Factors Affecting Unused Remaining Volume of Intravenous Patient-controlled Analgesia in Patients Following Laparoscopic Gynecologic Surgery

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Summary

Purpose: This study was undertaken to evaluate the factors affecting the unused remaining volume of intravenous patient-controlled analgesia (IV PCA) in patients who had undergone laparoscopic gynecologic surgery.

Methods: We retrospectively collected patient records from pre-existing PCA log sheets from 98 patients. Surgical factors and IV PCA-related data including remaining volume, administration duration, early discontinuation (yes or no), and adverse reactions were recorded. Chi-square test, one-way analysis of variance, and multiple linear regression were applied for data analysis.

Results: The average age of the 98 patients was 40.0 ± 8.24 years. The incidence of postoperative nausea and vomiting (PONV) and early discontinuation were not statistically significant among the different surgical groups (p = .540 and p = .338, respectively). Twenty-eight patients wanted discontinuation of IV PCA and the remaining volume was 33.6 ± 7.8 mL (range 20–55 mL). The significant determinants of remaining volume were whether IV PCA was discontinued due to PONV and duration of surgery (p < .001). The surgical duration was inversely correlated with the remaining volume.

Conclusion: Early discontinuation of IV PCA due to PONV is a major contributing factor to wastage of medicine. Prevention and treatment of PONV is needed to encourage patients to maintain PCA use for pain control.

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Introduction

Patient-controlled analgesia (PCA) allows patients to administer their own supplemental analgesics to relieve postoperative pain. Sechzer (1990) developed and introduced PCA in the 1970s. Then, effectiveness and management of PCA have been extensively discussed in the literature (Bollish, Collins, Kirking, & Bartlett, 1985; Hudcova, McNicol, Quah, Lau, & Carr, 2006). Since its introduction, PCA has become the mainstay of postoperative pain management strategy.

One frequently mentioned benefit of PCA is that it saves nursing time spent on analgesia-related activities, thus creating extra time for other duties (Koh & Thomas, 1994). On the other hand, nurses take the main responsibility for monitoring the adverse effects of PCA. Chan, Chung, McQuestion, and Gomez (1995) reported the significant amount of time saved was offset by the total extra time spent on hourly patient monitoring and flow sheet recording of drug consumption and patient response. Opioids are the most effective drugs for moderate-to-severe postoperative pain relief and the main analgesics for PCA. The distribution of opioids is tightly regulated to prevent illegal diversion and abuse (Korea Ministry of Government Legislation, 2011). Anesthesiologists are primarily accountable for the prescription and administration of PCA to surgical patients, as well as for the proper disposal of any unused opioids. However, widespread prescription of potent opioids for PCA along with the increasing use of PCA beyond the operating theater has increased the volume of opioids that require disposal at wards and has extended the responsibility for the safe disposal of unused drugs to nurses.

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Although many studies have investigated the relationship between patient characteristics or surgical characteristics and analgesic consumption, we could not find a report addressing the wastage issue with PCA. Patient weight and site of surgery have been known to influence total PCA requirements (Chang, Tsou, Chan, Sung, & Chang, 2006). In addition, it has been reported that intravenous PCA (IV PCA) morphine intake was higher in younger patients and increased morphine use was also associated with surgical procedure and duration (Gagliese, Gauthier, Macpherson, Jovellanos, & Chan, 2008).

Unused medication is a waste of resource and increases the chance of its illegal diversion, in case of opioids (Herring, Shah, & Gupta, 2008). In this regard, it is necessary to identify influential factors on analgesic consumption to minimize wastage of analgesics, especially opioids.

Our hypotheses were as follows: First, the extent of surgical injury would be the main factor that determines the remaining volume in laparoscopic gynecologic surgery because evidence suggests that the site or type of surgery is well correlated with analgesic consumption in PCA use (Chang et al., 2006; Yen et al., 2010). Second, premature discontinuation would also affect the remaining volume because PCA is occasionally aborted and switched to intermittent analgesic administration due to adverse reactions such as postoperative nausea vomiting (PONV), dizziness, and urinary retention (Momeni, Crucitti, & De Kock, 2006).

The objective of this study is to identify factors affecting the unused remaining volume of IV PCA in patients following laparoscopic gynecologic surgery, and ultimately to contribute to efficient utilization of human and material resources.

Methods

Study design

This is a retrospective study designed to find out major contributing factors that determine the unused remaining volume of IV PCA.

Setting and samples

The present study included 98 patients, 18–65 years old, who received IV PCA prepared with morphine and ketorolac following laparoscopic gynecologic surgery from September 2011 to February 2012. We collected data from a total inspection to illustrate a clear picture of PCA remaining volume and other predictors after laparoscopic gynecologic surgery. Therefore, we did not estimate minimum sample size. Pace (2008) recommended that the sample size be limited to the prevention of selecting falsely positive predictors. A regression model is likely to be reliable when the number of influential variables, which could determine the unused remaining volume of IV PCA in patients following laparoscopic gynecologic surgery (Harrell, 2001).

A total of 134 patient records were obtained from pre-existing PCA log sheets. After discarding incomplete PCA log file with missing remaining volume record, we collected 98 patients records.

Data analysis

SPSS (version 20.0; IBM SPSS Statistics, Chicago, IL, USA) was used for statistical analysis and a p value less than .05 was considered statistically significant.

General characteristics of the patients in the four groups were expressed as mean and standard deviation for continuous variables, and absolute number and percentage for discrete variables. Age, weight, surgical duration, remaining volume, and duration of IV PCA administration in the four groups were analyzed with one-way analysis of variance. The incidence of PONV and early discontinuation among different surgical groups were analyzed with chi-square test.

Linear model using stepwise variable selection method was applied to find out influential variables, which could determine the unused remaining volume of IV PCA. Inclusion criteria and exclusion criteria were set at a significance level of .05 and .10, respectively. The variables used for model selection were age, weight, surgical duration, type of surgery, and early discontinuation (yes or no).

Results

Patient characteristics, surgical factors and IV PCA-related variables with different surgical groups

The average age of the 98 patients was 40.0 ± 8.24 years (range 21–58 years). The length of surgery, patients’ age and duration of IV
PCA administration were statistically significant between distinct surgical procedures \((p < .001, p < .001, p = .017\) respectively). The incidence of PONV and early discontinuation were not statistically significant among the different surgical groups \((p = .540, p = .338\) respectively; Table 1).

Factors affecting remaining volume of IV PCA

The remaining volumes of IV PCA were 23.4 ± 14.5 mL in the single cystectomy group, 14.4 ± 17.7 mL in the complicated cystectomy group, 19.5 ± 13.6 mL in the myomectomy group and 12.1 ± 13.8 mL in the total hysterectomy group. Twenty-eight patients wanted discontinuation of IV PCA and the remaining volume was 33.6 ± 7.8 mL \((\text{range } 20–55 \text{ mL})\). The remaining volume with the other 70 patients who used IV PCA until the pain subsided was 11.5 ± 12.1 mL \((\text{range } 0–40 \text{ mL})\).

Linear model using stepwise variable selection method was applied to find out influential variables, which could determine the unused remaining volume of IV PCA. In the overall analysis, early discontinuation of IV PCA due to PONV and duration of surgery were significant determinants of remaining volume \((p < .001)\, \text{and} \, \text{surgery type and age were excluded (Table 2).}\)

Prediction of the remaining volume is accomplished by the following equation:

\[
Y = 20.98 - X_1 - 0.043 \cdot X_2 + 18.08
\]

Where \(Y\) refers to the remaining volume \((\text{mL})\), \(X_1\) is 0 if IV PCA is kept, or it is 1 if IV PCA is discontinued, and \(X_2\) refers to surgical duration \((\text{minute})\).

The duration of operation was inversely correlated with remaining volume. An increase of 1 minute in surgical duration reduced the remaining volume by 0.04 mL.

Discussion

This present study evaluated factors affecting the unused remaining volume of IV PCA. We confined the cases to patients who received same PCA regimen following laparoscopic gynecologic surgery to ensure comparability of the remaining volume, our primary interest.

Among the variables that are known to affect analgesic consumption, only patient weight was similar. Other variables such as surgical duration and patient age were different between distinct surgical groups. Dissimilarity in age reflects difference in affected age with each involved disease: the patient with ovarian cyst is younger than those with myoma \((\text{Hillard, 2012})\). Previous studies concluded age as a significant predictive factor for postoperative pain; age was separated into the younger \((<60\text{ years old})\) and older \((\geq 60\text{ years old})\) groups \((\text{Gagliese et al., 2008; Yen et al., 2010})\). The age range of this study \((21–58\text{ years})\) was not large enough to show a significant difference. Heterogeneity in surgical duration was anticipated from the beginning since the groups were categorized according to surgical invasiveness. Generally, extensive surgeries take longer, cause more postoperative pain and require prolonged PCA use \((\text{Ip, Abrishami, Peng, Wong, & Chung, 2009})\).

We initially postulated that the extent of surgical injury would be the key factor which determined remaining volume because evidence suggests that the site or type of surgery is well correlated with analgesic consumption in PCA use \((\text{Chang et al., 2006; Yen et al., 2010})\). However, early discontinuation of IV PCA, not the invasiveness of operation was found to be a significant predictor for remaining volume of IV-PCA in our study population.

Previous studies regarding PCA have addressed mainly the relationship between patient or surgical variables and PCA analgesic consumption \((\text{Chang et al., 2006; Gagliese et al., 2008; Yen et al., 2010})\). In this study, we discovered that substantial portions of prescribed PCA were discarded since patients requested their infusion to be stopped due to PONV. PONV is the most common adverse effect seen with opioid-based PCA \((\text{Momeni et al., 2006})\) and is the leading cause of discontinuation of IV PCA \((\text{Masada et al., 2013})\). We found that 75% of patients suffered from PONV and one third of them requested discontinuation of PCA. On average, more than half of the medication was discarded in this group, which was about three times the amount as that of the remaining patients who used PCA until pain subsided. High incidence of PONV was not surprising \((\text{Lee et al., 2012})\) in this surgical population since our PCA regimen did not include prophylactic antiemetic. However, the high rate of premature termination of IV PCA is alarming compared to a previous study, which reported IV PCA discontinuation in 8.2% of patients \((\text{Ishikawa et al., 2011})\). These results suggest that the effort should be made to reduce medical waste of IV PCA. This could be accomplished by preventing early discontinuation of PCA. As postoperative opioid use is one of the four independent predictive factors of postoperative nausea and vomiting \((\text{Apfel, Laara, Koivuranta, Greim, & Roewer, 1999})\), antiemetic combinations are recommended to the patients who receive opioid-based IV PCA \((\text{Gan et al., 2007})\). Prophylactic antiemetic strategies may be considered utilizing IV PCA as a method of postoperative analgesia without discontinuation in this high-risk population \((\text{Lee et al.; Tsui et al., 1999})\).

The nurse plays an important role in managing PCA at wards. While PCA is in use, they regularly check the patient’s vital signs, level of pain, and any signs of adverse reactions. Also, it has been suggested that patients receiving the proper education on the use of a PCA preferred keeping their PCA in the presence of adverse reaction \((\text{Hong & Lee, 2012})\). Therefore, perioperative nurses can make significant contributions to efficient PCA use by responding properly to adverse effects of PCA and delivering structured education program.

The duration of operation was also associated with remaining volume. The impact of surgical duration on remaining volume was much lesser than that of discontinuation of IV PCA. An increase of 60 minutes in surgical duration only decreased the remaining

<table>
<thead>
<tr>
<th>Table 1 Patient Characteristics, Surgical Factors and IV PCA Related Variables with Different Surgical Groups.</th>
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<tr>
<td>Simple cystectomy(^a)</td>
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<td>---------------------</td>
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<tr>
<td>Age (year) ((\text{n = 27}))</td>
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<td>Weight (kg) ((\text{n = 27}))</td>
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<td>The length of surgery (minute) ((\text{n = 27}))</td>
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<td>Duration of IV PCA administration (hour) ((\text{n = 27}))</td>
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<td>Nausea or vomiting, (n (%)) ((\text{n = 27}))</td>
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<tr>
<td>Early discontinuation (n (%)) ((\text{n = 27}))</td>
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</table>

\(^a\) Values are presented as \(M ± SD\).

Note: IV PCA = intravenous patient-controlled analgesia.
volume by 2.6 mL but the discontinuation of IV PCA increased the remaining volume by 21 mL. Furthermore, surgical duration cannot be controlled or predicted. It is therefore unfeasible to adjust volume of IV PCA to duration of procedure in advance.

In this study, surgical extent has no effect on analgesic consumption, which makes it inconsistent with previous results. In the study by Chang et al. (2006), gynecologic patients consumed the least morphine compared with other surgical groups. In addition, it has been reported that laparoscopic surgery reduces postoperative pain compared with conventional open surgery (Holzer, Jirecek, Illievich, Huber, & Wenzel, 2006; Kozol et al., 1997). Taken together, it is reasonable to assume that the extent of surgical injury during laparoscopic gynecologic surgery does not significantly affect postoperative analgesic consumption. However, this study is not well controlled due to its retrospective nature. Well-controlled prospective study that excludes early discontinuation cases is needed to evaluate the accurate relationship between the extent of the surgical approach and analgesic consumption.

Recently, because of the increasing public interest on drug abuse in health care personnel, the careful inventory of drugs with a high potential for abuse has become a major issue (Ahmed & Majeeed, 2007; Herring et al., 2008). To prevent illegal diversion, it is recommended that any leftover opioid from PCA should be returned to the pharmacy with proper documentation. Although the regulation regarding disposal of controlled substance has been strictly applied in anesthetic practice, by comparison we anesthesiologists were lax regarding disposal of controlled substances.

There are several limitations in this study including its retrospective design, small sample size and high rate of premature discontinuation of IV PCA. The result should be interpreted in context. In addition, PCA regimens vary from one institution to another, depending on a variety of practice settings. In our study, only patients who received IV PCA in this specific study period were included. As such, conclusions are limited to this segment of the surgical population. Well-controlled prospective study with validated sample size is needed to identify factors, which determine the unused remaining volume of IV PCA.

Conclusion

Early discontinuation of IV PCA due to PONV is a major contributing factor to the amount of an unused remaining volume in patients following laparoscopic gynecologic surgery.

Although prospective studies are needed to assess the effect of patient education and prevention of PONV on wastage reduction, perioperative nurses could play an important role in reducing the remaining volume of PCA by responding properly to side effects and providing structured education program. Prophylactic anti-emetic combinations should be considered to prevent premature discontinuation of IV PCA in this high-risk population.

Conflict of interest

The authors declare no conflict of interest.

References


