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Retrospective analysis of the incidence and predictors of postoperative nausea and vomiting after orthopedic surgery under spinal anesthesia

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Background: Postoperative nausea and vomiting (PONV) commonly occurs after spinal anesthesia; however, its incidence rate and predictors have been scarcely studied. Therefore, we aimed to investigate its incidence rate and potential predictors.

Methods: The electronic medical records of 6,610 consecutive patients undergoing orthopedic surgery under spinal anesthesia were reviewed between January 2016 and December 2020. The primary outcome was PONV incidence within 24 h after spinal anesthesia. Along with its incidence rate, we investigated its predictors using multivariable logistic regression analysis.

Results: Among the 5,691 patients included in the analysis, 1,298 (22.8%) experienced PONV within 24 h after spinal anesthesia. Female sex (odds ratio [OR]: 3.23, 95% CI [2.72, 3.83], P < 0.001), nonsmoker (OR: 2.12, 95% CI [1.46, 3.07], P < 0.001), history of PONV (OR: 1.52, 95% CI [1.26, 1.82], P < 0.001), prophylactic 5-hydroxytryptamine receptor antagonist use (OR: 0.35, 95% CI [0.24, 0.50], P < 0.001), prophylactic steroid use (OR: 0.53, 95% CI [0.44, 0.62], P < 0.001), baseline heart rate ≥ 60 beats/min (OR: 1.38, 95% CI [1.10, 1.72], P = 0.005), and postoperative opioid use (OR: 2.57, 95% CI [1.80, 3.67], P < 0.001), were significant predictors of the primary outcome.

Conclusions: Our study showed the common incidence of PONV after spinal anesthesia and its significant predictors. A better understanding of its predictors may provide important information for its management.

Keywords: Dexamethasone; Orthopedic procedure; Postoperative complications; Postoperative nausea and vomiting; Serotonin 5-HT_3 receptor antagonists; Spinal anesthesia.

Introduction

Postoperative nausea and vomiting (PONV) is a major postoperative complication that requires attention from anesthesiologists. PONV possibly results in delayed discharge from the post-anesthesia care unit, unanticipated readmission, and increased medical costs [1–3]. It is also the main cause of patient dissatisfaction with surgery and anesthesia [4,5]. Therefore, PONV management is essential to improve postoperative outcomes and patient satisfaction.

However, previous studies on PONV have been mainly conducted in patients under general anesthesia [6]. Specifically, information on the risk factors of PONV has been obtained from patients under general anesthesia [7,8]. The fourth consensus guidelines for the management of PONV has also focused on the management of PONV after general anesthesia [6]. Spinal anesthesia has been considered an effective strategy to reduce the

baseline risk of PONV, compared to general anesthesia [6]. However, PONV also commonly occurs after spinal anesthesia and reduces patient satisfaction with spinal anesthesia [9]. Additionally, several factors associated with spinal anesthesia, which are distinct from general anesthesia, can contribute to the incidence of PONV [10].

To the best of our knowledge, the incidence and risk factors of PONV in a large cohort of patients undergoing spinal anesthesia have not been investigated. From our experience with PONV after spinal anesthesia obtained from our acute pain service, we believe that anesthesiologists should pay as much attention as general anesthesia to prevent PONV after spinal anesthesia. Therefore, we conducted this retrospective observational study to investigate the incidence rate of PONV in patients who underwent orthopedic surgery under spinal anesthesia and its potential risk factors. We also investigated the association between prophylactic antiemetics and the incidence of PONV after spinal anesthesia. Our study may provide important information regarding the management of PONV after spinal anesthesia.

Materials and Methods

Study design and population

The protocols used in this study were approved by the Institutional Review Board of Seoul National University Hospital on November 24, 2021 (IRB no. 2111–086–1273), and individual patient consent was waived. This study was performed in accordance with the tenets of the Declaration of Helsinki-2013 and reported following the Strengthening the Reporting of Observational Studies in Epidemiology statement [11].

This study included adult patients with the American Society of Anesthesiologists (ASA) physical status I–III and who underwent orthopedic surgery under spinal anesthesia between January 2016 and December 2020. We excluded patients based on the following criteria: (1) reoperation within 24 h after anesthesia, (2) discharge within 24 h after anesthesia, (3) transfer to the intensive care unit after anesthesia, and (4) conversion into general anesthesia. Only the first surgery was included if the same patient underwent more than one surgery under spinal anesthesia during the study period. A prior sample size calculation was not performed due to the retrospective design of the study.

Anesthetic management

The choice of anesthetic management and perioperative care were decided by the attending anesthesiologists or surgeons. The overall institutional protocols are summarized here briefly. Patients were admitted to the operating room without any premedication. After routine monitoring, patients were anesthetized with spinal or combined spinal-epidural anesthesia (CSEA). Spinal anesthesia was induced using an intrathecal injection of 0.5% hyperbaric bupivacaine with or without 10–20 μg of fentanyl. For CSEA, the epidural test dose was administered via an epidural catheter after the same intrathecal injection to confirm that it was correctly placed at the epidural space using 3 ml of 2% lidocaine with 1 : 200,000 epinephrine. After confirming the adequate block level, intravenous midazolam (2–5 mg bolus) or dexmedetomidine (1 μg/kg for 10 min as a loading dose, followed by continuous infusion at a rate of 0.5 μg/kg/h throughout the surgery) was administered for intraoperative sedation according to the patient's preference. After surgery, patients were transferred to the post-anesthesia care unit. During the postoperative period, rescue antiemetics, such as 5-hydroxytryptamine receptor ($5\text{-}HT_3R$) antagonists (0.3 mg ramosetron or 4 mg ondansetron) or 5–10 mg metoclopramides, were administered at the attending physician's discretion.

For PONV prophylaxis, either (1) none, (2) 5 mg dexamethasone and/or 0.075 mg palonosetron before admission to the operating room, or (3) 0.3 mg ramosetron before the end of surgery was administered intravenously. The type and number of prophylactic antiemetics were selected based on the preference of the attending physician. For postoperative analgesia, patient-controlled analgesia (PCA) was provided unless contraindicated, under the informed consent of the patient. Intravenous PCA consisted of a combination of nefopam (0.8 mg/ml), fentanyl (10 μg/ml), and ramosetron (3 μg/ml) at a continuous infusion rate of 1 ml/h and a bolus of 1 ml, with a 15 min lockout interval. Some patients who underwent total knee replacement arthroplasty received a continuous femoral nerve block using 0.2% ropivacaine for postoperative analgesia. Epidural PCA, involving the administration of ropivacaine (50 or 100 μg/ml) at a continuous infusion rate of 1 ml/h and a bolus of 5 ml, with a 30 min lockout interval, was performed in some patients who received CSEA. The type of PCA was determined based on the attending anesthesiologist's preference.

Study outcomes, study groups, and data collection

The primary outcome was PONV incidence during the first 24 h postoperatively (overall PONV). The secondary outcomes were PONV incidence during the 0–6 (early) and 6–24 h (delayed) postoperatively. Nurses regularly evaluate and record PONV incidences in the post-anesthesia care unit and general wards in our institution.

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Demographic, medical history, and perioperative variable data, including PONV incidence and antiemetic use, was retrieved from electronic medical records using the Seoul National University Hospital Patients Research Environment (SUPREME) system. The following potential risk factors were also collected: surgical site, age, sex, body mass index (BMI) (kg/m^2), current smoking status, ASA physical status, history of PONV, intrathecal fentanyl administration, prophylactic use of 5-HT$_3$R antagonist, prophylactic use of steroid, peak level of sensory blockade (≥ T5 or not), intraoperative use of sedatives, baseline heart rate (≥ 60 beats/min), intraoperative hypotension (defined as mean arterial blood pressure < 65 mmHg), and postoperative opioid use during the first 24 h. Postoperative opioid use included intravenous PCA with opioids and rescue opioids. The Apfel score, which consists of four risk factors (female sex, history of PONV, nonsmoking, and use of postoperative opioids) was calculated from our data [7]. History of motion sickness could not be included in the calculated Apfel score due to lack of information.

Statistical analyses

First, we investigated the incidence of overall PONV with its 95% CI according to the calculated Apfel score and the number of prophylactic antiemetics.

Second, to identify the independent risk factors for the overall PONV after spinal anesthesia, we performed a multivariable binary logistic analysis with a backward stepwise conditional method. The variables that demonstrated trends suggesting statistical significance (P < 0.2) in univariable analyses were included in the next step of the multivariable logistic analysis. The following variables were included in the analysis: sex, age, BMI, current smoking status, history of PONV, ASA physical status, intrathecal fentanyl administration, prophylactic use of 5-HT$_3$R antagonist, prophylactic use of steroid, peak level of sensory blockade (≥ T5 or not), intraoperative use of sedatives, baseline heart rate (≥ 60 beats/min), intraoperative hypotension (mean blood pressure < 65 mmHg), and postoperative opioid use during the first 24 h postoperatively. We also performed a multivariable binary logistic analysis, in which the number of the prophylactic agent (none vs. single vs. dual) and calculated Apfel score (0 or 1 vs. 2 vs. 3 vs. 4) were included in the variables, instead of variables constituting them.

Variance inflation factor was used to evaluate multicollinearity between the variables included in the final multivariable model. Multivariable logistic analyses were also performed similarly as the secondary outcomes.

Finally, to investigate the association between the number of prophylactic antiemetics and PONV incidence during the first 24 h postoperatively, we calculated the adjusted OR of the number of prophylactic agents according to the baseline PONV risk (high risk, Apfel score [≥ 3]; low to moderate risk, Apfel score [< 3]) based on the calculated Apfel score. We additionally adjusted the variables included in the final model of the aforementioned multivariable logistic analysis. To investigate whether the baseline PONV risk (high risk vs. low to moderate risk) was an effect modifier, an interaction analysis for the overall PONV between the baseline PONV risk and the number of prophylactic agents was performed. Interaction P values of < 0.05 were considered significant.

Data were analyzed using R version.4.0.0 software (R Foundation for Statistical Computing, Austria). Continuous variables are presented as the median and interquartile range and were compared using the Mann–Whitney *U* test. Categorical variables are presented as numbers (%), and their differences were assessed using the χ^2 test or Fisher's exact test, where appropriate. A two-sided P value < 0.05 was considered statistically significant.

Results

During the study period, 6,610 patients underwent orthopedic surgery under spinal anesthesia. After 919 patients were excluded following the exclusion criteria, the remaining 5,691 patients were included in the final analysis (Fig. 1). Among them, PONV occurred within 24 h postoperatively in 1,298 patients (22.8%).

Table 1 and Supplementary Table 1 present the comparison of baseline characteristics between patients with and without overall PONV. There were significant between-group differences in the surgical site, age, sex, BMI, nonsmoker, history of PONV, prophy-

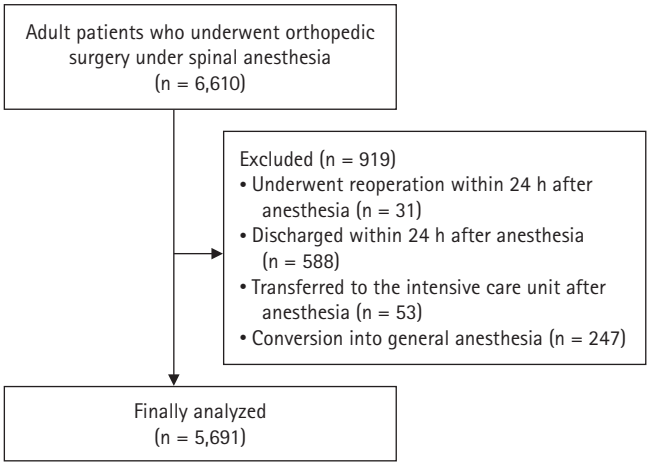

Fig. 1. Flow chart of the study.

Table 1. Perioperative Variables included in the Multivariable Logistic Analysis between Patients with and without PONV after Spinal Anesthesia

Variable	No PONV (n = 4,393)	PONV (n = 1,298)	P value*
Age (yr)	64 (53, 73)	66 (57, 73)	0.019
Female	2,699 (61.4)	1,096 (84.4)	< 0.001
BMI (kg/m^2)	25.4 (23.0, 28.0)	25.1 (23.1, 27.6)	0.046
Nonsmoker	3,967 (90.3)	1,264 (97.4)	< 0.001
ASA physical status (I/II/III)	1,233 (28.1)/2,946 (67.1)/214 (4.9)	380 (29.3)/861 (66.3)/57 (4.4)	0.583
History of PONV	436 (9.9)	212 (16.3)	< 0.001
Prophylactic steroid	1,124 (25.6)	221 (17.0)	< 0.001
Prophylactic 5-HT$_3$R antagonist	4,317 (98.3)	1,231 (94.8)	< 0.001
Intrathecal fentanyl	1,529 (34.8)	517 (39.8)	0.001
Intraoperative sedation	3,923 (89.3)	1,152 (88.8)	0.576
Peak block height ≥ T5	2,163 (50.4)	669 (52.4)	0.145
Baseline heart rate ≥ 60 beats/min	3,832 (87.2)	1,187 (91.4)	< 0.001
Intraoperative hypotension	2,191 (49.9)	673 (51.8)	0.211
Postoperative opioid use†	4,061 (92.4)	1,259 (97.0)	< 0.001

Values are presented as median (Q1, Q3) or numbers (%). PONV: postoperative nausea and vomiting, BMI: body mass index, ASA: American Society of Anesthesiologists, 5-HT$_3$R: 5-hydroxytryptamine receptor. *Categorical variables were compared by the chi-square test. Continuous variables were compared by the Mann-Whitney *U* test. †During the first 24 h postoperatively.

lactic agents, type of local anesthetic agent, intrathecal fentanyl, duration of anesthesia, baseline heart rate ≥ 60 beats/min, intraoperative bradycardia, vasopressor use, type of PCA, and postoperative opioid use. Fig. 2 shows the incidence rate of overall PONV according to the calculated Apfel score and the number of prophylactic agents. The number of prophylactic agents and incidence rates of an overall, early, and delayed PONV according to the calculated Apfel score are presented in Table 2. Table 3 presents the results of multivariable logistic regression analysis for the incidence of overall PONV. Multivariable analysis revealed independent association between the overall PONV incidence and female sex (OR: 3.23, 95% CI [2.72, 3.83], P < 0.001), nonsmoker (OR: 2.12, 95% CI [1.46, 3.07], P < 0.001), history of PONV (OR: 1.52, 95% CI [1.26, 1.82], P < 0.001), prophylactic 5-HT$_3$R antagonist use (OR: 0.35, 95% CI [0.24, 0.50], P < 0.001), prophylactic steroid use (OR: 0.53, 95% CI [0.44, 0.62], P < 0.001), baseline heart rate ≥ 60 beats/min (OR: 1.38, 95% CI [1.10, 1.72], P = 0.005), and postoperative opioid use (OR: 2.57, 95% CI [1.80, 3.67], P < 0.001). Supplementary Table 2 presents the results of multivariable logistic regression analysis, including the calculated Apfel score and the number of prophylactic agents. Supplementary Tables 3 and 4 present the logistic analyses for the secondary outcomes. Baseline heart rate ≥ 60 beats/min (OR: 1.51, 95% CI [1.12, 2.04], P = 0.007) was associated with an increase in early PONV incidence; however, not significantly associated with the incidence of delayed PONV. An interaction analysis revealed that use of a single prophylactic agent for PONV (vs. no agent) significantly decreased the risk of PONV in patients with low to moderate PONV risk (adjusted OR: 0.31, 95% CI [0.15, 0.65], P = 0.002) and those with high PONV risk (adjusted OR: 0.46, 95% CI [0.31, 0.70], P < 0.001), respectively (Table 4). There was no significant interaction for overall PONV between the use of a single prophylactic agent (vs. no agent) and baseline PONV risk (Interaction P = 0.342). The use of dual prophylactic agents (vs. single agent) was not associated with the risk of PONV in patients with low to

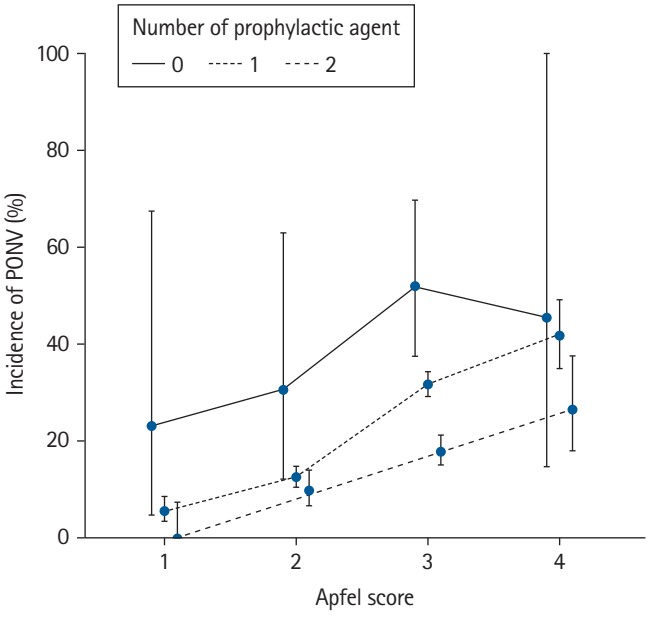

Fig. 2. Incidence of PONV after spinal anesthesia according to the Apfel score and number of prophylactic agents. Upper and lower whiskers represent 95% CI. PONV: postoperative nausea and vomiting.

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Table 2. Number of Prophylactic Agents and the Incidence of Postoperative Nausea and/or Vomiting according to the Calculated Apfel Score

Variable	Apfel score			
	0 or 1 (n = 478)	2 (n = 1,593)	3 (n = 3,139)	4 (n = 481)
Number of prophylactic agents				
None	13 (2.7)	23 (1.4)	85 (2.7)	11 (2.3)
1	413 (86.4)	1,242 (78)	2,221 (70.8)	349 (72.6)
2	52 (10.9)	328 (20.6)	833 (26.5)	121 (25.2)
Nausea, overall (0–24 h)	25 (5.2)	180 (11.3)	805 (25.6)	170 (35.3)
Nausea, 0–6 h	10 (2.1)	93 (5.8)	419 (13.3)	96 (20.0)
Nausea, 6–24 h	16 (3.3)	116 (7.3)	595 (19.0)	116 (24.1)
Vomiting, overall (0–24 h)	6 (1.3)	44 (2.8)	346 (11.0)	70 (14.6)
Vomiting, 0–6 h	3 (0.6)	24 (1.5)	152 (4.8)	28 (5.8)
Vomiting, 6–24 h	3 (0.6)	23 (1.4)	237 (7.6)	51 (10.6)
PONV, overall (0–24 h)	26 (5.4)	193 (12.1)	897 (28.6)	182 (37.8)
PONV, 0–6 h	10 (2.1)	102 (6.4)	471 (15.0)	103 (21.4)
PONV, 6–24 h	18 (3.8)	125 (7.8)	677 (21.6)	132 (27.4)

Values are presented as numbers (%). PONV: postoperative nausea and vomiting.

Table 3. Binary Logistic Regression Analysis for Factors associated with PONV after Spinal Anesthesia

Variable	Univariable analysis		Multivariable analysis	
	OR (95% CI)	P value*	OR (95% CI)	P value†
F (vs. M)	3.41 (2.90, 4.00)	< 0.001	3.23 (2.72, 3.83)	< 0.001
Age (10 yr)	1.07 (1.03, 1.11)	< 0.001		
BMI (kg/m^2)	0.98 (0.97, 1.00)	0.022	0.98 (0.97, 1.00)	0.063
Nonsmoker	3.99 (2.80, 5.69)	< 0.001	2.12 (1.46, 3.07)	< 0.001
History of PONV	1.77 (1.48, 2.12)	< 0.001	1.52 (1.26, 1.82)	< 0.001
ASA physical status				
I	Reference			
II	0.95 (0.83, 1.09)	0.450		
III	0.86 (0.63, 1.18)	0.362		
Intrathecal fentanyl administration	1.24 (1.09, 1.41)	< 0.001		
Prophylactic use of 5-HT$_3$R antagonist	0.32 (0.23, 0.45)	< 0.001	0.35 (0.24, 0.50)	< 0.001
Prophylactic use of steroid	0.60 (0.51, 0.70)	< 0.001	0.53 (0.44, 0.62)	< 0.001
Peak block height ≥ T5	1.10 (0.97, 1.24)	0.145		
Intraoperative sedation	0.95 (0.78, 1.15)	0.576		
Baseline heart rate ≥ 60 beats/min	1.56 (1.26, 1.93)	< 0.001	1.38 (1.10, 1.72)	0.005
Intraoperative hypotension	1.15 (1.01, 1.30)	0.033		
Postoperative opioid use‡	2.64 (1.88, 3.70)	< 0.001	2.57 (1.80, 3.67)	< 0.001

PONV: postoperative nausea and vomiting, OR: odds ratio, BMI: body mass index, ASA: American Society of Anesthesiologists, 5-HT$_3$R: 5-hydroxytryptamine receptor. *A univariable binary logistic regression analysis was performed for each variable, respectively. †A multivariable binary logistic analysis with backward stepwise conditional method including the variables with statistical significance (P < 0.2) in the univariable analyses was performed. ‡During the first 24 h postoperatively.

moderate PONV risk (adjusted OR: 0.79, 95% CI [0.53, 1.18], P = 0.251). However, in patients with high PONV risk, the use of dual prophylactic agents (vs. single agent) significantly decreased the risk of PONV after spinal anesthesia (adjusted OR: 0.48, 95% CI [0.40, 0.58], P < 0.001). Baseline PONV risk was an effect modifier for the association between dual prophylactic agents (vs. single agent) and overall PONV (Interaction P = 0.026).

Discussion

In this study, the baseline heart rate and well-known risk factors of PONV after general anesthesia showed significant associations

Table 4. Interaction of PONV Occurrence after Spinal Anesthesia between the Calculated Apfel Score and Number of Prophylactic Agents

Variable	Adjusted OR (95% CI)*	P value*	Interaction P value†
Single agent (vs. no agent)‡			0.342
Low to moderate PONV risk (Apfel score 0–2)	0.31 (0.15, 0.65)	0.002	
High PONV risk (Apfel score 3 or 4)	0.46 (0.31, 0.70)	< 0.001	
Dual agents (vs. single agent)§			0.026
Low to moderate PONV risk (Apfel score 0–2)	0.79 (0.53, 1.18)	0.251	
High PONV risk (Apfel score 3 or 4)	0.48 (0.40, 0.58)	< 0.001	

PONV: postoperative nausea and vomiting, OR: odds ratio. *Multivariable logistic regression analyses were performed after adjusting for the following variables: body mass index, and baseline heart rate ≥ 60 beats/min. †Interaction analyses for the overall PONV between the baseline PONV risk and number of prophylactic agents were performed. ‡This included 4,357 patients who received no or single prophylactic agent for PONV. §This included 5,559 patients who received single or dual prophylactic agents for PONV.

with the PONV incidence in patients undergoing orthopedic surgery under spinal anesthesia. Additionally, there was a significant association between the use of prophylactic dexamethasone and 5-HT_3R antagonist and decreased PONV incidence after spinal anesthesia. Furthermore, there was a significant interaction between their combination and high PONV risk, suggesting the need for multimodal PONV prophylaxis in patients with high-risk PONV under spinal anesthesia.

Our result suggests that four risk factors for PONV included in the Apfel score could be still valid for predicting PONV after spinal anesthesia [7]. The recent prospective observational study reported female sex and a history of PONV as significant risk factors for PONV after spinal anesthesia [12]. This previous study did not show a significant association between smoking and PONV incidence due to a lack of smokers [12]; however, our study revealed a significant association between them. The effect of postoperative opioid use on PONV after spinal anesthesia could be estimated from previous studies regarding opioid-sparing analgesia in spinal anesthesia [13], and there was a significant association between the use of postoperative opioids and PONV incidence after spinal anesthesia in our study. The predictive power of the Apfel score for PONV after spinal anesthesia should be evaluated through prospective studies.

We also investigated several possible risk factors of PONV in spinal anesthesia, distinguished from general anesthesia [10]. One prospective study reported an addition of vasoconstrictor to the local anesthetic, baseline heart rate ≥ 60 beats/min, intraoperative hypotension, and peak block height ≥ T5 as significant risk factors for nausea and vomiting during spinal anesthesia [14]. However, this study investigated only intraoperative nausea and vomiting, not postoperative. In our study, only baseline heart rate ≥ 60 beats/min showed a significant association with PONV incidence after spinal anesthesia. Sympathetic blockade by spinal anesthesia causes an unopposed vagal effect, contributing to PONV incidence [10]. It can be presumed that the unopposed vagal effects caused by spinal anesthesia have been obscured in patients with preoperative bradycardia due to their adaptation to parasympathetic hyperactivity [15]. Intraoperative hypotension causes nausea and vomiting during spinal anesthesia via brain stem and gut ischemia [10]. However, considering the short duration of intraoperative hypotension and supplemental oxygen in our patients, it would have been difficult to cause brainstem or gut ischemia enough to cause PONV. Since we did not add vasoconstrictors to local anesthetics, we could not investigate its effect on PONV incidence. Moreover, several sedatives used for intraoperative sedation such as dexmedetomidine, midazolam, and propofol, reduce PONV in general anesthesia [6,16–18]. However, we could not find a significant association between intraoperative sedation using dexmedetomidine or midazolam and PONV incidence after spinal anesthesia. A wide variation in dosage of sedatives and duration of their administration in our study might have affected the negative result. Additionally, unlike morphine, intrathecal fentanyl has no effect on PONV incidence, and our study findings were consistent with this previous result [10]. Further studies on the risk factors of PONV in spinal anesthesia are required to better predict PONV after spinal anesthesia.

Our study also highlighted the need for multimodal PONV prophylaxis in spinal anesthesia. To the best of our knowledge, there seems to be limited evidence for multimodal PONV prophylaxis in spinal anesthesia [19,20]. A previous randomized controlled trial (RCT) reported that the combination of metoclopramide with dexamethasone was more effective in preventing PONV compared to dexamethasone alone [21]. However, this study included patients undergoing general or regional anesthesia [21], and metoclopramide is currently not recommended as a first-line prophylactic agent for PONV [6]. Moreover, the prophylactic effects of the combination of dexamethasone with droperidol on PONV have been investigated [22]. However, the use of

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droperidol is significantly limited in many countries, due to its risk of sudden cardiac death [6]. Another RCT reported that the combination of ondansetron with dexamethasone significantly reduced the incidence of postoperative nausea in patients undergoing cesarean section compared to each single agent [23]. However, this study did not consider other risk factors that could affect the incidence of PONV, and the observation period of the PONV incidence was only during the stay in the recovery room [23]. Our present study used a retrospective study design; however, we included a large cohort of patients undergoing spinal anesthesia and also attempted to adjust several risk factors of PONV after spinal anesthesia. In our study, prophylactic dexamethasone, 5-HT_3R antagonist, and their combination showed a significant association with decreased PONV incidence. Furthermore, there was a significant interaction between their combination and high PONV risk, suggesting a significant effect of multimodal PONV prophylaxis, including dexamethasone and 5-HT_3R antagonist, compared to single-agent prophylaxis, in the high-risk group. Therefore, optimal PONV prophylaxis according to the predicted risk of PONV would be required in patients receiving spinal anesthesia.

Our study results should be interpreted cautiously for several reasons. First, the inherent limitation of our study's retrospective design; unmeasured or unknown covariates could have affected our results. Our data sources lacked important clinical details, such as history of motion sickness and amount of postoperative opioid consumption. Additionally, the reliability of PONV incidence determined from our nursing documentation could have affected our findings. PONV incidence was routinely recorded in our institution; however, mild or transient nausea, which the patient did not complain of, was not likely to be recorded in medical records. Second, it is difficult to generalize our findings since our results were obtained from a single institution. Third, we could not include intraoperative PONV incidence in the analysis due to its insufficient records. Further studies are required to investigate on the association between intraoperative nausea and vomiting and PONV in spinal anesthesia. Finally, we could not analyze the use of rescue antiemetics that could reflect the severity of PONV due to our routine use of 5-HT_3R antagonists on the first day postoperatively. Despite these limitations, to the best of our knowledge, this study is the first to investigate the association between several factors and PONV incidence in a large cohort of patients receiving spinal anesthesia.

In conclusion, we discovered significant associations between several variables and PONV incidence during the first 24 h after spinal anesthesia. We also observed a significant association between multimodal PONV prophylaxis using dexamethasone and 5-HT_3R antagonist and a lower PONV incidence in the high-risk group for PONV. Our study highlights the importance of PONV management after spinal anesthesia and is an important reference for future studies regarding PONV after spinal anesthesia.

Funding

None.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

Jae-Woo Ju (Data curation; Formal analysis; Writing – original draft)
Jina Kwon (Data curation)
Seokha Yoo (Data curation; Formal analysis)
Hojin Lee (Conceptualization; Supervision; Writing – review & editing)

Supplementary Materials

Supplementary Table 1. Perioperative variables not included in the multivariable logistic analysis between patients with and without postoperative nausea and vomiting (PONV) after spinal anesthesia.
Supplementary Table 2. Results of binary logistic regression analysis for factors associated with postoperative nausea and vomiting during the first 24 h after spinal anesthesia, including the calculated Apfel score and number of prophylactic agents.
Supplementary Table 3. Results of binary logistic regression analysis for factors associated with postoperative nausea and vomiting during the postoperative 0–6 h after spinal anesthesia.
Supplementary Table 4. Results of binary logistic regression analysis for factors associated with postoperative nausea and vomiting during the postoperative 6–24 h after spinal anesthesia.

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