

Electronic Ordering System Improves Postoperative Pain Management after Total Knee or Hip Arthroplasty

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Keywords

Patient controlled anesthesia (PCA), computerized physician order entry (CPOE), arthroplasty, electronic health records and systems, medication management

Summary

Objectives: The authors investigated the impact of computerized provider order entry (CPOE) on the delivery times of analgesia and subsequent patient outcomes. We hypothesized that patients would report less pain and use less pain medications compared with the previous paper-based system.

Methods: Two groups of patients after a total hip (THA) or knee arthroplasty (TKA) were retrospectively compared: one comprising 106 patients when the paper-based ordering system was in effect (conventional group), and one comprising 96 patients after CPOE was installed (electronic group). All patients received a regional anaesthetic at surgery (combined spinal-epidural). TKA patients also received a single-injection femoral nerve block. After transfer to the postoperative anaesthesia care unit (PACU), a patient-controlled epidural analgesia (PCEA) infusion was initiated. The following data was collected from the PACU record: time to initiation of analgesia, visual analog scale (VAS) pain scores at initiation of analgesia and hourly for the first postoperative day (POD), volume of pain medication used, length of stay (LOS) in the PACU and the hospital.

Results: The time to initiation of analgesia from arrival in the PACU was significantly lower in the electronic group compared to the conventional group (24.5 ± 28.3 minutes vs. 51.1 ± 26.2 minutes; mean \pm SD, $p < 0.001$), as were VAS pain scores (0.82 ± 1.08 vs. 1.5 ± 1.52 , $p < 0.001$) and the volume of PCEA needed to control pain (27.9 ± 20.2 ml vs. 34.8 ± 20.3 ml, $p = 0.001$) at 4 hours postoperatively. PACU LOS and hospital LOS did not significantly differ in the two groups.

Conclusions: After implementation of CPOE, patients received their postoperative analgesia faster, had less pain, and required less medication.

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1. Background

After total hip arthroplasty (THA) and total knee arthroplasty (TKA), patients typically experience considerable pain, which, if not adequately treated, may delay the start of physical therapy, impede rehabilitation, prolong hospitalization, and increase medical costs. Early rehabilitation can be crucial to overall functional outcome, as it may prevent postoperative adhesions, intra-articular fibrous tissue deposits, and deep venous thrombosis [1]. Conventional analgesic regimens rely on parenteral opioids given at predefined intervals. This method is commonly associated with significant side effects. These include respiratory depression, delayed bowel function, nausea and vomiting and central nervous system effects. Decreasing the amount of opioids needed for pain control has become an important goal of postoperative analgesia.

The clinical practice guideline on pain management published by the Agency for Healthcare Research and Quality (1992) found that half of all patients who received conventional therapy for their pain did not experience adequate relief; that patients put on an “as-needed” program may delay asking for pain medication; and that prevention is better than treatment, because established pain is harder to suppress [2]. A decade later, a large national survey found that 30–80% of patients experienced moderate to severe postoperative pain [3]. It has also been reported that more than half of TKA and THA patients do not receive adequate relief [4, 5].

2. Objectives

The purpose of this study was to examine the extent to which instituting CPOE with its attendant changes in workflow would speed the delivery of PCEA to our postoperative patients, and improve their postoperative analgesia compared to the use of pre go-live standard paper orders.

3. Methods

3.1 Setting

The Hospital for Special Surgery (HSS) is a 150+bed hospital in New York City devoted exclusively to the care of patients with musculoskeletal disease. In 2012, a total of 26900 orthopedic procedures were performed at HSS. An important element of our postoperative pain protocol is the initiation of analgesia before the level of pain becomes difficult to control. However, we found that in many cases the patient’s regional anesthetic had worn off before patient controlled epidural analgesia (PCEA) could be instituted in the post anesthesia care unit (PACU).

Our workflow analysis revealed a number of steps that could be contributing to the delay in achieving pain control. These include the time required to place the order, time required for the pharmacy to validate and prepare the drug mixtures, the time required to transport the PCEA medication to the PACU and the time required for the nurse to connect the PCEA and initiate the infusion.

HSS implemented an electronic clinical information system (CIS), Sunrise Clinical Manager (SCM) Allscripts (Chicago, IL). Our implementation included basic documentation, flow sheets, electronic medication administration record (eMAR), computerized provider order entry (CPOE) and clinical decision support. We developed over 250 standardized order sets, including specific order sets to support the Department of Anesthesia, and the Acute Pain Service. We hypothesized that after the electronic ordering system was instituted, differences in workflow and turnaround time would allow patients to have improved outcomes compared with conventional paper ordering. We therefore measured the differences (pre and post go-live) for the following: time to pain control, total dose of narcotics, and length of stay (LOS).

3.2 Patients

After receiving approval from the Institutional Review Board at the Hospital for Special Surgery (New York, NY), we retrospectively compared data from two groups of patients. The first group included 106 patients who underwent THA or TKA (THA, n=59; TKA, n=47) one month prior to implementing CPOE (conventional ordering) and the second group comprised of 99 patients (THA, n=48; TKA, n=51) who were operated on one year later and were after go-live (electronic ordering). Patients were excluded from the study if they had revision or bilateral procedures, general anesthesia, or if they had not received PCEA postoperatively. Demographic data is shown in ► Table 1.

In the conventional group, paper medication orders were written by the anesthesiologist in the operating room, brought to the PACU along with the patient at the end of surgery, and faxed to the pharmacy by a nurse. The paper orders contained the drugs typically used at standard concentrations with suggested rates of administration, lockout and total doses. The drugs were then prepared by the pharmacist and sent to the PACU. In the electronic group, the anesthesiologist sent the medication order electronically to the pharmacy, and the medication was prepared and delivered to the PACU generally before the patient arrived. The electronic order sets also contained standard drugs at standard concentrations with defaulted rates of administration, lockout and total doses.

3.3 Anesthesia /Analgesia

In the operating room the THA patients received a combined spinal/epidural anesthetic with 3–4 ml of 1.5% mepivacaine, while the TKA patients received 2–3 ml of 0.5% bupivacaine and a single-shot femoral nerve block (FNB). In the PACU, the PCEA was initiated through the epidural catheter with 0.06% bupivacaine, 10 µg/ml hydromorphone at initial settings of 4 ml/h, with a bolus of 4 ml, a lock-out period of 10 minutes, and a maximum dose of 20 ml/h.

3.4 Data Collection

In the PACU, records are kept according to a standardized protocol that includes data on the operation, epidural catheter placement, time of entry to the PACU, time of PCEA initiation, pain scores (recorded at initiation and then hourly), volume of medication delivered (recorded from the PCEA pump), vital signs, level of sedation, as well as adverse events (e.g., nausea, vomiting, respiratory compromise).

The time to PCEA initiation, volume of drugs administered through the PCEA, and amount of pain experienced by patients up to postoperative day (POD) 1 were extracted from the medical records. The visual analog scale (VAS) was used to measure pain levels, from 0 to 10 (nil to worst possible pain).

3.5 Outcome measures

Records were retrospectively reviewed to determine four primary outcome measures: 1) time to initiation of PCEA, 2) amount of pain experienced during the first day as measured by the VAS, 3) amount of pain medication used, and 4) length of PACU and hospital stay.

3.6 Statistical Methods

Continuous variables are presented as means and standard deviations and categorical variables are presented as counts and percentages. Continuous demographic variables were compared between groups using two-sample t-tests, and categorical demographic variables were compared between groups using chi-square or Fisher's exact test, as appropriate. Outcomes with a single measurement per patient were compared between groups while adjusting for age, sex, BMI, and procedure via multiple linear regression for continuous outcomes and multiple logistic regression for binary outcomes. Outcomes measured at multiple timepoints per patient were compared between groups via regression based on the generalized estimating equations (GEE) approach with an autoregressive [AR(1)] correlation structure and adjustment for age, sex, BMI, and procedure. The GEE method

accounts for the correlation between repeated measurements on the same patient, where the AR(1) correlation structure assumes a greater degree of correlation among measurements recorded closer in time. All statistical tests were two-sided, with statistical significance defined as $p < 0.05$. Statistical analyses were performed with Statistical Package for the Social Sciences (SPSS 14, SPSS, Chicago, IL) and SAS (Version 9.3, SAS Institute, Cary, NC).

4. Results

4.1 Demographics

There were 106 patients in the conventional group (59 THA and 47 TKA) and 96 in the electronic group (46 THA and 50 TKA). The two groups did not differ significantly on surgery type, age, sex, weight, height, or BMI (► Table 1).

4.2 Time to Initiation of PCEA

PCEA was initiated significantly earlier in the electronic group (24.5 ± 28.3 min) compared with those in the conventional group (51.1 ± 26.2 min, $p < 0.001$) for both THA and TKA patients, while adjusting for age, sex, BMI and procedure. This time was measured starting from entry to the PACU to initiation of PCEA. The time to initiation of PCEA was similar for both TKA and THA patients in each group.

4.3 Amount of Pain Experienced during the First Day

The VAS scores for THA and TKA patients combined were lower for the electronic group at all time points measured, while controlling for age, sex, BMI and procedure. At initiation of PCEA, the scores were 1.5 ± 2.9 for the conventional group and 0.5 ± 2.0 for the electronic group ($p = 0.001$). At 4 hours postoperatively, scores were 1.6 ± 2.2 for the conventional group and 0.8 ± 1.8 for the electronic group ($p = 0.011$). The mean VAS score throughout the time spent in the PACU was 1.5 ± 1.52 for the conventional group and 0.82 ± 1.08 for the electronic group ($p < 0.001$). One-third of the patients in the conventional group had a VAS in the PACU of 6 or greater, whereas only one-fifth of the patients in the electronic group had pain at that level (► Table 2). The THA patients in the conventional group had higher VAS scores than all the other groups (THA electronic, TKA) while in the PACU (► Figure 1). THA patients had a short-acting neuraxial anesthetic for surgery that regresses rapidly in the PACU, leaving these patients more vulnerable to a time lag in the initiation of PCEA. On POD 1, the longer acting neuraxial anesthetic and FNB resolved in the TKA patients, and these patients exhibited slightly more pain than the THA patients.

4.4 Amount of Pain Medication Used

The volume of PCEA administered at 4 hours was significantly lower for the electronic group (27.9 ± 20.2 ml) compared with the conventional group (34.8 ± 20.3 ml, $p = 0.001$), while adjusting for age, sex, BMI and procedure (► Table 3). Also, the electronic group had a significantly lower mean volume than the conventional group for PCEA administered at 8, 12, and 20 hours with difference in mean values of -5.9 ml (95% CI, -9.6 ml, -2.16 ml, $p = 0.002$), -4 ml (95% CI, -7.7 ml, -0.3 ml, $p = 0.034$), and -5.1 ml (95% CI, -8.8 ml, -1.39 ml, $p = 0.007$), respectively, while adjusting for age, sex, BMI and procedure. Also, patients in the electronic group received a lower volume of PCEA than the conventional group postoperatively extending into POD 1 (► Figure 2). At 8 hours into POD 1, TKA patients required a higher volume of PCEA than THA patients.

4.5 Length of Stay in PACU and in Hospital

Neither length of stay in the hospital nor time spent in the PACU was significantly different between the two groups (► Table 3).

5. Discussion

We compared patients who underwent total joint arthroplasty and received postoperative PCA before and after the implementation of CPOE. To our knowledge, this is the first study to address how the implementation of a CIS with CPOE affects post-operative pain relief. We found that after implementation of CPOE, it was possible to provide patients postoperative analgesia more quickly, thus reducing their pain levels, as well as the amount of pain medication required.

From a clinical perspective, early initiation of pain medication is extremely important because it constitutes “preemptive analgesia.” Preemptive analgesia is the delivery of analgesic medications before a patient experiences pain. It is used in an attempt to reduce central sensitization and to control the wind-up phenomenon.

In 2002, Møiniche et al. [11] published a meta-analysis of 80 randomized controlled trials of preemptive analgesia that had been reported between 1983 and 2000. Only a few of these trials demonstrated reduced postoperative pain in the preemptive analgesia group compared with the control. A 2004 update by the same authors [12], which included additional 30 randomized controlled trials, reported the same modest results. We speculate that one factor may have been the lapse of time in the PACU before post-operative analgesia was initiated, during which time the patient was left unprotected. For preemptive analgesia to be effective, adequate pain control must be present at all times. In the present study that gap was closed in the post-implementation group, with significantly positive results.

It is clear that significant changes in workflow occur after CPOE is implemented [15]. We found that post go-live PCA workflow is also considerably more efficient. Pre go-live, a standardized paper order set was prepared, and faxed from the PACU. The pharmacist would then verify the orders and prepare the PCA. Post go-live, the anesthesiologist orders from a standardized PCA order set, which is instantly received by the pharmacy. The pharmacist can view all incoming orders and prioritize those needing to be acted on immediately.

A number of studies have shown that implementation of CPOE improves medication Turn Around Time (TAT). In one study performed in a rehabilitation unit, there was a 23% reduction in TAT [16]. In another study, a comparison of 2 hospitals –one using paper and the other on an electronic system – showed a 56% improvement in time from ordering to the first dose of antibiotic [17]. Similar results were found in a surgical intensive care unit [18], in a surgical organ transplant unit [19], in a neonatal intensive care unit [20], and in labor and delivery [21]. Many studies have been performed in large academic centers, but these improvements have also been demonstrated in community-based medical centers [22].

Improvements in TAT have been attributed to a number of factors. The first is the instantaneous transmission of the order to the pharmacist, which in one study accounted for all the improvement in medication TAT [23]. In addition, with CPOE, orders are less likely to require pharmacist intervention because they are legible, and more likely to contain all the correct information needed by the pharmacist (e.g., the five rights: the right patient, right drug, right dose, right route, and right time, as well as other information such as concentration, etc.) which also decreases TAT [24].

Although it might be assumed that improved TAT for antibiotics and cardiac medications would result in improved clinical outcomes, there are few, if any, studies which demonstrate improved outcomes. To our knowledge, there have been no studies that focus specifically on TAT for PCA, where early delivery is imperative for preemptive analgesia to be successful. We have demonstrated both improved TAT as well as improved outcomes.

Although we did not directly address this, the use of standardized order CPOE, smart pumps and bar coding improves the overall safety of PCA use. This includes a decrease in severe respiratory depression attributed to the implementation of standardized order sets [25], as well as a decrease in reported post adverse drug events of all types [26]. We believe that because our post go-live group used less narcotics, a safety benefit might accrue.

Despite our improved analgesia and the reduced need for PCEA in the electronic group, we were unable to demonstrate earlier discharge from the PACU or hospital for these patients. However, it should be noted that discharge from both PACU and the hospital are based on multiple non-PCA related factors. . In addition, we have no information regarding differences in the length of time the PCA remained in the conventional group versus the electronic group. Our sample size was also

relatively small, which may be a reason why statistical significance was not demonstrated in some of our primary outcomes, such as LOS in hospital. Confounding is possible in retrospective studies when baseline characteristics may not be equal between the groups. In this study there were proportionally more THA patients in the conventional group than the electronic group.

6. Conclusions

Because pain management and early rehabilitation are crucial factors in functional outcome as well as patient satisfaction, we are constantly improving our pain control techniques. This study demonstrates that when using an electronic ordering system, patients received their analgesia in the PACU sooner, had less postoperative pain, and used less narcotics compared with patients under the previous paper-based ordering system. The institution of drug management through CPOE has made a significant contribution to the management of postoperative orthopedic pain.

Clinical Relevance Statement

We have demonstrated that the use of an electronic ordering system for postoperative PCA results in better outcomes for patients undergoing TKR and THR. Patients received analgesia sooner, had less postoperative pain, and used less medications compared with patients undergoing surgery under the previous paper-based ordering system.

Conflicts of Interest

The authors declare that they have no conflicts of interest in the research.

Human Subjects Protection

This study was performed in compliance with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects, and was reviewed by the Hospital for Special Surgery Institutional Review Board.

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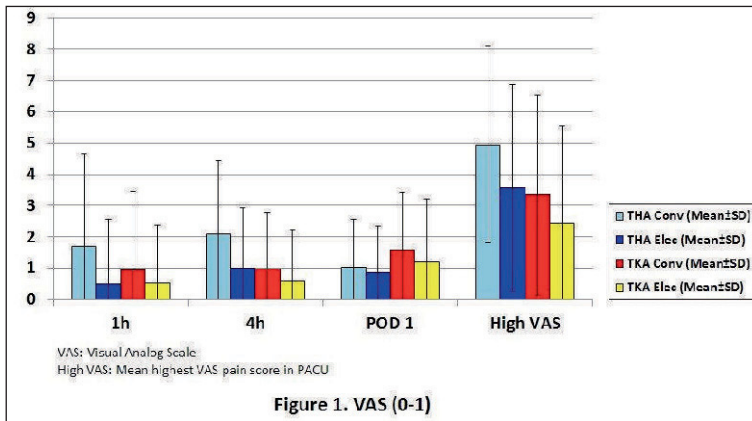


Fig. 1 VAS (0-1)

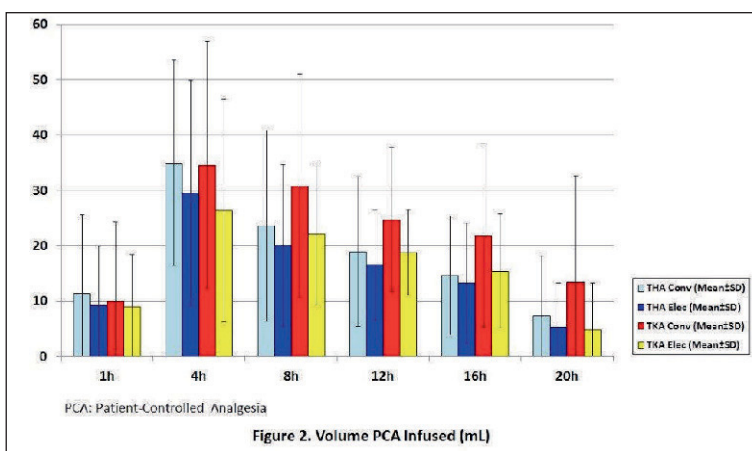


Fig. 2
Volume PCA Infused (ml)

	Electronic Group	Conventional Group	P value
All patients (n)	99	107	
Male, n (%)	38 (39.6)	44 (41.5)	0.758
THA patients, n (%)	46 (47.9)	59 (55.7)	0.304
TKA patients, n (%)	50 (52.1)	47 (44.3)	0.304
Age, Mean \pm SD (y)	66.9 \pm 10.9	67.1 \pm 11.2	0.925
Weight, Mean \pm SD (kg)	82.3 \pm 19.3	81.2 \pm 21.5	0.703
Height, Mean \pm SD (cm)	167.6 \pm 9.9	166.9 \pm 11.4	0.527

Table 1 Patient Demographics

THA, total hip arthroplasty; TKA, total knee arthroplasty.

Table 2 Summary of Results for VAS

	Electronic Group	Conventional Group	Difference in mean or Odds Ratio (95% CI)*	P value*
VAS: Initiation of PCEA, Mean \pm SD	0.5 \pm 2.0	1.5 \pm 2.9	-1 (-1.6, -0.38)	0.001
VAS in the PACU, Mean \pm SD	0.82 \pm 1.08	1.5 \pm 1.52	-0.7 (0.3, 1.0)	< 0.001
VAS: 1 h postoperatively, Mean \pm SD	0.5 \pm 2.0	1.4 \pm 2.8	-0.8 (-1.4, -0.2)	0.009
VAS: 2 h postoperatively, Mean \pm SD	0.7 \pm 1.9	1.5 \pm 2.7	-0.8 (-1.4, -0.15)	0.014
VAS: 3 h postoperatively, Mean \pm SD	1.1 \pm 2.2	1.8 \pm 2.5	-0.7 (-1.3, -0.1)	0.021
VAS: 4 h postoperatively, Mean \pm SD	0.8 \pm 1.8	1.6 \pm 2.2	-0.8 (-1.4, -0.18)	0.011
Patients (n) with VAS \geq 6, n (%)	16 (16.7)	36 (34.0)	0.39 (0.20, 0.79)	0.009

PACU, post-anesthesia care unit; PCEA, patient-controlled epidural analgesia; VAS, visual analog scale for pain, from 0 (none) to 10 (worst possible); CI, confidence interval.

*Obtained from regression models that were adjusted for age, sex, BMI and procedure

Table 3 Summary of Results for PCEA, PACU duration and LOS

	Electronic Group	Conventional Group	Difference in mean or Odds Ratio (95% CI)*	P value*
Time to PCEA infusion, Mean \pm SD (min)	24.5 \pm 28.3	51.1 \pm 26.2	-26.7 (-34, -19.3)	<0.001
Volume of PCEA at 4 h, Mean \pm SD (ml)	27.9 \pm 20.2	34.8 \pm 20.3	-7.1 (-10.8, -3.37)	0.001
Volume of PCEA at 8 h, Mean \pm SD (ml)	21.1 \pm 13.6	26.8 \pm 18.9	-5.9 (-9.6, -2.16)	0.002
Volume of PCEA at 12 h, Mean \pm SD (ml)	17.7 \pm 8.84	21.5 \pm 13.5	-4 (-7.7, -0.3)	0.034
Volume of PCEA at 20 h, Mean \pm SD (ml)	5.0 \pm 8.0	10.0 \pm 15.0	-5.1 (-8.8, -1.39)	0.007
PACU duration, Mean \pm SD (h)	10.7 \pm 11.4	9.2 \pm 8.3	1.4 (-1.23, 4.1)	0.287
LOS: THA, Mean \pm SD (days)	3.8 \pm 1.2	3.6 \pm 0.9	-0.2 (-0.6, 0.1)	0.213
LOS: TKA, Mean \pm SD (days)	4.1 \pm 2.1	4.1 \pm 0.9	-0.1 (-0.8, 0.5)	0.685

LOS, length of stay (hospital); PACU, post-anesthesia care unit; PCEA, patient-controlled epidural analgesia; THA, total hip arthroplasty; TKA, total knee arthroplasty; CI, confidence interval.

*Obtained from regression models that were adjusted for age, sex, BMI and procedure

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