

USP Quality Review

Patient-Controlled Analgesia Pumps

In noncritically ill patients, patient-controlled analgesia (PCA) has been shown to improve pain management with less sedation, less opioid consumption, and potentially fewer adverse effects (e.g., respiratory complications). PCA pumps offer several safety features to prevent the administration of excessive amounts of analgesic medication (e.g., a “lockout interval” that specifies the minimum amount of time between each dose and an established maximum allowable amount of drug during a predefined time period). Despite these advantages, medication errors involving PCA pumps continue to occur.

Data Analysis

USP examined medication errors submitted to its MEDMARXSM and USP Medication Errors Reporting (MER) Program from September 1, 1998, through August 31, 2003. To obtain PCA errors in MEDMARX, a text search for “PCA” in the *Error Description* field was conducted. Together, both programs yielded a total of 5,377 records. A total of 425 records (7.9%) were categorized as harmful (Category E-I¹) (Table 1). Given that the average overall harm rate for error reports submitted to MEDMARX over the past several years has been approximately 2 percent, it appears that when PCA pumps are involved, the chance for patient harm increases more than 3.5 times.

Table 1: PCA-Related Errors

ERROR CATEGORY ¹	COUNT	PERCENT (%)
A	474	8.8%
B	1,288	24%
C	2,568	47.8%
D	622	11.6%
E	387	7.2%
F	26	0.5%
G	0	0%
H	7	0.1%
I	5	0.1%
TOTAL	5,377	

¹For complete Error Category definitions, visit www.nccmerp.org/medErrorCatIndex.html.

The most common types of error involving PCA pumps were *Improper dose/quantity* (38.9%), *Unauthorized drug* (18.4%), and *Omission error* (17.6%) (Table 2).

Table 2: Types of Error¹

TYPE OF ERROR	COUNT	PERCENT (%)
Improper dose/quantity	1,873	38.9%
Unauthorized drug	887	18.4%
Omission error	846	17.6%
Prescribing error	443	9.2%
Wrong administration technique	230	4.8%
Extra dose	227	4.7%
Wrong drug preparation	203	4.2%
Wrong time	160	3.3%
Wrong patient	118	2.5%
Wrong dosage form	79	1.6%
Wrong route	29	0.6%
Deteriorated/expired product	15	0.3%
TOTAL	5,110	

¹Based on 4,812 records, making 5,110 selections for Type of Error

Selected Cases from MER

1 A male patient was admitted with intractable back pain and a history of arthritis and diabetes and was currently taking oral steroids. The patient was admitted after the pharmacy had closed for the night. For pain



control, the patient was ordered morphine PCA with a loading dose of 10 mg, a PCA dose of 4 mg every eight minutes, plus a continuous infusion dose of 2 mg/hour, with a four-hour limit of 130 mg. The patient received 81.7 mg for the first 5.5 hours and 21.3 mg for the next four hours. The patient was found to be unresponsive. A code was called and the patient did not respond and died due to respiratory arrest. The patient had been checked for vitals every hour as per routine. It was discovered after the event that the patient may have had undiagnosed sleep apnea.

2 Settings and concentrations for morphine PCA were ordered per standard protocol. In 1.5 hours, the patient received 4 doses of morphine via the PCA device and was noted as being “talkative, eating, and drinking.” Three hours later, a second nurse noted the patient as unresponsive but did not contact the physician. Over the course of the night, the patient received 3 more doses of morphine via the PCA device. Toward the end of the night shift, a third nurse noted that the patient was unresponsive and “gurgling” with lung crackles. The physician was contacted and ordered suctioning, naloxone, and furosemide. The patient’s condition improved but again deteriorated later in the day. The patient later expired. When the nurse was cleaning the room, she turned off the PCA device and removed the morphine solution. She noted that the solution in the IV bag did not correlate to the pump. The pump indicated the bag should contain 20 mL with a dose of 8 mg delivered. The nurse calculated that the bag should contain at least 80 mL. The nurse contacted a supervisor, who reviewed the pump settings, and discovered that the pump had been incorrectly programmed to deliver 1 mg/mL instead of 0.1 mg/mL.

3 A PCA-related error occurred in a hospital and it was discovered that the error was not due to a wrong drug, dose, or programming error, but from the overdosage of an opioid as a result of a practice-related error. The nurse, when assessing the patient's pain, would wake the patient to perform the assessment and then would push the PCA pump button on behalf of the patient. The nurse was attempting to assist the patient, but in reality was causing extreme over-sedation and the patient died.

4 A patient was ordered morphine PCA on the evening shift. A nurse mistakenly removed a meperidine PCA syringe from an automatic dispensing machine as an override medication. When the pharmacy reviewed the override medication removals the next morning, the error was discovered. The pump was checked and found to contain a meperidine PCA

cartridge, but the dose settings were programmed for morphine. The patient received two doses of 10 mg meperidine instead of 1 mg morphine. In this case, the pump does not read the syringe bar code to verify the correct medication, which might have prevented this error.

Recommendations Based on Analysis of Medication Errors

GENERAL

- ▶ Conduct a Failure Modes & Effects Analysis (FMEA) for existing pumps, as well as for new pumps that are brought into the facility. Consider what default settings are preprogrammed. Consider if the pumps can be programmed by drug (e.g., morphine PCA vs. hydromorphone PCA). Consider if the pump resets to a default (other than “000,” which would require active entry) after it turns off.
- ▶ Include bar codes on all PCA medications in facilities where point-of-care bar code systems or other item identification technologies (i.e., Radio Frequency Identification, etc.) are implemented.
- ▶ Review policies concerning patient’s own pump being used in the hospital.
- ▶ Educate patients, family members, and staff (including physical therapists, X-ray technicians, etc.) on the use of the pumps.
 - STAFF: Require proper and complete training and demonstration of competency before staff is permitted to work with pumps.
 - PATIENTS AND FAMILY MEMBERS: Written instructions should be provided to patients. Instruct family members **NOT** to administer PCA doses—PCA by definition should be administered at the patient’s perception of need. Document education of patient and family members.
- ▶ Dosing errors are usually by a factor of 10. Errors include the following:
 - Underdoses when lockout is at 4 hours (default) instead of 1 hour.
 - Order calls for 1 mg/hour but the pump is set at 0.1 mg/hour.
 - Order calls for 0.05 mg but the pump is set at 0.5 mg.
 - Other errors include insertion of the wrong drug or wrong concentration in the PCA device.

- ▶ Pumps should have upstream occlusion alarms.
- ▶ Educate staff on sound-alike and look-alike drugs, especially when bar code technology is not part of the existing system. Many wrong drug errors with PCA pumps are due to name confusion (e.g., morphine vs. hydromorphone vs. meperidine). Auxiliary labeling or posted warnings could be used to highlight differences. Limit the number of products and strengths used/stocked in the facility. Create alerts in computer systems with dosing limits specific to the drug being selected. Do not store sound-alike or look-alike drugs together in a single drawer of the dispensing cabinet on the floor. To view USP's list of similar drug names, visit www.usp.org/patientSafety/briefsArticlesReports/qualityReview/qr792004-04-01. USP also has a list of tips for using this resource at <http://www.usp.org/patientSafety/briefsArticlesReports/practitionerReportingNews/prn1182004-09-10.html>.

PRESCRIBING

- ▶ Lockouts should be required with bolus dosing.
- ▶ Have standing orders for all medications used in PCAs. Be certain that standing order forms have complete information to avoid handwriting information or drug names. Include specific dosing guidelines and protocols for individualizing therapy to patients based on pain response. Standardize concentrations available for PCA drugs.
- ▶ If using preprinted order forms, prohibit writing over information on the form. For example, one provider using a PCA order form that was preprinted with "meperidine" crossed out the drug and wrote "hydromorphone" without changing the basal rate, loading dose, and lockout dose, which caused the patient to become unresponsive, requiring an antidote.
- ▶ Avoid duplication of pain management therapy when PCA is in use. Develop protocols to transition to oral therapy from PCA therapy.

DISPENSING

- ▶ Standardize the strengths/concentrations available in your facility. Be sure physicians are aware of the standard concentrations in use. If higher concentrations are needed for a particular patient or certain settings, conduct FMEA to ensure additional safeguards are in place.

- ▶ Separate PCA syringe locations in automated dispensing systems to prevent selection of the wrong drug.

ADMINISTERING

- ▶ Double-check clamp (to open position) before closing the pump.
- ▶ Check that the pump is turned on.
- ▶ Check whether connections are to IV or epidural lines to prevent wrong-route errors.
- ▶ Check for kinked tubing in the pump door. Despite a kink in the tubing, at times no alarm may sound and the volume may be counting down.
- ▶ Perform double checks for initial setup and maintenance, and dose changes/change orders.
- ▶ Standard orders should be on the medication administration record.
- ▶ Conduct staff education on the importance of not administering oral medications (i.e., narcotics and controlled substances) to a patient with a PCA in use unless specifically ordered.
- ▶ Temporary nurses (agency or supplemental staff) need to review and be familiar with policies and protocols regarding PCAs and demonstrate competency in the use of this technology.
- ▶ Do not accept defaults blindly.
- ▶ Set pumps to be programmed in mg, NOT mL.
- ▶ Pumps should be assessed on a regular basis.

MONITORING

- ▶ If patient complains of pain, reassess pump settings. Check that the basal rate has been entered. Also check that the tubing is not kinked.

Acknowledgment is given to the following members of the USP Safe Medication Use Expert Committee, who provided review and comment on these recommendations:

- Mark Sullivan, PharmD, MBA, BCPS
Vanderbilt University Medical Center
- Marjorie Shaw Phillips, RPh, MS, FASHP
Medical College of Georgia Health System
- Philip Schneider, MS
Ohio State University

USP operates two complimentary error reporting programs: the USP Medication Errors Reporting Program, presented in cooperation with the Institute for Safe Medication Practices, and MEDMARXSM. For information on how to report errors, visit www.usp.org/patientsafety or call 1-800-23-ERROR (1-800-233-7767).