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Research Article

Factors Influencing Satisfaction with Patient-Controlled Analgesia Among Postoperative Patients Using a Generalized Ordinal Logistic Regression Model

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SUMMARY

Purpose: The purpose of this study was to identify the factors affecting the satisfaction with patient-controlled analgesia (PCA) of patients using a generalized ordinal logistic regression model and to evaluate the difference in results of the ordinal regression from those of binary regression.
Methods: The study design involved secondary analysis of electronic medical records from a single tertiary care hospital in Seoul, Korea. It included 2,409 patients treated with PCA for postoperative pain management after open or laparoscopic abdominal surgery. Binary logistic regression and generalized ordinal logistic regression were used to identify factors affecting satisfaction.
Results: Binary logistic regression analysis showed that there was insufficient information for analysis. Generalized ordinal logistic regression revealed that sex, age, pain, PCA usage, and side-effects were common factors affecting PCA satisfaction. However, the effect of some factors affecting PCA satisfaction differed with the level of satisfaction. In open surgery patients, the effect of pain at 6 hours after surgery was significantly greater in the group with lower satisfaction. While, in the laparoscopic surgery patients, the effect of pain at 6–24 hours after surgery was significantly greater in the group with lower satisfaction.
Conclusion: Generalized logistic regression may be an appropriate statistical method for analyzing ordinal data. Degree of postoperative pain and assessment interval are the most important factors associated with PCA satisfaction. Because the factors affecting PCA satisfaction were different for the two types of abdominal surgeries, customizing PCA to individual patients may potentially improve pain management and consequently increase PCA satisfaction.

Introduction

Pain is considered to be the fifth vital sign, and failure to adequately control postoperative pain can lead to various complications in surgery patients. Uncontrolled pain decreases the quality of sleep [1], impairs bodily functions, and increases fatigue and depression [2,3]. In addition, uncontrolled pain can interfere with postoperative recovery [4] and can reduce reported satisfaction with postoperative pain management [5].

Patient-controlled analgesia (PCA) refers to any method that allows a person experiencing pain to self-administer analgesics using a device (typically an infusion pump) that can be activated when the patient feels pain [6]. PCA is reported to be effective for acute postoperative pain management [6]. PCA is used to control pain after most surgical procedures where acute pain is expected. Effective pain management through PCA usage improves patient satisfaction and postoperative recovery [4,7]. It is important to assess patient satisfaction when monitoring the quality of pain management [8,9]. Therefore, PCA satisfaction may serve as an outcome indicator of pain management methods. Nevertheless, there are several cases where PCA cannot be used because of potential side-effects [10]. Moreover, the side-effects of analgesics

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may be among the factors that lower patient satisfaction with pain management. The previous studies reported that age, sex, and severity of pain affected the patient satisfaction with pain treatment [5,11–13].

The majority of previous studies on patient satisfaction with pain management have collected and analyzed data in multiple unordered or ordered categories such as “very unsatisfactory,” “dissatisfied,” “normal,” “satisfactory,” and “very satisfied”. An ordinal categorical scale is an easy and convenient method to rank outcome variables such as attitude, behavior, and disease severity [14–16]. In numerous previous studies, ordinal data have been converted into binary data because the number of cells was small [11,17]. However, when data are categorized using an ordinal scale with five to seven levels, determining cutoff points is a major problem. In addition, when an ordinal scale for satisfaction variables is converted to an interval scale [7,18], often multiple linear regression analyses cannot be performed because the dependent variable is not normally distributed [11]. Even when ordinal logistic regression is used, the associations between the predictors and outcome variable may not be constant across the ordered categories. Consequently, the intervals used for the levels (levels 1, 2, and 3) of a scale may not necessarily be equivalent, and the order number of the levels may not be representative of the actual relationship among the levels (outcome in level 3 may not be thrice the outcome in level 1). Moreover, additional parallel line test has to be satisfied. However, parallel line test has many limitations, and it is difficult to accept [14,19]. Therefore, alternative tests must be considered.

Very few studies have analyzed ordinal data for treatment methods using ordinal logistic regression [20] because of the difficulty of completing this type of analysis. However, Williams' generalized ordered logit model (*gologit2*) can overcome the limitations of ordinal data analysis because parallel testing is less restrictive, and the model results are concise and easy to interpret. *Gologit2* can also evaluate the magnitude of the impact of factors at each level (order) [19], and researchers can determine how the relationship between the factors and outcome changes at each level. Therefore, the tool can provide information that may be useful for decision-making in a clinical setting.

Ordinal logistic regression appears to be a useful method to assess factors influencing PCA satisfaction in patients. This study aimed to investigate factors affecting PCA satisfaction after open and laparoscopic abdominal surgery, using a generalized regression model. In addition, the difference in results of the binary regression analysis from those of the ordinal regression analysis was evaluated. Finally, the researchers assessed the magnitude of the effect of each factor at each level of satisfaction.

Methods

Study participants

The study participants were patients that used intravenous PCA for pain management after undergoing abdominal surgery at a single tertiary care hospital in Seoul, Korea, from March 2014 to August 2015. The Institutional Review Board of Yonsei University Health System, Severance Hospital (Approval no. 4-2016-1150) approved the study, and the requirement of written informed consent was waived. The study utilized the medical records of 2,409 patients. The inclusion criteria for the participants were as follows: communicative adult, aged 19 to 80 years who used PCA after laparoscopic or open surgery, and patients that underwent general anesthesia. Patients who needed postoperative respiratory care or intensive care were excluded. The patient selection flow chart is shown in the study profile (Supplementary file 1).

PCA protocol

All patients used the same model of the disposable PCA pump (Accufuser plus® P2015M or Accufuser plus® P5015L, Woo Young Medical, Chungbuk, Korea). The pump was programmed to deliver 2 ml/hr as the background infusion and 0.5 ml per demand, with a 15-min lockout during a 48 hour period. Alternatively, it could deliver 5 ml/hr as the background infusion and 0.5 ml per demand, with a 15-min lockout during a 48 hour period. The PCA regimen typically consisted of fentanyl (2–20 mcg/ml) plus normal saline (total volume of 100 ml or 250 ml). At the discretion of the attending anesthesiologists, 90–120 mg of ketorolac, 20–160 mg of nefopam, or 1000–6000 mg of denogan was added as an adjuvant to the PCA regimen depending on the patient's condition. Prophylactic antiemetics (5-HT_3 antagonists) were administered immediately after surgery. The PCA nurse specialists, who were part of the acute pain service team, monitored patients at the -6, -24, -48 hour intervals after surgery.

Measurements

Demographic and clinical characteristics

Demographic characteristics were assessed such as sex, age, and smoking history and clinical characteristics such as medical diagnosis, surgical site, surgical type, American Society of Anesthesiologists physical status class, duration of anesthesia, duration of surgery, and additional analgesics.

Pain

Pain was measured using the numerical rating scale, with values ranging from zero (no pain) to 10 (most severe pain), at -6 hours, -24 hours, and -48 hours after surgery. Essentially, a higher score indicated a greater degree of pain [21]. The degree of pain in the postanesthesia care unit (PACU) was measured using the Wong–Baker pain scale, for which patients identify a cartoon facial expression and provide a written description of their level of pain. Again, a higher score on the Wong–Baker pain scale indicated a greater degree of pain [21].

PCA usage

Total PCA usage was defined as the percentage of total dose (prescribed by an anesthesiologist) that was used by the end of the infusion. For example, when an anesthesiologist prescribed a total of 100 ml of medication, total PCA usage was 60% if only 60 ml was injected because of side-effects.

Adverse effects

Adverse effects were recorded, and they included nausea, vomiting, dizziness, headache, sedation, pruritus, urinary retention, and hypotension [22]. Participants responded with “yes” or “no”, depending on the presence of symptoms. In addition, based on the electronic medical records, the researchers confirmed the presence of adverse effects.

Patient satisfaction

Satisfaction with use of PCA for pain management was measured at the end of PCA infusion. A scale with scores ranging from 1 to 5 (1 = not satisfied at all; 5 = very satisfied) was used for the measurement.

Statistical analyses

The 2,409 patients were classified based on the type of surgery reported in their records: open or laparoscopic abdominal surgery. Laparoscopic surgery patients included patients that underwent

robotic surgery. The Stata program (version 13, StataCorp., College Station, TX, USA) was used to analyze patient demographics and to identify the factors affecting PCA satisfaction. To compare the demographic characteristics, degree of pain, adverse effects, and total PCA usage in open and laparoscopic surgery groups, an independent *t* test and Chi-square test were used. The Chi-square test, Fisher's exact test, and analysis of variance were used to find variables that affected satisfaction.

First, a typical satisfaction analysis was conducted. The researchers tried to use the linear regression model to identify the factors affecting satisfaction, but the data did not satisfy the normality test. Therefore, the satisfaction level 1 and 2 groups were classified as the dissatisfaction group, and the satisfaction level 3, 4, and 5 groups were classified as the satisfaction group. Next, binary logistic regression was performed to identify factors affecting satisfaction.

Generalized ordinal logistic regression was the second method used to identify factors affecting satisfaction. Before using this method, the parallel test was performed, and we confirmed that the requirements of the parallel test were not met. Therefore, *gologit*2 with the partial proportional odds model was used because it did not satisfy the parallel test. The *gologit2* is a user-written Stata program [19] that estimates generalized logistic regression models for ordinal-dependent variables. This model is a less restrictive method than ordinal logistic regression and overcomes the limitations of the parallel test by fitting the data into the partial proportional odds model. In this study, there were five levels of satisfaction; therefore, four logit models were used. The logit effects of all variables were presented across four models, and comparisons were made for probabilities of being in a higher category versus being at or below that category. Each group of categories was compared based on the satisfaction level as follows: step 1: 2, 3, 4, and 5 versus 1; step 2: 3, 4, and 5 versus 1 and 2; step 3: 4 and 5 versus 1, 2, and 3; and step 4: 5 versus 1, 2, 3, and 4. Hence, positive coefficients indicated that higher values of the explanatory variable increase the likelihood of the respondent being at a higher satisfaction level than at the current or lower satisfaction levels, whereas negative coefficients indicated that higher values of the explanatory variable increase the likelihood of the respondent being at the current or lower satisfaction levels than at a higher satisfaction level. The magnitude of the coefficient implied the magnitude of the effect of the explanatory variable. Depending on

Table 1 *Patient Demographics and Characteristics (N = 2,409).*

Variable	Open (n = 949)	Laparoscopic (n = 1,460)	Total (N = 2,409)	t or x^2 (*p*)
	n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	
Sex				
Women	371 (39.1)	599 (41.0)	970 (40.3)	0.89 (.350)
Men	578 (60.9)	861 (59.0)	1,439 (59.7)	
Age (yrs)	56.62 ± 12.80	57.02 ± 11.91	56.86 ± 12.67	-0.78 (.434)
19–30	40 (4.2)	23 (1.6)	63 (2.6)	
31–40	70 (7.4)	117 (8.0)	187 (7.8)	
41–50	165 (17.4)	268 (18.3)	433 (18.0)	
51–60	280 (29.5)	470 (32.2)	750 (31.1)	
61–70	261 (27.5)	365 (25.0)	626 (26.0)	
71–80	133 (14.0)	217 (14.9)	350 (14.5)	
Medical diagnosis, n (%)				
Lower GI, 872 (36.2)	249 (100.0)	623 (100.0)	872 (100.0)	
Cancer	184 (73.9)	581 (93.2)	765 (87.7)	
Obstruction	28 (11.2)	8 (1.3)	36 (4.1)	
Others[a]	37 (14.9)	34 (5.5)	71 (8.2)	
Upper GI, 861 (35.7)	197 (100.0)	664 (100.0)	861 (100.0)	
Cancer	187 (94.9)	633 (95.3)	820 (95.2)	
Mass	6 (3.1)	27 (4.1)	33 (3.8)	
Others[b]	4 (2.0)	4 (0.6)	8 (1.0)	
Biliary and pancreatic, 491 (20.4)	330 (100.0)	161 (100.0)	491 (100.0)	
Cancer	284 (86.1)	73 (45.3)	357 (72.7)	
Mass	26 (7.9)	28 (17.4)	54 (11.0)	
Gallbladder disease	14 (4.2)	45 (28.0)	59 (12.0)	
Others[c]	6 (1.8)	15 (9.3)	21 (4.3)	
Kidney transplantation, 135 (5.6)	135 (100.0)	0 (100.0)	135 (100.0)	
Others[d], 50 (2.1)	38 (100.0)	12 (100.0)	50 (100.0)	
Pain score				
PACU pain score	5.80 ± 2.31	5.10 ± 2.14	5.37 ± 2.24	7.47 (<.001)
-6 h pain score	6.54 ± 2.29	5.79 ± 2.34	6.09 ± 2.35	7.74 (<.001)
-24 h pain score	4.53 ± 2.09	3.97 ± 1.93	4.19 ± 2.01	6.61 (<.001)
-48 h pain score	3.34 ± 1.86	2.91 ± 1.61	3.08 ± 1.72	5.88 (<.001)
Nausea and vomiting				
Yes	264 (27.8)	525 (36.0)	789 (32.8)	17.30 (<.001)
No	685 (72.2)	935 (64.0)	1,620 (67.2)	
Dizziness				
Yes	125 (13.2)	307 (21.0)	432 (17.9)	24.12 (<.001)
No	824 (86.8)	1,153 (79.0)	1,977 (82.1)	
Headache				
Yes	20 (2.1)	35 (2.4)	55 (2.3)	0.22 (.642)
No	929 (97.9)	1,425 (97.6)	2,354 (97.7)	
PCA usage (%)	97.72 ± 11.77	94.91 ± 16.53	96.02 ± 14.90	4.86 (<.001)

Note. [a]Others (lower GI) = irritable bowel syndrome, hernia, etc.; [b]Others (upper GI) = gastroesophageal reflux disease, perforation, etc.; [c]Others (biliary & pancreatic) = adrenal disease, spleen disease, etc.; [d]Others = ovary cancer, ovary mass, abdominal mass, etc.
GI = gastrointestinal; h = hours; M = mean, PACU = postanesthesia care unit; PCA = patient-controlled analgesia; SD = standard deviation; yrs = years.

the comparison step, how the effect size of the explanatory variable changed could be confirmed. The level of significance or α was set at 0.05 for all statistical tests.

Results

The demographic characteristics of patients have been presented in Table 1. This study included 970 women (40.3%) and 1,439 men (59.7%). The medical records indicated that 949 (39.4%) patients had open abdominal surgery, and 1,460 (60.6%) had laparoscopic surgery. Among these, 872 (36.2%) had lower gastrointestinal, 861 (35.7%) had upper gastrointestinal, and 491 (20.4%) had biliary and pancreatic surgeries. The most common indication for surgery was cancer.

Pain score, adverse effects, and PCA usage

Table 1 presents the maximum pain score for each time period (in the PACU, -6 hours, -24 hours, and -48 hours postoperatively). The maximum pain score at all time points was significantly higher after open abdominal surgery than after laparoscopic surgery. Nausea/vomiting and dizziness significantly differed between the open surgery and laparoscopic surgery groups. Total PCA usage (%) was significantly higher in open surgery patients compared with that in laparoscopic surgery patients.

Factors affecting PCA satisfaction: binary logistic regression

To identify the factors affecting PCA satisfaction, age, sex, PCA usage, additional analgesics, pain, and side-effects were used as related variables, and binary logistic regression analysis was performed by dividing the patients into the PCA satisfaction group and dissatisfaction group (Table 2). In open surgery patients, as age increased, there was a higher probability of satisfaction [odds ratio (OR): 1.25, 95% confidence interval (CI): 1.01–1.53], and when PCA usage increased, the probability of satisfaction was higher (OR: 1.05, 95% CI: 1.03–1.07). When pain at 6 hours (OR: 0.71, 95% CI: 0.57–0.87) and 6–24 hours (OR: 0.79, 95% CI: 0.65–0.96) after surgery increased, the probability of satisfaction was lower. If there was dizziness, the probability of satisfaction was higher than when there was no dizziness (OR: 3.23, 95% CI: 1.08–9.62). In laparoscopic surgery patients, when PCA usage increased, the probability of satisfaction was higher (OR: 1.03, 95% CI: 1.02–1.04). When pain at 6 hours (OR: 0.82, 95% CI: 0.69–0.97) and 6–24 hours (OR: 0.81, 95% CI: 0.67–0.97) after surgery increased, the probability of satisfaction was lower. If there was headache, the probability of satisfaction was lower than when there was no headache (OR: 0.27, 95% CI: 0.09–0.79).

Comparison of variables by levels of satisfaction

In open surgery patients, there were significant differences in sex, age, pain score for each time period (in the PACU, -6 hours, -24 hours, and -48 hours postoperatively), additional analgesics, nausea and vomiting, dizziness, and PCA usage by levels of satisfaction (Table 3). In laparoscopic surgery patients, there were significant differences in sex, age, pain score for each time period (in the PACU, -6 hours, -24 hours, and -48 hours postoperatively), additional analgesics, nausea and vomiting, dizziness, headache, and PCA usage by levels of satisfaction (Table 3). There were no significant differences in smoking history, American Society of Anesthesiologists physical status class, duration of anesthesia, duration of surgery, sedation, pruritus, urinary retention, and hypotension (Supplementary file 2).

Table 2 *Factors Affecting Patient-Controlled Analgesia (PCA) Satisfaction: Binary Logistic Regression (N = 2,409).*

Open surgery						
Variable	β	SE	*p*	OR	95% CI	
Sex (ref: women)	0.37	0.29	.204	1.45	0.82	2.56
Age	0.22	0.11	.038	1.25	1.01	1.53
PCA usage (%)	0.04	0.01	<.001	1.05	1.03	1.07
Additional analgesics (ref: no)	−1.47	1.06	.165	0.23	0.03	1.83
PACU pain score	−0.02	0.07	.736	0.98	0.86	1.11
-6 h pain score	−0.35	0.11	.001	0.71	0.57	0.87
-24 h pain score	−0.24	0.10	.019	0.79	0.65	0.96
-48 h pain score	−0.07	0.09	.438	0.93	0.78	1.12
N/V (ref: no)	0.39	0.35	.263	1.48	0.75	2.93
Dizziness (ref: no)	1.17	0.56	.035	3.23	1.08	9.62
Headache (ref: no)	−0.83	0.77	.281	0.44	0.10	1.97
	Dissatisfaction group (n = 67), Satisfaction group (n = 882)					
Laparoscopic surgery						
Variable	β	SE	*p*	OR	95% CI	
Sex (ref: women)	0.04	0.29	.876	1.05	0.60	1.83
Age	0.20	0.11	.060	1.22	0.99	1.50
PCA usage (%)	0.03	0.01	<.001	1.03	1.02	1.04
Additional analgesics (ref: no)	−0.17	0.55	.753	0.84	0.29	2.46
PACU pain score	−0.02	0.06	.795	0.98	0.87	1.12
-6 h pain score	−0.20	0.09	.021	0.82	0.69	0.97
-24 h pain score	−0.22	0.10	.024	0.81	0.67	0.97
-48 h pain score	−0.16	0.10	.092	0.85	0.71	1.03
N/V (ref: no)	−0.22	0.29	.452	0.80	0.45	1.42
Dizziness (ref: no)	−0.10	0.31	.745	0.91	0.50	1.65
Headache (ref: no)	−1.30	0.54	.016	0.27	0.09	0.79
	Dissatisfaction group (n = 68), Satisfaction group (n = 1,392)					

Note. CI = confidence interval; h = hours; N/V = nausea and vomiting; OR = odds ratio; PACU = postanesthesia care unit; ref = reference; SE = standard error.

Table 3 *Comparison of Variables by Level of Satisfaction with Patient-Controlled Analgesia (PCA) (N = 2,409).*

Variable		PCA satisfaction (open abdominal surgery)						F or x^2 (*p*)
		1 (n = 26)	2 (n = 41)	3 (n = 215)	4 (n = 206)	5 (n = 461)	Total (n = 949)	
		n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	
Sex	Women	16 (61.5)	19 (46.3)	93 (43.3)	95 (46.1)	148 (32.1)	371 (39.1)	21.69 (<.001)
	Men	10 (38.5)	22 (53.7)	122 (56.7)	111 (53.9)	313 (67.9)	578 (60.9)	
Age (yrs)		49.88 ± 12.93	54.41 ± 13.53	57.97 ± 12.46	55.64 ± 12.87	57.00 ± 12.74	56.62 ± 12.80	3.13 (.014)
Postoperative pain score	PACU	6.81 ± 2.59	6.80 ± 2.36	6.12 ± 2.34	5.82 ± 2.29	5.50 ± 2.24	5.80 ± 2.31	6.29 (<.001)
	-6 h	9.10 ± 0.98	7.68 ± 1.97	7.19 ± 1.86	6.83 ± 1.99	5.87 ± 2.44	6.54 ± 2.29	28.54 (<.001)
	-24 h	6.92 ± 2.10	5.63 ± 2.29	5.31 ± 1.88	4.60 ± 1.83	3.91 ± 2.03	4.53 ± 2.09	33.70 (<.001)
	-48 h	5.50 ± 2.14	3.95 ± 2.17	3.87 ± 1.80	3.57 ± 1.67	2.82 ± 1.73	3.34 ± 1.86	26.61 (<.001)
[a]Additional analgesics	Yes	26 (100.0)	40 (97.6)	204 (94.9)	188 (91.3)	393 (85.3)	851 (89.7)	(<.001)
	No	0 (0.0)	1 (2.4)	11 (5.1)	18 (8.7)	68 (14.7)	98 (10.3)	
Nausea and vomiting	Yes	8 (30.8)	12 (29.3)	70 (32.6)	77 (37.4)	97 (21.0)	264 (27.8)	22.48 (<.001)
	No	18 (69.2)	29 (70.7)	145 (67.4)	129 (62.6)	364 (79.0)	685 (72.2)	
Dizziness	Yes	1 (3.9)	4 (9.8)	33 (15.4)	38 (18.5)	49 (10.6)	125 (13.2)	10.90 (.028)
	No	25 (96.1)	37 (90.2)	182 (84.6)	168 (81.5)	412 (89.4)	824 (86.8)	
[a]Headache	Yes	1 (3.9)	2 (4.9)	5 (2.3)	4 (1.9)	8 (1.7)	20 (2.1)	(.409)
	No	25 (96.1)	39 (95.1)	210 (97.7)	202 (98.1)	453 (98.3)	929 (97.9)	
PCA usage (%)		86.65 ± 32.16	95.85 ± 18.02	97.53 ± 12.12	97.41 ± 9.97	98.73 ± 8.94	97.72 ± 11.77	7.08 (<.001)
Variable		PCA Satisfaction (laparoscopic abdominal surgery)						F or x^2 (*p*)
		1 (n = 23)	2 (n = 45)	3 (n = 278)	4 (n = 296)	5 (n = 818)	Total (n = 1,460)	
		n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	n (%) or M ± SD	
Sex	Women	14 (60.9)	24 (53.3)	118 (42.4)	141 (47.6)	302 (36.9)	599 (41.0)	17.84 (.001)
	Men	9 (39.1)	21 (46.7)	160 (57.6)	155 (52.4)	516 (63.1)	861 (59.0)	
Age (yrs)		53.30 ± 14.65	52.62 ± 11.25	55.71 ± 12.25	56.52 ± 12.00	58.00 ± 11.61	57.02 ± 11.91	4.48 (.001)
Postoperative pain score	PACU	6.09 ± 2.50	5.58 ± 2.54	5.51 ± 2.19	5.26 ± 2.10	4.85 ± 2.07	5.10 ± 2.14	7.57 (<.001)
	-6 h	7.22 ± 2.09	7.27 ± 2.16	6.70 ± 1.97	6.25 ± 2.13	5.20 ± 2.35	5.79 ± 2.34	36.32 (<.001)
	-24 h	5.22 ± 2.00	5.27 ± 2.19	4.81 ± 1.85	4.12 ± 1.73	3.53 ± 1.85	3.97 ± 1.93	34.80 (<.001)
	-48 h	3.70 ± 2.14	3.96 ± 1.68	3.41 ± 1.57	3.09 ± 1.55	2.60 ± 1.54	2.91 ± 1.61	22.62 (<.001)
[a]Additional analgesics	Yes	23 (100.0)	41 (91.1)	256 (92.1)	270 (91.2)	693 (84.7)	1,283 (87.9)	(.001)
	No	0 (0.0)	4 (8.9)	22 (7.9)	26 (8.8)	125 (15.3)	177 (12.1)	
Nausea and vomiting	Yes	14 (60.9)	21 (46.7)	127 (45.7)	133 (44.9)	230 (28.1)	525 (36.0)	52.05 (<.001)
	No	9 (39.1)	24 (53.3)	151 (54.3)	163 (55.1)	588 (71.9)	935 (64.0)	
Dizziness	Yes	7 (30.4)	15 (33.3)	83 (29.9)	76 (25.7)	126 (15.4)	307 (21.0)	37.81 (<.001)
	No	16 (69.6)	30 (66.7)	195 (70.1)	220 (74.3)	692 (84.6)	1,153 (79.0)	
[a]Headache	Yes	0 (0.0)	5 (11.1)	7 (2.5)	11 (3.7)	12 (1.5)	35 (2.4)	(.004)
	No	23 (100.0)	40 (88.9)	271 (97.5)	285 (96.3)	806 (98.5)	1,425 (97.6)	
PCA usage (%)		59.43 ± 39.06	90.62 ± 22.36	93.85 ± 17.34	96.27 ± 13.61	96.02 ± 14.58	94.91 ± 16.53	31.34 (<.001)

Note. [a]Additional analgesics and headache were analyzed by the Fisher's exact test.
h = hours; M = mean; PCA = patient-controlled analgesia; SD = standard deviation; yrs = years.

Factors affecting PCA satisfaction by level of satisfaction: generalized ordinal logistic regression, open abdominal surgery

The factors affecting PCA satisfaction in open surgery patients have been presented in Table 4. In all steps, male participants were more likely to be at a higher satisfaction level than at the current satisfaction level at all steps. In other words, men were significantly and positively associated with satisfaction (coefficient = 0.30, $p = .025$). However, the total drug usage was not invariant across the three steps, and separate interpretations were required. Total drug usage was positively associated with satisfaction, and the coefficients were different for each cutoff point: 0.06, 0.04, 0.02, and 0.02. The total drug usage was associated with the likelihood of the respondent being at a higher satisfaction level. Effects of the total drug usage weakened when the satisfaction level moved from low to high; further, the largest effect was identified at step 1 (satisfaction level from 2 to 5 vs. 1). In steps 1 (coefficient = 0.31, $p = .037$) and 2 (coefficient = 0.24, $p = .017$), age was positively associated with satisfaction. In step 4, side-effects of nausea and vomiting were negatively associated with satisfaction (coefficient = −0.47, $p = .005$). In all steps, pain was negatively associated with satisfaction. Notably, the coefficients for pain reported at 6 hours after surgery were different for each cutoff point: −0.88, −0.45, −0.17, and −0.15. Pain present 6 hours after surgery was associated with the likelihood of the respondent being at a lower satisfaction level. The effects of 6 hours pain strengthened when the satisfaction level moved from high to low; further, the largest effect was identified in the first comparison of step 1. Therefore, the maximum level of pain reported at -6 hours after surgery affected satisfaction more in the low-satisfaction group, and step 1 had about six fold greater influence of pain level than step 4.

Factors affecting PCA satisfaction by level of satisfaction: generalized ordinal logistic regression, laparoscopic surgery

The factors affecting PCA satisfaction in laparoscopic surgery patients have been presented in Table 5. In all steps, age was positively associated with satisfaction (coefficient = 0.13, $p = .003$). The side-effects of nausea and vomiting (coefficient = −0.57, $p < .001$), dizziness (coefficient = −0.44, $p = .001$), and headache (coefficient = −0.71, $p = .027$) were negatively associated with satisfaction. In steps 1, 2, and 3, total PCA usage was positively associated with satisfaction, and the coefficients were different for each cutoff point: 0.07, 0.03, and 0.01. In all steps, pain was negatively associated with satisfaction. Notably, the coefficients for pain reported between -24 hours after surgery were different for each cutoff point: −0.37, −0.26, −0.23, and −0.14.

Table 4 *Results of Factors Affecting Patient-Controlled Analgesia (PCA) Satisfaction by Level of Satisfaction: Generalized Ordinal Logistic Regression, Open Abdominal Surgery (N = 2,409).*

Step	Variable	Coef.	SE	z	$p > \|z\|$	95% CI	
Step 1:	Sex (ref: women)	0.30	0.14	2.24	.025	0.04	0.57
2, 3, 4, 5	Age	0.31	0.15	2.09	.037	0.02	0.59
vs. 1	Total usage (%)	0.06	0.01	4.66	<.001	0.04	0.09
	AD (ref: no)	−0.49	0.25	−1.94	.052	−0.98	0.00
	PACU pain score	0.00	0.03	0.09	.929	−0.06	0.06
	-6 h pain score	−0.88	0.18	−4.89	<.001	−1.24	−0.53
	-24 h pain score	−0.17	0.05	−3.6	<.001	−0.27	−0.08
	-48 h pain score	−0.12	0.05	−2.38	.017	−0.21	−0.02
	N/V (ref: no)	0.80	0.54	1.47	.142	−0.27	1.87
	Dizziness (ref: no)	0.11	0.19	0.59	.558	−0.26	0.49
	Headache (ref: no)	−0.14	0.43	−0.33	.738	−0.99	0.70
Step 2:	Sex (ref: women)	0.30	0.14	2.24	.025	0.04	0.57
3, 4, 5	Age	0.24	0.10	2.39	.017	0.04	0.44
vs. 1, 2	Total usage (%)	0.04	0.01	3.94	<.001	0.02	0.06
	AD (ref: no)	−0.49	0.25	−1.94	.052	−0.98	0.00
	PACU pain score	0.00	0.03	0.09	.929	−0.06	0.06
	-6 h pain score	−0.45	0.09	−4.85	<.001	−0.63	−0.27
	-24 h pain score	−0.17	0.05	−3.6	<.001	−0.27	−0.08
	-48 h pain score	−0.12	0.05	−2.38	.017	−0.21	−0.02
	N/V (ref: no)	0.45	0.32	1.41	.159	−0.18	1.08
	Dizziness (ref: no)	0.11	0.19	0.59	.558	−0.26	0.49
	Headache (ref: no)	−0.14	0.43	−0.33	.738	−0.99	0.70
Step 3:	Sex (ref: women)	0.30	0.14	2.24	.025	0.04	0.57
4, 5	Age	−0.04	0.06	−0.62	.532	−0.15	0.08
vs. 1, 2, 3	Total usage (%)	0.02	0.01	2.32	.02	0.00	0.03
	AD (ref: no)	−0.49	0.25	−1.94	.052	−0.98	0.00
	PACU pain score	0.00	0.03	0.09	.929	−0.06	0.06
	-6 h pain score	−0.17	0.04	−3.81	<.001	−0.26	−0.08
	-24 h pain score	−0.17	0.05	−3.6	<.001	−0.27	−0.08
	-48 h pain score	−0.12	0.05	−2.38	.017	−0.21	−0.02
	N/V (ref: no)	−0.04	0.18	−0.24	.813	−0.38	0.30
	Dizziness (ref: no)	0.11	0.19	0.59	.558	−0.26	0.49
	Headache (ref: no)	−0.14	0.43	−0.33	.738	−0.99	0.70
Step 4:	Sex (ref: women)	0.30	0.14	2.24	.025	0.04	0.57
5	Age	0.02	0.05	0.34	.735	−0.09	0.13
vs. 1, 2, 3, 4	Total usage (%)	0.02	0.01	2.65	.008	0.01	0.04
	AD (ref: no)	−0.49	0.25	−1.94	.052	−0.98	0.00
	PACU pain score	0.00	0.03	0.09	.929	−0.06	0.06
	-6 h pain score	−0.15	0.04	−3.82	<.001	−0.23	−0.07
	-24 h pain score	−0.17	0.05	−3.6	<.001	−0.27	−0.08
	-48 h pain score	−0.12	0.05	−2.38	.017	−0.21	−0.02
	N/V (ref: no)	−0.47	0.17	−2.8	.005	−0.79	−0.14
	Dizziness (ref: no)	0.11	0.19	0.59	.558	−0.26	0.49
	Headache (ref: no)	−0.14	0.43	−0.33	.738	−0.99	0.70

Number of observations = 949; Log likelihood ratio Chi-square (22) = 244.95; Probability > Chi-square = 0.0000; Log likelihood = −1066.6169; Pseudo R^2 = 0.1030
Note. AD = Additional analgesics; Coef. = coefficient; CI = confidence interval; h = hours; N/V = nausea and vomiting; PACU = postanesthesia care unit; ref = reference; SE = standard error.

Discussion

The purpose of this study was to identify the factors affecting the satisfaction with PCA of patients who underwent open and laparoscopic abdominal surgery using a generalized ordinal logistic regression model and to evaluate the difference in results of the ordinal regression from those of binary regression. The key findings of this study have been detailed below. First, the factors affecting PCA satisfaction identified by generalized ordinal regression and binary logistic regression were different. Second, using generalized ordinal logistic regression, the factors affecting satisfaction differed with the level of satisfaction, and the factors were different for laparoscopic and open surgery patients.

When the factors affecting satisfaction were analyzed using generalized ordinal logistic regression, the factors associated with greater PCA satisfaction were less pain experienced during all time intervals, fewer side-effects, higher PCA drug usage, and patients who were older and male. These results are consistent with the results of previous studies on the satisfaction of pain management [5,12,13,16,17]. Svensson et al [5] reported that 50-year-old men who experienced severe pain had a 10% probability of being dissatisfied, whereas 50-year-old women who experienced severe pain had a greater than 40% probability of being dissatisfied. In this study, nausea and vomiting were side-effects that followed both open and laparoscopic surgeries, and these were negatively associated with PCA satisfaction. This finding is similar to previously reported results that fear of side-effects decreases the probability of being satisfied [17]. It has been reported that postoperative nausea and vomiting delay discharge and recovery as well as decrease the quality of life [23,24]. In particular, nausea and vomiting have been reported as serious side-effects that lead to patients refusing pain management [22]. Therefore, to increase patient satisfaction with postoperative pain management, healthcare providers should emphasize proper dosage control and management of the side-effects of narcotic analgesics.

Unlike generalized ordinal logistic regression, binary logistic regression analysis revealed fewer factors influencing satisfaction (in open surgery patients: age, PCA usage, pain score at -6 hours and -24 hours postoperatively, and dizziness; in laparoscopic surgery patients: PCA usage, pain score at -6 hours and -24 hours

Table 5 *Results of Factors Affecting Patient-Controlled Analgesia (PCA) Satisfaction by Level of Satisfaction: Generalized Ordinal Logistic Regression, Laparoscopic Abdominal Surgery (N = 2,409).*

Step	Variable	Coef.	SE	z	$p > \|z\|$	95% CI	
Step 1:	Sex (ref: women)	−1.09	0.56	−1.94	.053	−2.19	0.01
2, 3, 4, 5	Age	0.13	0.04	2.96	.003	0.04	0.22
vs. 1	Total usage (%)	0.07	0.01	6.46	<.001	0.05	0.08
	AD (ref: no)	−0.29	0.18	−1.60	.109	−0.65	0.07
	PACU pain score	−0.36	0.11	−3.21	.001	−0.57	−0.14
	-6 h pain score	−0.18	0.03	−5.72	<.001	−0.24	−0.12
	-24 hr pain score	−0.37	0.12	−3.02	.003	−0.61	−0.13
	-48 hr pain score	−0.09	0.04	−2.08	.038	−0.17	−0.01
	N/V (ref: no)	−0.57	0.12	−4.83	<.001	−0.80	−0.34
	Dizziness (ref: no)	−0.44	0.13	−3.38	.001	−0.70	−0.18
	Headache (ref: no)	−0.71	0.32	−2.21	.027	−1.34	−0.08
Step 2:	Sex (ref: women)	−0.15	0.29	−0.53	.596	−0.72	0.41
3, 4, 5	Age	0.13	0.04	2.96	.003	0.04	0.22
vs. 1, 2	Total usage (%)	0.03	0.01	4.96	<.001	0.02	0.04
	AD (ref: no)	−0.29	0.18	−1.60	.109	−0.65	0.07
	PACU pain score	−0.02	0.06	−0.40	.691	−0.14	0.09
	-6 h pain score	−0.18	0.03	−5.72	<.001	−0.24	−0.12
	-24 h pain score	−0.26	0.08	−3.50	<.001	−0.41	−0.12
	-48 h pain score	−0.09	0.04	−2.08	.038	−0.17	−0.01
	N/V (ref: no)	−0.57	0.12	−4.83	<.001	−0.80	−0.34
	Dizziness (ref: no)	−0.44	0.13	−3.38	.001	−0.70	−0.18
	Headache (ref: no)	−0.71	0.32	−2.21	.027	−1.34	−0.08
Step 3:	Sex (ref: women)	−0.22	0.14	−1.58	.114	−0.49	0.05
4, 5	Age	0.13	0.04	2.96	.003	0.04	0.22
vs. 1, 2, 3	Total usage (%)	0.01	0.00	3.52	<.001	0.01	0.02
	AD (ref: no)	−0.29	0.18	−1.60	.109	−0.65	0.07
	PACU pain score	0.01	0.03	0.22	.827	−0.06	0.07
	-6 h pain score	−0.18	0.03	−5.72	<.001	−0.24	−0.12
	-24 h pain score	−0.23	0.05	−5.05	<.001	−0.32	−0.14
	-48 h pain score	−0.09	0.04	−2.08	.038	−0.17	−0.01
	N/V (ref: no)	−0.57	0.12	−4.83	<.001	−0.80	−0.34
	Dizziness (ref: no)	−0.44	0.13	−3.38	.001	−0.70	−0.18
	Headache (ref: no)	−0.71	0.32	−2.21	.027	−1.34	−0.08
Step 4:	Sex (ref: women)	0.03	0.12	0.29	.776	−0.20	0.27
5	Age	0.13	0.04	2.96	.003	0.04	0.22
vs. 1, 2, 3, 4	Total usage (%)	0.01	0.00	1.53	.126	0.00	0.01
	AD (ref: no)	−0.29	0.18	−1.60	.109	−0.65	0.07
	PACU pain score	0.01	0.03	0.41	.682	−0.05	0.07
	-6 h pain score	−0.18	0.03	−5.72	<.001	−0.24	−0.12
	-24 h pain score	−0.14	0.04	−3.38	.001	−0.22	−0.06
	-48 h pain score	−0.09	0.04	−2.08	.038	−0.17	−0.01
	N/V (ref: no)	−0.57	0.12	−4.83	<.001	−0.80	−0.34
	Dizziness (ref: no)	−0.44	0.13	−3.38	.001	−0.70	−0.18
	Headache (ref: no)	−0.71	0.32	−2.21	.027	−1.34	−0.08

Number of observations = 1,460; Log likelihood ratio Chi-square (22) = 337.05; Probability > Chi-square = 0.0000; Log likelihood = −1490.8586; Pseudo R^2 = 0.1016
Note. AD = Additional analgesics; Coef. = coefficient; CI = confidence interval; h = hours; N/V = nausea and vomiting; PACU = postanesthesia care unit; ref = reference; SE = standard error.

postoperatively, and headache). Especially, in the open surgery patients, dizziness was associated with an approximately three-fold increase in the probability of satisfaction (OR: 3.23, 95% CI: 1.08–9.62). These results differed from those of previous studies as well as from the results obtained from generalized logistic regression in this study. In addition, it is well known that postoperative nausea and vomiting are the most reported adverse effects, and they affect satisfaction [25]. However, there were no significant effects of nausea and vomiting in the results of binary logistic regression in this study. Logistic regression analysis gave erroneous results for patient satisfaction. However, the results of ordinal regression analysis were representative of real-world observations and provided more detailed characteristics of PCA satisfaction. It seems that there was loss of information when five levels of satisfaction were compressed into only two levels: “satisfaction” and “dissatisfaction”. This was done without using an appropriate cutoff point and disregarding the effect of factors on satisfaction at each level. In nursing research, ordinal data should be analyzed with appropriate statistical methods to understand real-world phenomenon.

In this study, we were able reduce the loss of information by using a generalized logistic regression model and concluded that the factors affecting satisfaction with PCA were different for the two types of surgeries (open or laparoscopic). In patients who underwent open surgery, when the statistical results of steps 1 and 2 were analyzed, we observed that at only low satisfaction levels, older patients showed greater satisfaction with PCA. Additionally, when the statistical results of step 4 were analyzed, at only high satisfaction levels, nausea and vomiting affected satisfaction. The group with high satisfaction reported low pain in this study. In other words, in a highly satisfied group, in which pain was relatively well controlled, age did not affect the degree of satisfaction, and nausea and vomiting were the factors that influenced satisfaction. In contrast, in laparoscopic surgery patients, age, nausea and vomiting, headache, and dizziness affected the satisfaction in all steps. The magnitude of influence was the same at all satisfaction levels, possibly because pain is generally well-controlled after laparoscopic surgery [26]. Factors other than pain appear to affect satisfaction in all satisfaction groups after laparoscopic surgery, particularly the high incidence of postoperative nausea and

vomiting [27]. PCA-related side-effects may aggravate nausea and vomiting after laparoscopic surgery and decrease patient satisfaction with PCA.

Using a generalized logistic regression model in this study, it was found that the impact of pain was different at different levels of satisfaction. The magnitude of the influence of pain on satisfaction was higher in the group with lower satisfaction than in the group with higher satisfaction. In particular, the pain level reported at 6 hours after open abdominal surgery affected PCA satisfaction more in the group with low satisfaction. This result appears to be consistent with previous studies that found postoperative pain following open surgery to be greatest at 6 hours after surgery [28]. Therefore, pain management in the first 6 hours after surgery is important for patients undergoing open surgery.

Unlike open surgery, in laparoscopic surgery patients, the magnitude of the influence of pain -24 hours after surgery on PCA satisfaction was greater in the group with lower satisfaction than in the group with higher satisfaction. Patients who undergo laparoscopic abdominal surgery tend to return to ambulation earlier than patients who have open surgery [29], and it appears that the inverse association of degree of pain during -24 hours after laparoscopic surgery with PCA satisfaction was related to ambulation in our study. In previous studies, patients experienced the greatest degree of postoperative pain when moving from the bed or during exercise [18]. In laparoscopic surgery patients, intensive pain assessment and management may be necessary even if the patient does not indicate pain on ambulation.

Implications for clinical practice

This study has two main implications for patient satisfaction with PCA using generalized logistic regression model. First, postoperative pain management was the most significant factor influencing reported satisfaction with PCA. Second, the factors affecting PCA satisfaction and the magnitude of influence of these factors were different at different levels of PCA satisfaction.

Overall, the most important factor for improving patient satisfaction with PCA was degree of reported pain, whereas other factors influenced satisfaction in the group where pain was well-controlled. Because younger patients and women had lower satisfaction with PCA in this study, special considerations for younger female patients may be advisable when developing improved pain management protocols. Nonpharmacological pain interventions are effective [30], and pain management protocols for open abdominal surgery patients should include not only pharmacological management but also nonpharmacological pain interventions. In addition, nursing staff should prioritize pain management in open surgery patients. Conservative treatments such as acupressure have been proven to be effective in preventing nausea and vomiting [31]. Therefore, patients with well-controlled pain after laparoscopic surgery might report greater satisfaction with PCA, if nursing care is combined with conservative treatment and prophylactic use of antiemetic drugs.

Ordinal data are often used in the analysis of satisfaction and disease staging [11,15], but ordinal logistic regression has rarely been used because of the difficulty of conducting such analyses. However, a generalized logistic regression model can be used to identify other influencing factors at each level and to assess the magnitude of their influence. In this study, the researchers found that it is important to control pain for -6 hours postoperatively in open abdominal surgery patients and to control pain at -24 hours postoperatively in laparoscopic surgery patients. Therefore, open surgery patients should receive frequent pain assessment and preventive pain medications [32]. They should also be advised to frequently use PCA up to 6 hours after surgery. On the other hand, laparoscopic surgery patients should be given additional preventive analgesics prior to ambulation, and nurses should educate the patients about PCA usage before ambulation. Patient satisfaction with postoperative pain management may increase by identifying the magnitude of their effect as well as the factors impacting satisfaction with PCA, and applying the findings to pain management policy.

Limitations

This study has certain limitations. First, even though the analyses are stratified based on the type of abdominal surgery (open and laparoscopic), other surgery-related variables such as surgery type and surgeon were different and not considered. Second, although only the patients who received PCA by intravenous administration were included, the regimens were not necessarily the same for all patients. Consequently, the degree of pain management may have been different even for patients who underwent the same type of surgery. In addition, the researchers did not control for pain management methods used during surgery. Third, although nonpharmacological pain interventions that could affect patient satisfaction might have been provided after surgery, they were not included among the variables used in our regression analyses. Finally, this study did not control for cancer-related patient characteristics even though they might affect the experience of pain. These limitations may be addressed in further studies to confirm the results of PCA satisfaction in this population.

Conclusion

This study analyzed PCA satisfaction using both a generalized ordinal logistic regression model and binary logistic regression model. Comparing the two methods, it was found that ordinal data should be analyzed in an ordinal logistic regression to draw conclusions without loss of information. In the generalized ordinal logistic model, it was possible to analyze the factors affecting satisfaction with PCA and the magnitude of these factors at each level. Therefore, the results of this study may be used to improvement satisfaction with PCA by customizing nursing services to patient characteristics and surgical procedures. Pain is the most important factor in patient-reported satisfaction with PCA, but patient satisfaction with postoperative pain management is complex and does not depend solely on pain intensity [33]. Patient satisfaction with postoperative PCA may be improved by adjusting various environmental factors such as amount and intensity of ambulation, side effects, and PCA usage.

Conflict of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.anr.2020.03.001.

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