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An Anesthesia Quality Improvement Project to Improve Postoperative Pain Outcomes After Hysterectomy

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Abstract

An anesthesia quality improvement initiative implemented an evidence-based, preemptive, preventive multimodal analgesic regimen to improve perioperative pain outcomes for women undergoing hysterectomy. Although statistical significance was not achieved, clinically significant decreases in post-anesthesia care unit (PACU) narcotic usage, pain ratings, time in the PACU, and opioid-related side effects were observed. This analgesic regimen was easily implemented, readily modifiable, and suitable for expansion to multiple surgical populations to supplement customary anesthesia perioperative care.

INTRODUCTION

Background

Each year, over 100 million inpatient and outpatient surgeries occur,[1,2] with over 80% of these patients complaining of postoperative pain.[3] Eighty-six percent of these patients will describe their pain as moderate, severe, or extreme.[3] Ineffective control of pain after surgery prevents early mobilization, increases side effects related to treatment, lengthens post-anesthesia care unit (PACU) stay, increases hospital admission rates, delays discharge home, and decreases patient satisfaction.[4,5] The effect on health care costs is dramatic. Hospital stays in the United States cost $1960 per day, on average.[6] Poor early postoperative pain management not only increases a patient's length of stay but is reported to be a primary cause of chronic pain,[7] now costlier on an annual basis than treatment of cancer, heart disease, or diabetes.[8] Moreover, opioids, the mainstay of postoperative pain management,[9] have demonstrated efficacy but their use potentially contributes to these escalating costs. Oderda et al[4] demonstrated that 2.7% of patients experience an opioid-related adverse event resulting in significant increases in length of stay (0.53 days) and an additional $840 in hospital costs per event.

Postoperative pain is nondiscriminatory, affecting patients across the surgical spectrum. However, women who undergo hysterectomies are a uniquely vulnerable population. Each year, 500,000 hysterectomies are performed in the United States, making this the second most common major surgery for women.[10] Minimally invasive techniques, such as vaginal or laparoscopic hysterectomies, have been shown to decrease overall complication rates, the length of hospital stay, and pain, when compared with abdominal hysterectomy.[11] Nevertheless, high ratings of pain occur even when minimally invasive techniques are used, with patients rating their pain as moderate to severe.[12,13]

An ideal anesthesia analgesic regimen is safe, inexpensive, rapidly administered, and effective.[14] Unfortunately, effective analgesic techniques, such as epidurals or spinals, carry intrinsic risks, are time-intensive, require special postoperative monitoring, and do not always appeal to patients.[5] The American Association of Nurse Anesthetists (AANA) Standards for Nurse Anesthesia Practice[15] and the American Society of Anesthesiologists (ASA) *Practice Guidelines for Acute Pain Management in the Perioperative Setting*[16] recommend utilization of preemptive,[15] multimodal[15,16] pain management regimens when possible. Preemptive analgesia is the administration of an analgesic prior to noxious stimuli with the goal of decreasing acute pain upon insult and decreasing pain-related modulation of the central nervous system, thereby inhibiting postoperative pain.[17] Multimodal analgesia is the administration of 2 or more different agents that act by different mechanisms to provide better analgesia than single modalities and minimize analgesic-associated side effects.[8] This quality improvement project was undertaken to implement an evidence-based, preemptive, multimodal analgesic regimen to improve perioperative pain management outcomes in patients undergoing hysterectomy in a local setting where 5 to 10 hysterectomies are performed monthly.

Local Problem

Between June 2014 and September 2014, at the author's local institution, data were prospectively collected on 25 consecutive hysterectomies demonstrating that women undergoing hysterectomies experience moderate to severe postoperative pain. Data collected included (1) the amount of analgesics (morphine equivalents) administered in the PACU, (2) pain ratings every 15 minutes (on an 11-point numeric rating scale, a validated pain assessment tool,[18] with 1-3 indicating mild pain, 4-6 moderate pain, and 7-10 severe pain), (3) the incidence of opioid-related adverse events, and (4) time spent in the PACU. The median time in the PACU was 72 minutes, determined by PACU admission time until discharge criteria were achieved, and the total median analgesic dose administered in the PACU, in morphine equivalents, was 7.5 mg. Opioids administered during the data collection period were exclusively fentanyl, morphine, and hydromorphone. A median pain rating of 5 was reported on admission, 6 after 15 minutes, 5 after 30 minutes, 5.5 after 45 minutes, and 5 after 60 minutes. No preemptive analgesia was observed and 20% of these patients had analgesic regimens that were non-multimodal and consisted entirely of opioids. The incidence of opioid-related adverse events was 20%, with 4 patients complaining of nausea and 1 patient experiencing respiratory depression.

Intended Improvement

This quality improvement project aimed to utilize a preemptive, multimodal analgesic regimen for 100% of patients undergoing hysterectomy to decrease postoperative opioid use, opioid-related adverse events, PACU pain scores, and time in the PACU.

Quality Improvement Question

The primary question addressed was, "In women undergoing hysterectomy, will the addition of an evidence-based preemptive analgesic regimen improve pain control, decrease the requirement for opioid pain medications, decrease opioid-related adverse events, and decrease the time spent by patients in the PACU compared to customary analgesic regimens?"

METHODS

Ethical Issues

No protected health information was logged for this project. All data were retrieved from the patient's electronic medical record on the day after surgery and recorded in an SPSS (IBM Corp) dataset for analysis. The data collected during this quality improvement project did not include information that would allow any person to identify the participants. The SPSS dataset was saved on a Department of Defense secure server in a password-protected folder.

The project was submitted to the local Institutional Review Board (IRB) for a quality improvement study determination and did not satisfy the definition of "research" under US Code of Federal Regulations 32 CFR 219.[19] The IRB application stated the project was aimed at "improving local systems of care utilizing an accepted multimodal approach to perioperative analgesia in accordance with practice guidelines" (M Abel, unpublished memorandum, April 1, 2014). Subsequent to local IRB determination, the project was also submitted to the Duke University IRB, which concurred with the local determination.

Setting

The setting was a military treatment facility located in the southwestern United States serving over 100,000 beneficiaries who receive care within the military health system. Beneficiaries of this military health system include all age groups and consist primarily of active duty service members and families, National Guard/Reserve members, and retired service members and families.[20] The surgical department comprised 10 operating rooms, encompassing approximately 800 surgeries per month, of which 5 to 10 were hysterectomies performed by the obstetrical-gynecological surgical service (E Leiter, personal communication, March 20, 2014). The anesthesia staff consisted of 23 certified registered nurse anesthetists (CRNAs) and 9 physician anesthesiologists.

Planning the Intervention

The analgesic regimen instituted consisted of preoperative administration of 600 mg oral gabapentin and 1 g intravenous (IV) acetaminophen. The regimen was derived from the ASA Practice Guidelines for Acute Pain Management in the Perioperative Setting recommendations,[16] the AANA Standards for Nurse Anesthesia Practice,[15] a review of the literature, and anesthesia staff experience with multimodal regimens in other institutions similar to the author's. There was much discussion on whether to utilize oral versus IV acetaminophen. Owing to a lack of evidence comparing the 2 routes, we selected the IV formulation secondary to the varied absorption rates of oral acetaminophen prior to surgery,[21] increased peak plasma levels of IV acetaminophen,[22] increased cerebral spinal fluid levels of IV acetaminophen,[22] and the preference for IV over oral by our anesthesia providers.

The sample and inclusion criteria consisted of (1) patients scheduled for hysterectomy (total laparoscopic, laparoscopic assisted, vaginal, or transvaginal), (2) 20-55 years of age, and

(3) physical status score of I-III, representing patients without severe systemic disease processes. Exclusion criteria consisted of (1) hypersensitivity to gabapentin or acetaminophen, (2) renal insufficiency, or (3) liver disease. No patients were required to be excluded. Patients were identified 5 days prior to surgery via the operating room schedule. On the day of surgery, patients followed the normal protocol, arriving at the hospital at least 2 hours in advance of their surgery. Upon arrival to the preoperative holding area, approximately 1 hour before the start of surgery, the patient received 600 mg gabapentin with a small sip of water, administered by the preoperative holding area nurse or anesthesia staff. Approximately 30 minutes prior to the start of surgery, 1 g IV acetaminophen was administered over 15 minutes. The administration of IV acetaminophen and gabapentin at these times was important, as their respective peak effects coincided with the onset and cessation of the surgery, respectively. Any additional analgesics required were determined in the customary way by the assigned anesthesia provider to that surgical case. Assessment in the PACU was done in standard PACU fashion (pain assessments, pain interventions, and traditional modified Aldrete scoring every 15 minutes) with no additional assessments required by the PACU staff.

Planning the Study of the Intervention

The project aimed to improve postoperative analgesic outcomes following hysterectomy. Analysis of the outcomes consisted of a pre/post design with a period of pre-implementation (customary analgesic regimens) data collection, a period of instruction to applicable staff (surgeons, anesthesia providers, PACU nurses) regarding implementation of the quality improvement project, and a period of post-implementation (preemptive multimodal regimen of IV acetaminophen and gabapentin supplemented by our customary analgesic regimens) data collection. Quantitative data collected by the PACU nurses for every hysterectomy patient in the recovery room were used to evaluate the aims. Additionally, age, weight, duration of surgery, type of hysterectomy, and the presence of preoperative chronic pain were collected as baseline variables. These items were predetermined by the gynecological and anesthesia staff as possible variables that could affect the outcomes independent of the analgesic regimen.

Methods of Evaluation

Data evaluating the aims of this project were collected directly from the patient's chart by the author and input into an SPSS dataset on the day after surgery. Prior to data collection, the author analyzed the patient's electronic medical record and ensured the designated regimen had been performed in the proposed manner. Primary outcomes were reflective of the aims of the project, whereas secondary outcomes provided additional analysis. Primary outcomes were (1) pain assessment on admission to the PACU, and at each 15-minute subsequent assessment, using an 11-point verbal rating scale; (2) PACU total opioid use converted to morphine equivalents; (3) time from PACU admission to the time at which criteria were met for discharge; and (4) absence or presence of opioid-related adverse events defined as nausea, vomiting, respiratory depression, dizziness, or sedation. The secondary outcomes were (1) intraoperative opioid use converted to morphine equivalents; (2) time from the end of surgery to removal of the endotracheal tube (extubation); and (3) time to first analgesic administration in the PACU.

Analysis

The aims of this project were to improve analgesic outcomes as evidenced by decreased opioid administration, pain ratings, opioid-related adverse events, and time in the PACU. Descriptive statistics were used to summarize the data and comparisons were made between the pre-implementation and post-implementation groups to determine if the aims were achieved. We further compared the groups by using inferential statistics, as determined by the distribution of the data and assumptions of proposed statistical tests. For interval and ratio level data that met assumptions, a two-tailed independent t-test was utilized (time in the PACU). Mann-Whitney U tests were conducted if assumptions were not met (PACU morphine equivalents, pain ratings). Categorical secondary outcomes (absence or presence of opioid-related adverse events) were analyzed by using Pearson's chi-squared test. Relationships between variables were further investigated by using a Pearson or Spearman's correlation. Analysis was executed by using SPSS Statistics version 21 (IBM Corp).

RESULTS

Outcomes

There were no significant differences in baseline characteristics between the pre- and post-implementation groups. Each group was similar in age, weight, duration of surgery, preexisting chronic pain, and type of hysterectomy (Table 1).

Table 1. Baseline Characteristics of the Groups[a]

	Pre-QI Implementation Data (n= 25)	Post-QI Implementation Data (n=25)	P Value
Age, years (± SD)	39.32 ± 6.16	41.16 ± 7.69	0.36
Weight, kg (± SD)	86.08 ± 18.37	79.34 ± 17.61	0.19
Duration of surgery, min	103	110	0.15
Preexisting chronic pain (yes/no)	1/24	5/20	0.19
Type of hysterectomy, trans/TVH/TLH/ LAVH (number of each performed)	5/17/1/2	7/15/1/2	0.93

Abbreviations: LAVH, laparoscopically assisted vaginal hysterectomy; QI, quality improvement; TLH, total laparoscopic hysterectomy; trans, transvaginal hysterectomy; TVH, total vaginal hysterectomy.

[a]The pre-implementation group did not receive preoperative gabapentin and IV acetaminophen. The post-implementation group received 600 mg preoperative gabapentin and 1 g IV acetaminophen. There were no significant differences between the pre-implementation and post-implementation groups.

Compared with patients in the pre-implementation group, patients in the preoperative gabapentin and IV acetaminophen group showed improvements in all primary outcomes and in all but one of the secondary outcomes (Table 2). PACU analgesics in morphine equivalents were reduced 33%, and time in the PACU (minutes) was reduced by 13%. In both groups, the opioids utilized were exclusively fentanyl, morphine, and hydromorphone. Secondary outcomes showed similar improvements for 2 of the outcome measures, whereas 1 of the outcomes slightly worsened. Comparing patients in the pre-implementation group with those in the post-implementation group, intraoperative analgesic administration was reduced in morphine equivalents by 21% and time to first analgesic administration was delayed 5%, whereas the time from the end of surgery to extubation was prolonged by 6.2%.

Table 2. Primary and Secondary Outcomes Before and After Implementation[a]

	Pre-QI Implementation Data (n=25)	Post-QI Implementation Data (n=25)	P Value	Percentage Change
PACU analgesics, morphine equivalents	7.5	5	0.62	33% reduction
Time in PACU, min (± SD)	75.12 ± 32.81	65.12 ± 22.01	0.21	13% reduction
Intraoperative analgesics, morphine equivalents	31.67	25	0.14	21% reduction
Time to extubation, min (± SD), from end of surgery	5.8 ± 3.10	6.16 ± 5.12	0.77	6% increase
Time to first analgesic in PACU, min (± SD)	19.83 ± 13.16	20.79 ± 13.02	0.83	5% increase

Abbreviations: PACU, post-anesthesia care unit; QI, quality improvement.

aPre-implementation group received customary care decided by anesthesia provider. Post-implementation group received preoperative gabapentin and IV acetaminophen in addition to typical care as determined by anesthesia provider.

Percentage change in pain scores varied from a 5% to 10% reduction at admission, 15, 45, and 60 minutes in the PACU, although there was no difference in pain scores at 30 minutes. The incidence of opioid-related adverse events was reduced by 80% (Table 3).

Table 3. Comparison of Pain Ratings Before and After Implementation[a]

Numeric Rating Scale	Pre-QI Implementation Data (n=25)	Post-QI Implementation Data (n=25)	P Value	Percentage Change
Admission	5	4	0.94	10% reduction
15 minutes	6	5	0.88	10% reduction
30 minutes	5	5	0.68	0% reduction
45 minutes	5.5	5	0.36	5% reduction
60 minutes	5	4.5	0.44	5% reduction
Opioid-related adverse events, No. of episodes	Nausea (4) Respiratory depression (1)	Nausea (1)	0.20	80% reduction

[a]Pre-implementation group received customary care as determined by anesthesia provider. Post-implementation group received preoperative gabapentin and IV acetaminophen in addition to typical customary care decided by anesthesia provider.

Numerous relationships were observed between variables. Morphine equivalents administered in the PACU and time in the PACU displayed a large, positive correlation [rs (48) = 0.528, P<0.000]. Additionally, pain on admission and time in the PACU had a moderate, positive association [rs (48)= 0.349, P<0.01]. Notably, the largest association with opioid-related adverse events (a small negative correlation) was with whether the patient received the preoperative analgesic regimen. Administration of the preoperative analgesic regimen was associated with fewer opioid-related adverse events [rs (48) = -0.25, P=0.085].

Statistical significance was not achieved for any inferential statistical test. This was likely due to the small sample of the quality improvement project. Given a medium effect size (0.50), alpha set to 0.05, and power set to 0.80, a sample size of 75 would have been required in each group to achieve statistical significance for a two-tailed independent t-test. This would have necessitated 15 to 30 months to complete at the author's institution. Given that this was a quality improvement study, utilizing analgesics already supported by Category A1 evidence,[16] a shorter duration was preferred to achieve results consistent with the literature and to assess successful implementation of the project.

DISCUSSION

Summary

Prior to this quality improvement project, there were no existing preemptive analgesic protocols in this author's department and concerns existed that staff resistance may lead to difficulty with implementation. However, this preemptive, multimodal project was well received by all anesthesia providers. The strength of this project was the simplicity with which the regimen was instituted coupled with the documented efficacy of the analgesic regimen. Postoperative opioid use and opioid-related adverse events showed marked improvement, and all other primary objectives trended positively. Minor changes were made to the project during implementation. One change related to the timing of the gabapentin as patients arrived at the operating room holding area. Initially, patients were to receive the oral gabapentin upon arrival to the holding area. However, administration at this time resulted in the patients receiving the gabapentin 2 to 3 hours early for 2 of the first 5 patients in the post-implementation group. This was identified early and overcome by holding the gabapentin until physical confirmation of the previous operation nearing completion, as evidenced by the onset of suture closure of the surgical incisions.

Despite the minor adjustment to protocol, the project was successful and met its intended goals. Significant improvements were noted by the large decrease in narcotic analgesics administered in the PACU, the decreased time spent by patients in the PACU, and the substantial decrease in opioid-related adverse events.

Relation to Other Evidence

The project's outcomes were consistent with the evidence appraised in the literature. Gabapentin and its effect on pain and pain-related outcomes have been studied extensively for both operative and nonoperative pain. Gabapentin, although similar in structure to gamma-aminobutyric acid (GABA), does not attach to the $GABA_A$ or $GABA_B$ receptors, but instead is an alpha-2 delta calcium channel blocker believed to exert its effect by decreasing neurotransmitter release.[23] Gabapentin has a high volume of distribution (60 L in healthy individuals) and achieves its maximum plasma concentration (Cmax) in 3 hours. Gabapentin is unbound to proteins and is cleared almost exclusively by the kidneys with an elimination half-life of 4.8-8.7

hours.[23] When administered 1 to 2 hours before hysterectomy, vaginal or abdominal, studies have reported a decrease in morphine consumption,[24-31] a decrease in pain scores,[24-26,28,31] and a decrease in nausea or vomiting.[24,26,29]

Although oral and rectal forms of acetaminophen have been available for over a century, the IV formulation is relatively new. IV acetaminophen was introduced in Europe in 2002 but was not approved for use in the United States until 2010, under the trade name OFIRMEV (Mallinckrodt Pharmaceuticals). IV acetaminophen is now found in many hospitals around the world.[22] The exact mechanism of IV acetaminophen is unknown but it has been shown to exert its action both centrally and peripherally, possibly altering the action on NMDA, COX, and/or serotonergic receptors.[23] The Cmax for IV acetaminophen is twice that of oral administration, achieved in 15 minutes, and IV acetaminophen has a duration of action of approximately 4 to 6 hours. IV acetaminophen has a volume of distribution of 69.2 L in healthy volunteers and does not bind extensively to proteins. It is metabolized extensively by the liver and has an elimination half-life of 2.7 hours.[32] Preemptive IV acetaminophen utilized as an adjunct to pain management for hysterectomy has been reported to decrease narcotic requirements,[33,34] decrease pain scores,[33] and decrease opioid-related adverse events.[33,34] When preemptive IV acetaminophen and gabapentin are combined, the decrease in narcotics and pain scores is significantly greater than placebo as well as when either drug is used independently.[35,36]

Limitations

With only 25 patients in each group, a greater number of disparities in practice among anesthesia providers for one group than the other may have affected the analgesic outcomes. For example, anesthesia providers interpret pain during surgery and treat it accordingly. Some providers may block the sympathetic response with nonanalgesic sympatholytics rather than analgesics, potentially leading to increased pain for patients while in the PACU until appropriate analgesia is achieved. The lack of controls regarding intraoperative actions by anesthesia providers was ultimately viewed as a strength of this quality improvement project, however, because altering individual anesthesia provider preferences would change the overall ability to determine this regimen's application in the author's setting.

Chronic pain is a common indication for hysterectomy and provides a unique postoperative pain management challenge owing to nervous system sensitization or tolerance to analgesics.[37] This factor was identified prior to implementation and comparisons were conducted to ensure homogeneity between groups. However, it was discovered after implementation had begun that the source for these data, the anesthesia preoperative assessment, was inconsistent with the surgeons' history and physical examinations. Therefore, many of those with chronic pain may not have been identified. It is possible that with only 25 patients in each group, one group may have included a statistically significantly greater number of patients with chronic pain, although this is unlikely.

The likelihood that observed outcomes would wane over time was considered possible if anesthesia providers abandoned the preemptive, multimodal nature of this intervention. Attempts were made by the author to maintain compliance over time. During dissemination of the study results to the anesthesia department, time for discussion was afforded to allow the CRNAs and anesthesiologists the opportunity to provide critiques and identify barriers not detected by the author. Encouragingly, the anesthesia staff expressed an overwhelmingly positive attitude, and further plans have been made to expand on the success of this project. Ideally, the author would have observed the continued use of preemptive, multimodal pain management regimens that followed the formal implementation group of this project. Unfortunately, there was no additional time to achieve this outcome.

Interpretation

This quality improvement project resulted in clinically significant improvements in practice outcomes with the implementation of minor alterations of practice. Despite the effectiveness of the instituted regimen, some modifications to future regimens could be considered, including the addition of nonselective COX inhibitors, selective COX-2 inhibitors, and/or alpha-2 antagonists, among other minor adaptations. This project instituted a fixed regimen for all women having a hysterectomy and did not allow for flexibility by the anesthesia provider to alter the gabapentin dose or substitute a preemptive analgesic, as they might have otherwise. Ideally, analgesic regimens should be individually tailored for patients according to the anesthesia provider's clinical expertise.

Hospital-costing practices can be highly variable and complex with differing methodologies resulting in difficulty performing a cost analysis for this analgesic regimen. Moreover, a cost comparison was not an intended outcome measure for this quality improvement project. However, a simple exploration of economic benefit was performed. For the author's institution, the direct cost of the addition of the analgesic regimen of gabapentin and IV acetaminophen (OFIRMEV) was $12.39, $0.56 per 600-mg dose of gabapentin and $11.83 per 1000-mg dose of IV acetaminophen (OFIRMEV) (S Blessing, A Pangelinan, personal communication, April 20, 2016). Given the modest cost of opioids and antiemetics, any financial benefit of the addition of gabapentin and IV acetaminophen (OFIRMEV) was not likely realized in drug cost-savings. Rather, the savings were more likely observed in the avoidance of opioid-related adverse drug events and the time and activity costs that are associated with them. In this project, opioid-related adverse events were reduced from an incidence of 5 to 1 (Table 3). Oderda et al4 reported that for every opioid-related adverse event, there is additional $840 in hospital costs. Thus, the small increase in costs for the regimen was quickly recovered.

Moreover, the cost of this regimen could be further reduced if the oral formulation of acetaminophen, costing $0.15 per 975-mg dose (S Blessing, A Pangelinan, personal communication, April 20, 2016), was administered in place of the IV formulation. Although there is good pharmacokinetic theory supporting the claim that IV acetaminophen would provide better analgesia,[21,22] there is limited evidence and much debate whether IV acetaminophen actually leads to better analgesic outcomes. Currently, multiple clinical trials are ongoing to compare the 2 formulations and answer these clinical questions.[38]

Conclusions

In summary, the analgesic regimen was easily implemented, increased the incidence of multimodal regimens, and improved analgesic outcomes for women undergoing hysterectomy at the author's institution. This regimen is easily modifiable, potentially cost-saving, and compatible for implementation with other patient populations. Future quality improvement projects of this kind would expand the regimen to other surgical populations and provide more flexibility in the analgesic regimen, particularly with regard to using additional preemptive analgesics, substituting analgesics when deemed appropriate, and increasing or decreasing doses as needed. Furthermore, future projects could thoroughly conduct a formal time-driven, activity-based costing algorithm to further explore the potential for cost-savings.

Summary of Key Points

-Easy-to-implement, evidence-based regimen consisting of preoperative gabapentin and IV acetaminophen

-Reduced opioid consumption, pain scores, opioid-related adverse events, and time in the PACU

-Cost-effective, easily modifiable, and appropriate to multiple populations across numerous surgical operations

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