescue antiemetic therapy	59 (80.82)	5 (6.85)	8 (10.96)	< 0.001

PICU postanesthesia intensive care unit

Table 4 Univariate and multivariate analysis for PONV incidence after LSG

	Univariate analysis			Multivariate analysis		
Variables	OR	95% CI	*P* value	OR	95% CI	*P* value
Age	1.04	1.01 ~ 1.08	0.036	1.02	0.97 ~ 1.06	0.455
BMI	1.00	0.96 ~ 1.04	0.985			
ASA grade	0.55	0.22 ~ 1.35	0.243			
Hypertension	0.63	0.27 ~ 1.47	0.192			
Diabetes mellitus	0.72	0.28 ~ 1.82	0.482			
Apfel risk socre	3.43	0.56 ~ 20.91	< .001	2.81	0.98 ~ 7.99	0.036
LSG time	0.99	0.98 ~ 0.99	0.017	0.99	0.98 ~ 1.00	0.253
PHC cohort	0.23	0.10 ~ 0.52	< .001	0.22	0.09 ~ 0.52	< .001

Discussion

To our knowledge, this study aimed at investigating the efficacy of PHC administration in preventing PONV following LSG is a novelty in this field. Our findings validate the effectiveness of infusing PHC intravenously in reducing both the incidence and severity of PONV after LSG, while also demonstrating favorable side effect and postoperative recovery outcomes. Moreover, our analysis revealed that higher Apfel risk scores and a lack of PHC intervention were identified as independent risk factors associated with an increased incidence of PONV after LSG. These results underscore the utility of PHC in predicting the occurrence of PONV following LSG, thus facilitating the development of personalized treatment plans for patients undergoing LSG.

PONV is a prevalent complication observed following LSG under general anesthesia, with the potential to adversely affect patient recovery and satisfaction [16]; however, the precise underlying mechanism of PONV remains unclear. Recent studies suggest that muscarinic receptors play crucial roles in the progression of PONV [12]. Owing to the high expression of M1 acetylcholine receptors in the vestibular system, anticholinergic medications can inhibit cholinergic signaling from the vestibular nucleus to the central nervous system and from the reticular formation to the emetic center. Both Klenke et al. [17]. and Wang et al. [18]. reported a close association between M3 acetylcholine receptors and the incidence of PONV. Consequently, anticholinergic drugs, particularly PHC with selective inhibitors of M1 and M3 acetylcholine receptors and prolonged elimination half-lives, not only offers guidance for clinical management but also inspires further investigations into optimizing strategies to prevent PONV following LSG. Research has shown the efficacy of PHC intervention in preventing PONV, including total thyroidectomy [19], strabismus surgery [20], and bimaxillary orthognathic surgery [21].

Notably, midazolam, sufentanil, etomidate, rocuronium, and prophylactic dexamethasone were intravenously administered for both anesthesia induction and maintenance in this prospective study, not only because of the primary necessity of general anesthesia, but also the requirement for reducing possible PONV incidence following LSG in the control cohort patients. Morever, to minimize the influence of these drugs on the assessment of PONV severity and intensity, the study maintained same anesthesia procedures through this study, with the only variation being the intervention.

In this randomized study, the prevalence of dry mouth was significantly higher in the intervention cohort (84/146) compared to the control cohort (15/73). This observed difference may be attributed to the pharmacological effects of PHC on M3 receptors, which are presumably responsible for the suppression of glandular secretion from respiratory submucosal glands. This finding aligns with the conclusions drawn by Zhao et al [13], who studied patients undergoing gynecological laparoscopic surgery. Conversely, a previous study conducted by Wang [21] reported no significant difference between the control group and the intervention group in patients undergoing bimaxillary orthognathic surgery, Therefore, further prospective studies are required to explore the impact of PHC adminstration on dry mouth, through the PHC administration could significantly reduce the need for rescue antiemetic therapy. Emergence agitation is a common adverse effect following laparoscopic surgery, but its physiopathologic mechanism remains unclear. The proposed risk factors of emergence agitation include surgery, anticholinergics, emergency operation, long duration of surgery, postoperative pain, and the presence of invasive devices. Emergence agitation is a infrequently observed adverse effect following laparoscopic surgery, yet its underlying pathophysiological mechanisms remain inadequately understood. Proposed risk factors for emergence agitation encompass the surgical procedure itself, the use of long-acting anticholinergic drug, emergency operations, prolonged surgical duration, postoperative pain, and the presence of invasive devices, et al. In this study, no significant differences were observed among the three cohorts with respect to other side effects and postoperative recovery outcomes, underscoring the safety of PHC in preventing PONV in patients undergoing LSG.

Logistic regression analyses were conducted to identify the independent risk factors associated with PONV. The Apfel risk score [22], comprising four independent factors—sex, nonsmoking status, history of MS and/or PONV, and opioid usage—was shown to be another significant predictor of PONV following LSG. Consistent with our findings, both Choy et al. [23]. and Zhao et al. [13]. suggested that the Apfel risk score is crucial in predicting PONV after surgery. According to current guidelines, opioids (sevoflurane and remifentanil) are recommended for relieving pain and ensuring comfort in patients undergoing LSG [24]. Notably, most participants in our study were female (70.32%), nonsmokers (81.28%), and had no history of smoking or PONV/MS (79.45%), and these factors were similarly distributed across the three cohorts ($P > 0.05$). However, the Apfel risk score has been identified as a robust predictor of PONV following LSG. This study revealed its superiority over individual factors in predicting PONV, thus highlighting the inadequacy of relying on a single factor to predict PONV after LSG. Additionally, the nomogram model revealed that a higher Apfel score was correlated with an increased incidence of PONV. Therefore,

the Apfel risk score serves as a valuable tool for identifying patients at high risk of PONV and therefore can be used to facilitate the development of early interventions to mitigate its occurrence in high-risk individuals undergoing LSG.

There are several limitations in our research that warrant acknowledgment. First, our study included a relatively small sample of patients undergoing LSG at a single center, thus multicenter prospective studies involving a larger sample of patients are needed to validate the efficacy of the nomogram model incorporating a PHC intervention in preventing PONV after LSG. Second, our study focused on patients who underwent LSG and were at very high risk of PONV and who adhered to a multimodal prophylaxis protocol recommended in current guidelines. Notably, this approach could limit the wide clinical applicability of our research findings, although PHC was proven effective in preventing PONV following LSG. Finially, this study not only investigates the effectiveness of PHC in preventing PONV after LSG but also evaluate side effects and postoperative recovery. In future investigations, we aim to explore the comparison of efficacy and side effects between PHC and other antiemetics (such as Granisetron, Metoclopramide, Atropine, Scopolamine, etc.) for preventing PONV incidence following LSG.

In conclusion, a PHC intervention is beneficial for decreasing the incidence of PONV, reducing the severity and intensity of PONV scores among patients who undergo LSG, without decreasing postoperative recovery outcomes. Significantly, higher Apfel risk scores and the absence of a PHC intervention were noted as independent risk factors linked to PONV following LSG.

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Data availability The study data may be provided by contacting the corresponding author.

Declarations

Conflict of interest The authors have no conflicts of interest to declare in this work.

Ethical Approval and informed consent His study received approval from the Institutional Ethics Committee, and informed consent was not required from the included participants (2022-YLJSA084), in compliance with the Helsinki.

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