Postoperative Patient-Controlled Analgesia in the Pediatric Cardiac Intensive Care Unit

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BACKGROUND High rates of uncontrolled pain in critically ill patients remain common. Patient-controlled analgesia is more effective than traditional intravenous as-needed dosing regimens for managing postoperative pain in older children and adults.

OBJECTIVE To determine whether pain-related clinical outcomes in patients from age 10 years to adult following cardiac surgery are improved by using patient-controlled analgesia as a pain management strategy.

METHODS Using the plan-do-study-act method of quality improvement, a process was instituted to have both staff and patients' families support the use of patient-controlled analgesia postoperatively as opposed to traditional pain control with as-needed analgesics. Use of as-needed medications and pain scores were retrospectively compared from before to after initiation of patient-controlled analgesia.

RESULTS The cumulative mean pain score from the time of extubation through the following 24 hours decreased from 4.14 (on a scale from 0 to 10) when strictly as-needed medications were used to 2.8 with patient-controlled analgesia. Further, the mean amount of opioid consumed decreased from 14.98 mg of morphine and 22.27 mg of oxycodone to 13.58 mg of morphine and 3.33 mg of oxycodone after implementation of patient-controlled analgesia.

CONCLUSIONS Standardized use of patient-controlled analgesia for postoperative pain management in patients 10 years of age through adulthood is efficient and effective, as evidenced by less medication being consumed by patients and lower mean pain scores. (*Critical Care Nurse*. 2017;37[1]:55-61)

Children are at increased risk for inadequate pain management, with age-related factors typically determining pain management regimens.[1] The challenge in pain management can include, but is not limited to, insufficient knowledge of pediatric pain and pain pathway development, uncertainty about appropriate dosages of analgesics in children, and difficulty assessing both pain and adequacy of analgesia in children, as well as adults.[2,3] Currently, few published reports describe investigation of pain management strategies to improve pain-related outcomes in children and adults following

CE 1.0 hour, CERP A

This article has been designated for CE contact hour(s). The evaluation tests your knowledge of the following objectives:
1. Identify potential barriers to postoperative pain management in patients 10 years of age through adulthood
2. Compare the use of as-needed pain medication for postoperative pain to the use of patient-controlled analgesia
3. Evaluate the importance of accurate reporting and documenting of pain scores

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cardiothoracic surgery. The purpose of this study was to further clarify these existing knowledge gaps by discussing the use of patient-controlled analgesia (PCA) for the management of pain in poststernotomy cardiac patients 10 years of age through adulthood in an intensive care unit (ICU) at a medical university and teaching hospital in a southeastern city of the United States.

According to data collected by Naguib and colleagues,[4] PCA is more effective than traditional intravenous as-needed dosing regimens in both older children and adults. Researchers determined that if acute postoperative pain is not well managed, a patient is at risk of forming a "pain memory" along with experiencing chronic pain, both of which have long-term physical, psychological, social, and developmental consequences.[2] The smaller, more frequent dosing regimen of PCA leads to fewer adverse effects and greater consistency in pain control.[4] Staff education is integral to the implementation of such a protocol for minimizing patient safety concerns and optimizing patient outcomes. Therefore, with appropriate preoperative teaching and encouragement as well as postoperative application, PCA can be an effective means of postoperative pain relief in the pediatric cardiac ICU (PCICU) for patients 10 years of age through adulthood.

A general assessment of current practice shows many options available for pain control, yet they often are underused. The available evidence-based research indicates that pain control can be achieved by effectively training pediatric (at least 10 years of age per the parameters set forth in this study) and adult patients to closely self-regulate pain management with the use of PCA while accurately documenting pain scores. Yet, the use of PCA for pain management in children age 10 years and older focuses on a population that has not been specifically targeted in the PCICU at which this study is being implemented. By eliminating fluctuating effects associated with bolus injections of a short-acting opioid at an interval of several hours, PCA initiates and maintains steady, flexible patient-enhanced pain control.[5] This practice improvement project was guided by the following question: Will PCA improve postoperative pain management in patients age 10 years through adulthood admitted to the PCICU after cardiothoracic surgery via sternotomy as studied during a 2-month period, compared with the exact 2-month period the year prior?

Methods

Ethical Issues

In this practice improvement project, the confidentiality of all participants' data was preserved during and after the data collection phase. Only the patient's age has been identified; all other facets of the participants' identity were undisclosed. All individuals directly involved in collecting data were hospital employees or those contracted by the hospital, and all are bound by the same Health Insurance Portability and Accountability Act (HIPAA) compliance standards, thus ensuring confidentiality of all patients involved. This study was exempt from formal approval from the institutional review board because there were no patient identifiers, codes, or links to the identity of individuals' data collected both before and after the intervention as described in the HIPAA 45 CFR §46.101(b)(2), §46.102(f), and §164.514(a)-(c).[6]

Setting

The PCICU is a 14-bed unit in a nationally ranked teaching hospital in the southeastern United States. It is one of few centers in the country dedicated exclusively to congenital heart care. Once a congenital heart defect is diagnosed, admission into the PCICU for postsurgical observation is continuous through the patient's life span. The PCICU team provides comprehensive care for complex medical and surgical patients from newborns to adults. The PCICU is equipped to provide the highest complexity of medical and surgical therapies, including surgical intervention, extracorporeal membrane oxygenation, administration of inhaled nitric oxide, and ventricular assist devices. The team that cares for these patients includes specialized nurses, respiratory therapists, pharmacists, clinical assistants, clinical nutritionists, and specifically trained fellowship and attending physicians in pediatric cardiology and critical care medicine. All registered nurses and physicians are certified in

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basic life support, pediatric advanced life support, and advanced cardiac life support owing to the various ages of the patients for whom they provide care.

The Department of Pediatric Cardiology is inclusive of several entities. To begin the admitting process of a patient, each is admitted to the hospital under the care of the pediatric cardiac surgical team. Patients may transfer from outlying institutions, come to the hospital from home, or already be in the hospital. Each patient completes a preoperative workup that includes a chest radiograph, laboratory tests, electrocardiography, discussion of the surgical process and recovery, and finally providing consent for the surgical procedure. Nurses, nurse practitioners, ICU fellows, ICU attending physicians, a cardiothoracic surgeon, and an anesthesiologist all meet with the patient and the patient's family and discuss what to expect in the coming days from each of their areas of expertise. It is here that the patient and family are first introduced to PCA.

A purple notebook inclusive of all pertinent materials for the nurse, the patient, and the patient's family (hospital policies, a project proposal outline, a "how-to" manual for appropriately programming the pump, a list of what and how to document, as well as a list of frequently asked questions for both the nurse and the patient) guides the nurse through explaining to the patient how to use the PCA, when to use it, who may and may not press the analgesic button, and how to appropriately describe pain using the numeric rating scale. White labels with "PCA" typed on them in purple were also in this notebook. Placing one of these stickers on the spine of the patient's chart indicated to the operating room staff, as well as the ICU staff, that the patient had been educated on the use of PCA preoperatively. In comparison, if a patient was in the hospital before his or her surgery, the unit the patient was in or the ICU was responsible for completing the teaching material in the same fashion with an identical notebook available in each unit. If no time was available for PCA to be discussed preoperatively, PCA use was taught and initiated in the ICU as soon as the patient was extubated and able to understand simple instructions.

Inclusion and Exclusion Criteria

As this is a quality improvement project that uses an evidence-supported intervention with equipment available in the hospital, consent was unnecessary. Although training in PCA was subject to each physician's judgment, each postoperative patient more than 10 years old admitted to the ICU in the 2 months of studied execution should have received education on and implementation of PCA. Parents, patients, or both were able to refuse the use of PCA at any time during their admission, although none chose to do so.

If no time was available for PCA to be discussed preoperatively, PCA use was taught and initiated in the ICU as soon as the patient was extubated.

Exclusions from this study included chemically paralyzed and sedated patients and/or individuals with severe neurological disorders within the desired age range who were unable to comprehend the use of PCA.

Planning the Intervention

The investigators conducted a retrospective analysis through a chart review to gather pain scores, the number of as-needed medications, and the dosages of as-needed medications in patients age 10 years and older who were admitted to the PCICU from July 1, 2013, through September 1, 2013. Before the intervention, data collection included pain scores reported by PCICU patients' age 10 years through adulthood during the year before the implementation of PCA. The dates chosen for this quality improvement project are based on a typically higher volume of older patients with congenital heart defects due to the summer vacation and a higher percentage of "elective" operations. Although the surgical operation was unique to the individual patient, surgical interventions were performed by 1 of 2 certified cardiothoracic surgeons, and each patient returned from the operating room with at least 1 chest tube. All procedures required pain palliation for effective recovery.

Planning the Study of the Intervention

Close communication with the surgeons, attending physicians, and pharmacist in the PCICU was crucial to gaining authorization to implement this study. After receiving approval, staff meetings were held in each pediatric cardiology location (ICU, step-down unit, preoperative surgery) the month before the scheduled implementation date, with the primary investigator attending each meeting. Purple PCA notebooks were compiled beforehand, and all contents were thoroughly explained to all members of the team in attendance. An

e-mail with the contents of the notebook was also sent to all members of the pediatric cardiology team with the implementation date, inclusion criteria, and instructions on the ordering of PCA in the electronic medical record.

Included in the purple PCA binder were phone numbers of all necessary personnel for the collection of materials to begin PCA, as well as item numbers for tubing and channels. This way, no matter the time or day, all information for successful execution was readily available in one place. Additionally and perhaps most importantly, the manual explained how to effectively document pain scores to ensure that the data could be compared with preimplementation data. A spreadsheet was created and placed in the purple PCA binder stating intervals at which pain scores should be documented. Upon initiation of PCA, pain scores were to be documented every hour for 4 consecutive hours. If at any time additional medication was delivered as an adjunct to PCA, a pain score must be documented, with pain reassessed and documented an hour thereafter. Following the initial 4 hours, pain scores were to be documented every 2 hours for 4 hours, and then at least every 4 hours thereafter. The PCA pumps were required to be cleared every hour so that the nurse could document the patient's demand and the amount of medication they received. If the patient asked for medication delivery often and received medication delivery without adequate pain relief (as subjectively stated by the patient), additional as-needed medications were attempted and PCA dosing was adjusted appropriately. On weekdays, 2 clinical unit leaders who are registered nurses are in charge of the unit during the day shift (7 AM-7 PM) when most operative cases come into the unit. Also available is the clinical pharmacist who is a strong advocate for this quality improvement project. Additionally, night shift (7 PM-7 AM) and weekend charge nurses have welcomed this new process and encouraged its execution.

If the patient asked for and received medication without adequate pain relief, additional as-needed medications were attempted and PCA dosing was adjusted.

Postintervention data after the 8-week trial (which began July 1, 2014, and ended September 1, 2014) were collected: pain scores of all PCA users through their stay in the PCICU, supplemental as-needed pain medications, dosages, and pain scores before and after delivery.

Methods of Evaluation

In order to collect accurate data, an appropriate pain scale was used. The numeric rating scale is known as one of the simplest and most frequently used instruments in clinical practice to measure pain intensity in children 8 years and older.[7] Patients verbally rate the intensity of pain on a scale from 0 (no pain) to 10 (worst pain possible).[7] The corresponding number was then recorded.

For a comparison group, we gathered outcomes and pain scores for patients during the preceding year who had received as-needed medications but would have met the criteria to be included in our intervention. Data on pain scores and administration and dosages of as-needed medications were gathered and analyzed retrospectively. A cumulative mean pain interval and cumulative medication dose were compiled. Similarly, after the 8-week implementation of PCA, data on pain scores and additional as-needed medications were compiled. Cumulative mean values for pain scores and administration and dosages of PCA medication (and any additional as-needed medications) were calculated.

Analysis

The hospital's electronic medication records were used to collect data before the implementation of PCA. A search was conducted to include patients age 10 years through adulthood who were admitted to the PCICU between July 1 and September 1, 2013. This method allowed the inclusion of similar patient admissions by using the same time of year, simply 1 year apart. As one would expect, many older children or young adults choose to schedule an operation outside of the school year. The investigators also collected the number of as-needed medications that were administered and the doses of each. The following medications were considered to be as-needed: morphine, dilaudid, fentanyl, and oxycodone. Unfortunately, data on the use of parasternal or intercostal nerve blocks could not be collected for all patients, so those data were omitted. All pain scores were analyzed, and cumulative mean values were calculated for delivery of as-needed medications and of PCA use before and after PCA implementation. Identical to the information collected retrospectively, the number and dose of as-needed medications delivered to patients age 10 years through adulthood were collected, along with all pain scores in the post-PCA implementation period beginning

July 1, 2014, and ending September 1, 2014. All patients included in this study were poststernotomy patients, from 11 years to 40 years of age.

Results

Preimplementation data were available for 16 patients. Two of these patients were not postoperative admissions, 1 patient used PCA in the preimplementation period, 1 patient did not have any pain scores documented through 24 hours of being admitted postoperatively, and 1 patient used fentanyl as pain medication management, unlike all others, who used morphine. These patients were excluded when the cumulative means were compiled. In the end, 11 patients' pain scores and consumption of morphine and oxycodone were evaluated. The cumulative mean pain score through 24 hours after extubation using strictly as-needed medication was 4.14 on a numeric pain scale from 0 to 10. The cumulative mean dosages before PCA implementation were 14.98 mg for morphine and 22.27 mg for oxycodone. Adding oxycodone at scheduled intervals to as-needed morphine proved to lower pain scores.

Conversely, the sample after PCA implementation comprised 9 patients. One patient's pain was adequately controlled with acetaminophen (15 mg/kg per dose by mouth scheduled every 6 hours) and ketorolac (0.5 mg/kg per dose intravenous scheduled every 6 hours) alone. A second patient who met the inclusion criteria did not have a PCA started (the reasoning behind this is unknown). And last, a third patient had no pain scores recorded in the 24-hour period after extubation, which excluded that patient from the study. Therefore, 6 patients' pain scores, as well as morphine and oxycodone use (in milligrams) were evaluated. Of note, all PCAs contained morphine through each phase of this study, and all were bolus-only infusions. The cumulative mean pain score through 24 hours after extubation where PCA was initiated was 2.8 on a numeric pain scale from 0 to 10. The cumulative mean dosage was 13.58 mg for morphine and 3.33 mg for oxycodone. This provides evidence to suggest lower pain scores, as well as fewer medications delivered (in milligrams), with the initiation of PCA compared with pain management with only as-needed medications.

No resistance was met in the implementation of PCA at this facility from the physician or nursing staff, but 2 patients asked that the PCA be discontinued because of the adverse effects of nausea and dizziness that they were experiencing. Nausea and dizziness are 2 common side effects of narcotic use, as is the risk of respiratory depression. However, The Joint Commission recommends the use of PCA to reduce the risk of oversedation.[8] To this end, no episodes of respiratory depression associated with the use of narcotics were reported in this quality improvement project.

The biggest barrier to the full implementation of PCA was failure of the nurse or physician to advocate for use of PCA upon extubation. This may have happened for several reasons: the individuals may have forgotten about the inclusion terms for implementation of PCA; implementation began in July, when all new fellows are also introduced to the unit; physicians may have felt uncomfortable beginning an opioid on demand by patients who had just been extubated, making the physician more likely to be concerned about adequate airway maintenance. However, the evidence-based research points to the use of PCA as being more effective in managing pain than are traditional intravenous as-needed dosing regimens in adults and older children.[3]

Our findings suggest lower pain scores with the initiation of PCA compared with pain management with only as-needed medications.

Discussion

As medical care and treatment techniques have improved, babies and children with congenital heart defects are now living longer and healthier lives, with most living into adulthood. It is through ongoing, appropriate medical care that children and adults with a congenital heart defect are able to live as healthy and long a life as possible.[9] It is with this integration of an increasing number of adolescent and adult patients in mind that the investigators of this study evaluated pain control in patients age 10 years through adulthood postoperatively admitted to the PCICU in 8 weeks of studied implementation.

A standardized process to use PCA for postoperative pain management for patients 10 years of age through adulthood is an efficient and effective method of pain management. However, as evidenced by the data collected in this quality improvement project, close attention to documenting pain scores is necessary as with all methods of pain management. An in-service educational session for all members of the team, not simply the bedside nurses, director, and surgeons of the program,

would aid in the introduction of the quality improvement project and enable a discussion about the facts behind why what we are doing is not working and the plan for the proper and uniform introduction of PCA into the unit. In meeting with the nurses, stressing the importance of documenting pain scores routinely is paramount. In the absence of properly and comprehensively collected data, measuring outcomes is problematic. From a clinical standpoint, pain scores should be documented on initiation of PCA and then throughout its use at regularly scheduled intervals and as needed (every 1 hour for 4 hours, every 2 hours for 4 hours, and then every 4 hours for the duration of PCA use). Similarly, in order to evaluate the effectiveness of PCA, the medication delivered (in milligrams) must be documented as well at the regularly scheduled intervals just mentioned. Last, if an as-needed medication is delivered, pain scores must be documented before and 1 hour following its delivery.

In summary, the use of PCA has shown high reliability in the management of postoperative pain in numerous studies; however, the use of PCA in congenital heart patients 10 years of age through adulthood in the postoperative period remains a topic lacking extensive research. Few investigators have addressed the need for continued assessment and treatment of postoperative pain in the ICU. This quality improvement project has established an effective means for implementing an evidence-based practice change for pain control in the PCICU. Pain is a personal experience specific to the individual involved; therefore, promoting adequate reporting of pain scores through the use of an appropriate, uniform pain scale will enhance management of patients' pain and enable pain control throughout a patient's stay in the ICU.

The authors of a separate study[10] reported that the addition of dexmedetomidine to PCA morphine resulted in superior analgesia, was significant in decreasing morphine need, and provided the patient with less morphine-induced nausea while not affecting the patient's hemodynamics. This finding suggests an opportunity for developing a standardized protocol for PCA with the addition of dexmedetomidine in postoperative patients.[10,11]

Limitations

Limitations of this quality improvement project include its small sample size, due in part to limitations in the number of pain scores documented. Improved documentation would enable adequate and accurate analysis of all relevant data. A longer implementation period would enable more evidence to be collected and provide time to reflect on the first few months, what went correctly, and what could be improved. Then, problems such as pain assessment documentation could be addressed before outcomes data are assessed.

Conclusions

Pain management is an important part of an individual's plan of care throughout his or her hospital stay. Although pain is a common stressor, high rates of uncontrolled pain in critically ill patients remain common.[3] Staff education is integral to the implementation of a standing postoperative protocol such as the one evaluated in this study. An interprofessional approach that includes physicians, registered nurses, patients, and their families should be of highest priority. Changing behavior is the most challenging piece of implementing and sustaining quality improvement measures. Nurses are essential to the development of a standardized pain management process, although patients and their families play an important role as well. Unfortunately, this quality improvement project has not yet established a standard hospital protocol for the use of PCA to control postoperative pain in children 10 years and older, but it has provided our staff with evidence-based research about why it should be considered as a standardized protocol for postoperative implementation in the PCICU. Patient-controlled analgesia in the ICU will strengthen pain management throughout the postoperative period and offer a seamless transition as the patient's acuity deintensifies and pain management at home becomes the focus.

Postoperative cardiac patients have several pain management choices available to them, although several factors must be assessed when deciding what method and medication are best. A few of these factors include the patient's previous exposure to analgesic therapy, pain tolerance, and surgical procedure. A standardized process through the use of PCA for postoperative pain management for patients 10 years of age through adulthood is an efficient, effective, and evidence-based approach to combating pain. In the future, data can be gathered on adjunct medications, standardized dosing, and alternative treatments that improve pain relief through PCA even further. CCN

Financial Disclosures
None reported.

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