Misprogramming Patient-Controlled Analgesia Levels Causes Dosing Errors

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**Problem:** The Institute for Safe Medication Practices (ISMP) has received a small but worrisome number of reports of overdoses related to patient-controlled analgesia (PCA) as a result of pump-programming errors. Although every aspect in the PCA process has the potential to result in an error, the ISMP is especially concerned about errors related to the concentration of the narcotic. Accidentally entering a higher than actual concentration of drug in the pump results in the delivery of a lower PCA dose than prescribed. This can mean that the patient’s pain might not be controlled.

If an increased dose—and thus an increased rate of infusion—is prescribed to meet the patient’s needs, subsequent changes of the PCA syringe or bag, for which the concentration is then reprogrammed correctly, may result in the delivery of more drug than is necessary, causing a risk of respiratory depression. At the same time, dosing errors resulting from inadvertently programming a lower than actual concentration of the narcotic into the infusion pump results in the delivery of a higher PCA dose than prescribed—frequently 10 times more than intended. These are the more dangerous errors that have led to adverse drug events (ADEs), including fatalities. (A discussion on inverse relationships appears in the sidebar on page 75).

Although many organizations use a standard concentration for each PCA drug, occasionally morphine, hydromorphone, or fentanyl concentrations are customized for patients who are opioid-tolerant. These concentrations are significantly higher than those typically used for opioid-naive patients. The concentrated drug allows less frequent changes of the syringe or bag.

Errors in initiating PCA infusions can occur at any point in the programming process. By using a limited number of standard concentrations, standardizing order forms, implementing smart PCA pumps with dose error-reduction software (DERS), and requiring an independent double-check of the PCA programming, hospitals can develop effective tools to help reduce PCA dosing errors. However, the risk of a PCA error increases significantly when there are atypical orders, nonstandard concentrations, and unusually high doses.

In reports received by the ISMP related to concentrations of PCA infusions, several common findings merit attention:

- **A lower-than-intended programmed concentration.** Several reports were associated with programmed concentrations that were significantly lower than the actual drug concentration. For example, a 60-mL syringe with a standard concentration of 1 mg/mL was inadvertently programmed as containing a 1- mg/60-mL concentration. This resulted in a programmed concentration that was 1/60th of the actual concentration, and a single patient request for a 1-mg dose resulted in the delivery of 60 mg (60 mL) of the narcotic in the syringe.

- **Significance of low-concentration errors not always understood.** Some smart PCA pumps with dose error-reduction software can alert a nurse that the concentration is too low. The alert can be soft (which allows it to be overridden) or hard (requiring the user to reprogram the pump). The ISMP has evaluated such errors when smart PCA pumps with dose error-reduction software were used. When a higher custom concentration was accidentally programmed using the more typical lower concentration, the pumps identified the error with a low-concentration alert. However, the significance of low-concentration alerts might not have been appreciated. The soft alerts were sometimes overridden, and patients received PCA overdoses. Because the primary emphasis on averting intravenous (IV) errors has been focused on doses that are too high and exceed the maximum limits, it appears that the low-concentration soft alert could be interpreted incorrectly as being similar to “low-dose” alerts that are frequently displayed as the doses of drugs are being titrated downward before an infusion is stopped.

- **Confusing the concentration.** For clarity, the ISMP recommends that the PCA syringe and bag label include both the concentration, expressed as the amount of drug/mL, and the total amount of drug in the final volume. However, this does not eliminate the possibility of confusion and a misreading of the actual concentration, which could result in a programming error.

In one instance, a PCA pump that was equipped with dosing error-reduction software had two standard morphine concentrations (1 mg/mL and 5 mg/mL) in the drug library. A third custom concentration of “___ mg/___ mL” was included in the drug library to accommodate nonstandard concentrations. Although the PCA syringe contained 125 mg in 25 mL (the 5-mg/mL standard concentration), the custom concentration was selected and the concentration was programmed incorrectly as 5 mg/25 mL or 1/25th of the actual concentration. The soft low-concentration alert was overridden, and the entire syringe was administered the first time the patient pressed the dose request button. Fortunately, the patient had a high tolerance for opioids, and no harm occurred. In an opioid-naive patient, however, the outcome could have been catastrophic.

**Safe Practice Recommendations:** The following steps should be taken to reduce the potential for errors when a PCA pump is being programmed:
Assessing the procedure’s vulnerability to serious errors. Medication safety teams should review current practices concerning the use of customized concentrations. In particular, the team should assess the vulnerability to concentration-related programming errors and the use of multiple standard concentrations and custom concentrations. The risk of serious AEs resulting from these vulnerabilities should be communicated to all clinical staff members, and the recommendations that follow, as well as others that arise from the medication safety team’s assessment, should be implemented and monitored for effectiveness.

Limiting concentrations. When possible, a single, standard concentration for each PCA drug should be used. If the P&T committee decides that more than one concentration is necessary, the number of standard concentrations should be limited to two at the most. Use of custom concentrations should be minimized and, when possible, restricted to selected patient-care areas.

Distinguishing custom concentrations. When a custom concentration is necessary, the container label should be distinctive in appearance and should not look like the standard PCA syringe or bag label. Auxiliary (e.g., high-potency) labels and a different color pharmacy label, along with specific instructions for programming the pump, should be used for custom concentrations.

Clarifying the label. The ISMP usually recommends presenting the total drug concentration in the bag or syringe first, followed by the amount of drug per mL below this level within the same background or border on the product label. Depending on the PCA pump vendor, however, the user may be prompted to enter the concentration in a mg/mL strength. In these cases, it would be safest to express the concentration with the amount of drug per mL listed first, then the total amount of drug per total volume in the syringe or bag below this level.

Matching medication administration records (MARs) to the label. The concentration on the MAR should be listed the same way as it is presented on the PCA label. This practice can prevent confusion when the actual product label is compared with the verified order on the MAR.

Implementing an independent double-check method. The narcotics used for PCA are high-alert medications; thus, an independent double-check of the product and pump programming should be considered. When replacing an empty syringe or bag, the clinician should compare the empty container with the new container to verify that the concentrations are the same.

Adopting bar-coding technology. Some infusion pumps incorporate bar-coding technology. Scanning the bar code on the PCA bag usually helps to ensure that the correct concentration is entered during the programming of the PCA pump.

Using smart pumps. If possible, PCA pumps with dosing error-reduction software should be selected. Because the significance of a low-concentration alert is not always fully appreciated, low-concentration limits should always be set as hard limits. Clinical advisories are also encouraged to reinforce caution when custom concentrations are used.

The reports described in this column were received through the ISMP Medication Errors Reporting Program (MERP). Errors, close calls, or hazardous conditions may be reported on the ISMP Web site (www.ismp.org) or communicated directly to ISMP by calling 1-800-FAIL-SAFE or via e-mail at ismpinfo@ismp.org.