

Acute Care

ISMP Medication Safety Alert!®

Educating the Healthcare Community About Safe Medication Practices

Smart pump custom concentrations without hard “low concentration” alerts can lead to patient harm



PROBLEM: Earlier this month, ISMP held its second national summit on smart infusion pumps. The first summit, held in 2008, examined smart pump implementation, drug libraries, and clinical practice, and resulted in publication of the *ISMP Guidelines for Safe Implementation and Use of Smart Infusion Pumps* in 2009. Since then, smart pump technology has evolved, and its application has spread to nearly all US hospitals. During our latest summit, we focused on optimizing use of the technology during administration of secondary and intermittent infusions, patient-controlled analgesia (PCA), epidural infusions, plain IV solutions, and perioperative/anesthesia medications; preparing for pump-electronic health record (EHR) interoperability; and library analytics.

While preparing for the 2018 national summit, ISMP conducted several surveys to help inform the discussions. One of the surprising results was low compliance with setting hard stops (requires reprogramming) for minimum concentration limits when programming custom concentrations. Sometimes called “wild card” entries, programming a custom concentration entails selecting a drug from the library but then manually entering the concentration (e.g., xx mg/xx mL). According to a survey of more than 600 practitioners, only half of those who answered the question reported a hard stop for minimum concentration limits when programming custom concentrations. The survey also revealed that almost half of all respondents, including 29% who directly manage the drug library, were confused by the question or unsure whether their pumps had a hard stop for minimum concentration limits for custom concentrations.

The misuse of custom concentration options that do not employ a hard minimum concentration limit contributes largely to preventable errors given the counterintuitive, inverse relationship between the concentration and the volume. More concentrated drugs require less volume to deliver a specified dose; less concentrated drugs require more volume to deliver a specified dose. When using “fill-in-the-blank” custom concentrations, the con-

continued on page 2—[Low concentration alerts](#) >

Handling potentially flawed Carpuject syringes

Hospira, a Pfizer company, released a letter last week, in coordination with the US Food and Drug Administration (FDA), detailing instructions for handling certain drugs and lot numbers of **CARPUJECT** glass syringes that may have cracked needle hubs and/or contain particulate matter (www.ismp.org/ext/24). The list includes certain strengths and sizes of heparin, labetalol, **LORazepam**, morphine, and **HYDRO**-morphine. The letter may not have been clear in stating that the cracked needle hubs and particulates are separate issues the company identified during routine inspection/quality checks. Still, a cracked hub could allow air to reach the outer cartridge (but not the solution inside). We confirmed with Hospira that none of the affected lot numbers are currently in the field. Although the company says the probability of a cracked hub is low, it was enough to hold up distribution until now. To help reduce critical drug shortages, the company has begun to release the affected lots, which should reach wholesalers by mid-June.

Providers are being asked to unpack the syringes and visually inspect the cartridges to

continued on page 4—[Carpuject syringes](#) >

NANALERT

ISMP released a **National Alert Network (NAN)** alert last week about safe handling of concentrated electrolyte products from outsourcing facilities during critical drug shortages. The alert arose from complaints about unsafe conditions when outsourcing facilities provide concentrated electrolyte products that do not adhere to USP <7> and US Food and Drug Administration (FDA) labeling requirements, which must be followed by commercial manufacturers. Please review the alert here: www.ismp.org/node/1079.

SAFETY briefs



Preventing SUMAtriptan injection wrong route errors. On six occasions within a 4-month period in the same health system, **SUMAtriptan** has been given intravenously (IV) instead of subcutaneously. The errors have occurred in both large and small hospitals in the health system and in medical-surgical units and the emergency department (ED). Although the health system uses a barcode scanning medication administration system to verify that the right product at the right time is in hand for the right patient, the technology cannot detect if the drug is then administered by the wrong route. Most errors have occurred while practitioners are administering several IV medications to patients, and then have forgotten that **SUMAtriptan** should be administered sub-

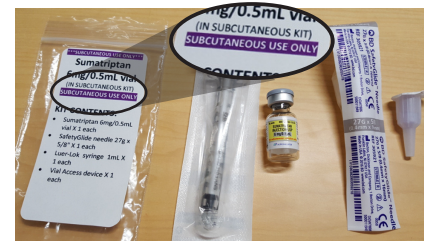


Figure 1. SUMAtriptan kit contains materials for subcutaneous injection, including a subcutaneous needle.

continued on page 2—[SAFETY briefs](#) >

> **Low concentration alerts**—continued from page 1

centration must be programmed into the pump so it can calculate the volume needed to deliver the prescribed dose. If the programmed concentration is lower than the actual concentration in the infusion bag or syringe, the pump will deliver an overdose. If the programmed concentration is higher than the actual concentration in the bag or syringe, the pump will deliver an underdose. Without a hard minimum concentration limit, the former scenario has led to life-threatening events, such as those described below.

*A physician prescribed IV **HYDRO**morphine 20 mg/100 mL (0.2 mg/mL) to infuse at 2.5 mg/hour. The standard concentration for this infusion was 0.1 mg/mL, so the custom concentration of 0.2 mg/mL had to be manually entered into the smart pump. The nurse selected the custom concentration option and then mistakenly entered 2.5 mg/100 mL as the concentration instead of 20 mg/100 mL. Given the erroneously programmed concentration of 0.025 mg/mL, the pump issued a soft (i.e., can be overridden) low concentration alert. The nurse overrode the warning, mistakenly believing the “low concentration” warning was inconsequential. The pump infused the drug at a rate of 100 mL/hour, while the intended rate was 12.5 mL/hour. The pump delivered the entire bag of **HYDRO**morphine 20 mg to the patient in 1 hour. The clinical outcome of the patient was not reported.*

An infusion of IV furosemide 10 mg/hour was prescribed. When programming the smart pump, a nurse selected the custom concentration option and then accidentally entered the concentration as 10 mg/100 mL (0.1 mg/mL) instead of the intended 100 mg/100 mL (1 mg/mL). The pump had a soft low concentration limit set at 0.2 mg/mL, so a soft alert was issued. The nurse bypassed the alert, and the entire bag containing 100 mg of furosemide infused in 1 hour instead of 10 hours. Fortunately, the patient was not harmed.

Milrinone IV was prescribed to infuse at 2.5 mg/hour. The pharmacy dispensed a 20 mg/100 mL (0.2 mg/mL) milrinone infusion bag. Using the custom concentration option, a nurse set the concentration as 0.2 mg/100 mL. The entire bag containing 20 mg infused in a matter of minutes instead of infusing over 8 hours. The patient required a bolus of IV fluids to treat hypotension, but no changes in the patient’s heart rhythm were reported.

Other serious smart pump-related errors have occurred when practitioners have unnecessarily selected a custom concentration option, and then entered the wrong concentration, even though a standard concentration option for the drug was available in the pump library. In these cases, programming errors would have resulted in a hard stop had the standard concentration pathways been employed. Examples of this type of error follow.

A physician prescribed IV heparin to infuse at 800 units/hour. The pharmacy dispensed 25,000 units of heparin in a 250 mL bag. Although this standard concentration was in the pump library, the nurse selected the custom concentration option and erroneously entered the heparin concentration as 800 units/250 mL. Given the erroneously programmed concentration of 3.2 units/mL, the pump infused the drug at 250 mL/hour, not the intended rate of 8 mL/hour. The pump delivered 25,000 units of heparin to the patient in 1 hour. The patient required IV protamine but did not experience significant bleeding.

A physician prescribed IV insulin (regular) 12.5 units/hour for a patient with hyperglycemia. A standard insulin infusion of 100 units/100 mL (1 unit/mL) was dispensed from the pharmacy. When programming the pump, the nurse failed to select the standard insulin concentration and instead used the custom concentration option to enter an erroneous concentration of 5 units/100 mL (0.05 units/mL). The pump infused the drug at a rate of 250 mL/hour. The entire bag containing 100 units of insulin infused in approximately 20 minutes. The patient’s outcome was not reported.

A physician prescribed morphine PCA for an opioid-tolerant patient with a demand dose of 1.5 mg, a lockout of 10 minutes, and a basal rate of 1.5 mg/hour. The pharmacy dispensed a 60 mL syringe of morphine 55 mg/55 mL. Instead of using the standard con-

continued on page 3—**Low concentration alerts** >

> **SAFETY** briefs cont’d from page 1

cutaneously. No other causal patterns have been identified.

To support correct subcutaneous administration, the health system is devising a kit that contains the drug vial, a 1 mL syringe, and a 27-gauge subcutaneous needle packaged in a small Ziploc bag. The bag has a label on the outside, stating the name and dose of the drug along with several distinct warning statements that it is intended for “SUBCUTANEOUS USE ONLY” (Figure 1, page 1). Other risk-reduction strategies include having pharmacy prepare and dispense syringes of **SUMAT**riptan as needed, with auxiliary labels to warn about subcutaneous use only, or stocking the nasal formulation of **SUMAT**riptan, which has a similar onset of action, in appropriate patient care areas such as the emergency department. Prompting nurses to document the location of the subcutaneous injection may also serve as a reminder that the drug should be administered by that route. There are also auto-injectors and pens available, but these are meant for self-injection by patients.



Yellow fever vaccine overdoses. Organizations that operate travel clinics authorized to administer yellow fever vaccine (**YF-VAX**) and issue vaccination certificates, might want to examine how the vaccine is supplied. The vaccine should be administered to individuals who are at least 9 months old who are traveling to or living in areas around the world with risk for yellow fever virus transmission. **YF-VAX** is available in single-dose or 5-dose vials. The single-dose vials are supplied in a package of 5 vials of lyophilized powder, with 5 vials of diluent (each containing 0.6 mL sodium chloride) provided separately. Vials containing 5 doses are larger in appearance, and the diluent, also supplied separately, is a 3 mL sodium chloride vial. The vaccination dose is 0.5 mL administered subcutaneously.

The Centers for Disease Control and Prevention (CDC) recently reviewed data submitted to the Vaccine Adverse Event Reporting System (VAERS) and identified 15 cases where military or civilian travelers were vaccinated using the entire 5-dose vial of **YF-VAX** reconstituted with 0.6 mL of diluent before administration (McNeil MM,

continued on page 3—**SAFETY** briefs >

> **Low concentration alerts**—continued from page 2

centration (1 mg/mL) option in the library, the nurse entered a custom concentration of 1.5 mg/55 mL, which resulted in a concentration of 0.027 mg/mL. Given the basal rate of 1.5 mg/hour, the patient received the entire 55 mg of morphine within an hour and was transferred to an intensive care unit for treatment. No outcome was reported.

Some of the above-cited errors appear to be mental mix-ups in which the “dose per hour” was paired with the total infusion volume—for example, a heparin dose of 800 units/hour from a 25,000 units/250 mL bag ended up as a concentration of 800 units/250 mL. One of the errors appears to be a mix-up in which the “per mL” concentration was paired with the total infusion volume—for example, a 0.2 mg/mL concentration of milrinone in a 20 mg/100 mL bag ended up as a 0.2 mg/100 mL concentration. Sometimes, the way the concentration is expressed on labels, particularly if the label includes technician instructions for admixture, has also contributed to mistaken concentrations. Custom concentration options that inadvertently remain in the drug library after a limited number of standard concentrations have been added to the library is another factor associated with errors. Custom concentrations may be required for some medications that are dosed according to body weight or surface area. But leaving the option open to enter the concentration of infusions that have since been standardized needlessly increases the risk of patient harm.

Another factor in some of the above-cited errors is misunderstanding the significance of a soft low concentration alert. Since the primary emphasis on averting IV errors is often on doses that exceed maximum limits, “low concentration” soft alerts may be misinterpreted as being similar to “low dose” alerts. Pharmacists responsible for building and maintaining pump libraries also may not fully appreciate the importance of building hard stops for low concentration alerts, particularly for high-alert medications.

SAFE PRACTICE RECOMMENDATIONS: There are several lessons to be learned from these events to maximize safety when using custom concentrations with smart infusion pumps.

Standardize concentrations. When possible, use a single, standard concentration for each drug infusion. If more than one concentration is necessary, limit the number of concentrations to two, and avoid concentrations that differ by a factor of 10 (e.g., 0.1 mg/mL and 1 mg/mL, 1 mg/mL and 10 mg/mL), which could be confused by a misplaced decimal. Be sure the pump library reflects the standard concentration(s) used for each drug. Use of custom concentrations should be curtailed and, when possible, restricted to selected patient care areas. Remove custom concentration options from the pump library when a standard concentration for that drug has been established and built into the library.

Set hard minimum concentration limits. For each drug, especially a high-alert medication, that allows a custom concentration option in the library, set a hard minimum concentration limit that requires reprogramming to avoid a catastrophic overdose.

Educate staff. Educate staff regarding the inverse relationship between the concentration and the volume, and the significance of low concentration alerts.

Distinguish custom concentrations. Should a custom concentration be unavoidable, make the container label distinctive compared to labels on containers containing a standard concentration. Affix auxiliary labels as appropriate.

Require doses to be expressed in the metric unit. Ensure that doses in protocols and order sets for infusions include the metric unit of dosing (mg/hour, mcg/kg/hour, etc.). An order for an infusion with just the infusion rate (e.g., mL/hour) should not be accepted, even if only one standard concentration of the medication is being used hospital-wide. Standardized order sets and electronic prescribing systems should allow the prescriber to select only the standard concentration(s) when applicable. Also, orders for infusions should not be prescriptive regarding the concentration—only the patient’s dose (mg/hour, mcg/kg/min, etc.) should be specified to avoid the risk of variable concentrations

continued on page 4—**Low concentration alerts** >

> **SAFETY briefs** cont’d from page 2

Hibbs BF, Miller ER, Cano MV. Notes from the field: Errors in administration of an excess dosage of yellow fever vaccine—United States, 2017. *MMWR Morb Mortal Wkly Rep.* 2018;67[3];109–10. Only one report described symptoms: a 30-year-old man was evaluated in an emergency department for intermittent upper abdominal and arm pain 1 day after inadvertent administration of the entire 5-dose vial. His symptoms resolved following supportive intravenous (IV) fluid therapy. In addition, the ISMP National Vaccine Errors Reporting Program (ISMP VERP) includes 4 cases in which the wrong diluent or wrong amount of diluent was used, including one diluent error involving the 5-dose vial.

CDC mentioned that preventive measures, such as more distinctive packaging and staff education in clinics that stock both the single- and multiple-dose vials might be helpful. However, ISMP recommends making only the single-dose vials available, which would eliminate the risk of administering the entire 5-dose vial as a single vaccine dose. The vials of lyophilized vaccine powder must be stored under refrigeration at 2° to 8°C (35° to 46°F) and must not be frozen. To decrease wrong diluent errors, such as the use of sterile water, establish a process to keep the sodium chloride diluent vials and lyophilized vaccine powder vials together. Dispense the products together in a bag with an auxiliary label to remind staff to use the diluent provided.



Error reports with Shingrix herpes zoster vaccine. SHINGRIX (zoster vaccine recombinant, adjuvanted, or RZV) must not be confused with ZOSTAVAX (zoster vaccine live, or ZVL). As mentioned in our February 22, 2018 newsletter, Shingrix and Zostavax have different vaccine schedules, storage requirements, components/diluents, and routes of administration. A table describing the key differences can be found at: www.ismp.org/ext/25. In the past 8 weeks, we have received 4 error reports involving these vaccines through our National Vaccine Errors Reporting Program (ISMP VERP). These involve improper storage as well as administration errors.

In our previous *Safety Brief*, we emphasized that the product components are not interchangeable. Both components of the
continued on page 4—**SAFETY briefs** >

> **Low concentration alerts**—continued from page 3

being ordered. If fluid restrictions are necessary for a patient, a “double” or “triple” concentration can be prescribed without specifying the amount of drug per mL.

Tailor labels to MAR/pump settings. The medication administration record (MAR) and the infusion label should present the drug and concentration (and infusion rate, if provided) in the same units and sequence required when programming the pump, with specific instructions for custom concentrations as necessary. Technician preparation instructions (e.g., calculations) should not be included on the final product label.

Verify pump programming. At hospital-defined steps (e.g., new bag/bottle/syringe, change in the rate of infusion) for selected high-alert medications, require an independent double check using the EHR/MAR/eMAR and available technology (e.g., smart pumps, barcode scanning technology) to verify and document the following before starting the infusion: drug/solution, drug concentration, rate of infusion, patient, channel selection, and line attachment. (With interoperability, the latter two elements still require practitioner verification if technology is employed to verify/autopopulate the other elements.) Exception: Titrated medications (e.g., vasopressors) to effect. Be sure the final infusion rate falls within an expected range. Entering an erroneous, low concentration will often result in a high, atypical infusion rate, which should serve as a signal to reverify the pump settings.

Analyze data. Routinely evaluate the metrics that are available with smart pumps to identify the use of custom concentrations, hard stops for minimum concentrations, soft alert overrides, actions taken in response to these alerts, and other vulnerabilities that may lead to errors. Take action to reduce identified risks. If nurses are using the custom concentration option to program standard concentration infusions that are available in the library, investigate the underlying reasons that may be driving this practice.

Look for our updated smart pump guidelines later this year! We will let readers know when the draft guidelines are available on our website for public comment.

> **Carpject syringes**—continued from page 1

confirm there are no cracks to the needle hub or visible particulate matter or discoloration. The letter includes photos that show what to look for. If cracks or particulates are observed, the syringes should be discarded. If not, photos show how to withdraw the medication from the Carpuject cartridges. The letter notes that the contents of all impacted Carpuject syringes should be filtered with a 5 micron filter needle to remove nonvisible particulates and prepare the drugs for administration.

ISMP believes that nurses should not be expected to inspect all syringes or use a filter needle to withdraw the Carpuject contents into another syringe. Using a cartridge as a vial is an unsafe practice that leads to unlabeled syringes and could impact sterility. It could also lead to the false assumption that the cartridges from other devices (e.g., pens) can be safely used as vials. We have heard from practitioners who are concerned about the letter recommending this practice. Although Hospira notes that using the Carpuject as a vial is not routine, the practice may be difficult to reverse once it is no longer needed. Furthermore, nurses are often not familiar with using filter needles to draw up products from Carpujects.

Instead, pharmacists should inspect the syringes. If no problems are visualized, staff should swab cartridge stoppers with alcohol (as with a vial), withdraw the contents per the company's instructions, and then dispense properly labeled syringes with a beyond-use date. Any controlled substances should be handled the same as a compounded controlled substance (e.g., tracking chain of custody, capping with a secure tamper-evident cap). This interim process will take substantial pharmacy time and resources. However, these are extraordinary times, and critical drug shortages have left us with few safe options.

The root cause of the cracked needle hubs and particulate has been identified, and corrective and preventative actions are now in place. Hospira told us new product that may be used as normal will reach wholesalers in July.

> **SAFETY briefs** cont'd from page 3

Shingrix vaccine, its lyophilized gE antigen component and its adjuvant suspension component, should be stored under refrigeration, before and after reconstitution (see package insert for details). If the lyophilized component or its adjuvant suspension are improperly stored in a freezer, they must be discarded. The storage requirements for Zostavax differ. The lyophilized vaccine (attenuated varicella-zoster virus) should be stored in a freezer, and the Merck-supplied sterile water diluent can be stored in a refrigerator or at room temperature. Also, Shingrix is administered intramuscularly (IM), and Zostavax is administered subcutaneously.

A system should be employed to ensure the Shingrix lyophilized component and adjuvant suspension vials are stored with one another to reduce the risk of using a diluent from another vaccine. The Centers for Disease Control and Prevention (CDC) recently updated the information about proper storage, administration, and handling of the two vaccines along with strategies to prevent administration errors (www.ismp.org/ext/22). Given that Shingrix and some other vaccines are administered IM in the deltoid, an infographic on preventing shoulder injuries when vaccines are given by this route is also provided. Improper IM injection of vaccines could result in bursitis, tendonitis, or other shoulder injuries. You can access and print a PDF of the infographic at: www.ismp.org/ext/23.

To subscribe: www.ismp.org/node/10



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