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Acute Care
ISMP Medication Safety Alert!®
Educating the Healthcare Community About Safe Medication Practices

Smart Pump Challenges Persist — Avoid Common Programming Pitfalls

Problem: In our October 20, 2022 article, Safety Considerations for Challenges When Using Smart Infusion Pumps, we discussed safety risks and limitations that healthcare practitioners face when trying to optimize drug libraries and implement important safeguards to prevent catastrophic programming errors. Unfortunately, practitioners continue to report a variety of smart pump-related errors to ISMP, highlighting that this safety concern is real and continues to exist. It is particularly risky when end users need to manually select between pump screen options due to medications with different indications, variable dosing units, dose limits, or administration rates. As with most preventable adverse events, many latent system issues need to align perfectly with active failures of individuals to reach the patient. It is also important to note that even before the pump programming step, there were several contributing factors at play in the error reports described below (e.g., verbal communication misinterpreted, pump programmed without an order on the medication administration record [MAR]). However, as you review these events, think about human and system factors and how user interaction with the smart pump screen options influenced the outcomes.

Recent Errors Reported to ISMP

Case 1: *An ICU prescriber consulted a neurologist for a patient who was seizing. The neurologist recommended a midazolam infusion "at status epilepticus dosing." The ICU prescriber verbally told the nurse that they wanted midazolam to "start at 2 mg," intending to order 2 mg/hour. The organization had configured the critical care drug library for midazolam infusions with two options based on indication; each had different dosing units. The "Sedation" option was set up as mg/hour, and the "Status Epilepticus" option was set up as mg/kg/hour. The nurse selected the "Status Epilepticus" option and entered "2," which had mg/kg/hour dosing units. After 30 minutes, the pump alarmed that there was air in the line, and the nurse saw that the midazolam bag was empty. It was then that the nurse realized the midazolam had infused at 2* ***mg/kg/hour*** *instead of* ***2 mg/hour*** *as intended. The dose error-reduction system (DERS) did not generate an alert for the 2 mg/kg/hour rate because this was within the dose range built for status epilepticus. The nurse notified the ICU prescriber and the pharmacist. The patient was intubated, and their blood pressure dropped slightly, but then returned to baseline.*

Case 2: *A hospital reported multiple errors after nurses accidentally programmed patients' titratable infusion doses into the rate field rather than the dose field, resulting in wrong infusion rates. The pump screen displays the rate (e.g.,* ***mL****/hour) first, followed by the dose (e.g.,* ***mg****/hour,* ***mcg****/min). In one case, a prescriber ordered a* ***HYDRO****morphone infusion (0.2 mg/mL) with instructions to start at 0.5 mg/hour and titrate up by 0.5 mg/hour. The nurse intended to program the infusion to begin at 0.5 mg/hour but entered 0.5 into the rate field instead of the dose field. The patient was administered 0.5 mL/hour (0.1 mg/hour), a 5-fold underdose. Nurses titrated the rate up several times, each time in the rate field rather than the dose field. The patient's dose was only increased each time by 0.1 mg/hour instead of 0.5 mg/hour. In another case, a prescriber ordered a norepinephrine infusion at 16 mcg/mL with instructions to titrate to a maximum dose of 30 mcg/min. The nurse thought they had titrated to the maximum dose, and vasopressin was prescribed and administered for additional pressor support. The nurse later identified that they had programmed the pump to run at 30 mL/hour (8 mcg/min) instead of 30 mcg/min (112.5 mL/hour).*

continued on page 2 — Smart Pump Challenges Persist >

SAFETY briefs

Procainamide Prefilled Syringes Pose Risk for Undiluted IV Push. Due to a nationwide shortage of procainamide injection 1,000 mg/10 mL vials, an organization was allocated procainamide 1,000 mg/10 mL supplied in prefilled luer-lock syringes. The procainamide cartons and syringes look similar to ready-to-administer emergency intravenous (IV) medications, including **EPINEPH**rine, atropine, and sodium bicarbonate, which are all designed to be administered undiluted via IV push. The reporting organization expressed concern that the entire procainamide prefilled syringe could accidentally be given as an IV push due to this similarity, rather than being diluted and administered as an IV infusion as intended.

On the procainamide carton, the statement "FOR THE PREPARATION OF I.V. INFUSIONS ONLY" appears in small text that may be missed during urgent or emergent situations (**Figure 1**). In a high-stress environment, a practitioner could reasonably assume the product is appropriate for IV push based on its presentation and packaging, potentially leading to a serious or fatal medication error. The procainamide prefilled syringes are manufactured by International Medication Systems, which also makes several emergency medications in similar prefilled syringe formats designed for IV push use.

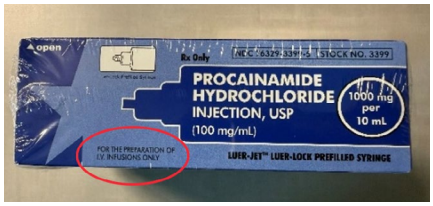

Figure 1. The carton containing a 1,000 mg/10 mL procainamide syringe states "FOR THE PREPARATION OF I.V. INFUSIONS ONLY," but a practitioner could administer the entire contents via IV push.

continued on page 2 — SAFETY briefs >

> Smart Pump Challenges Persist — continued from page 1

Case 3: *Another hospital reported an event that occurred during a code in the ED. A prescriber gave a verbal order to a nurse to administer a 1 mg/kg lidocaine intravenous (IV) bolus to the patient due to repeated episodes of ventricular tachycardia. The nurse searched for a lidocaine order in the electronic health record (EHR) and selected an order for lidocaine 2 g in 250 mL of 5% dextrose in water infusion at 1 mg/min. The nurse added a free-text comment "verbal order for weight-based bolus 1 mg/kg, patient weight 60 kg, 60 mg bolus over 75 seconds followed by drip." The nurse removed a bag of lidocaine from the code tray. When the nurse attempted to program the lidocaine bolus dose in the smart infusion pump drug library, they received an unknown error message and administered the lidocaine without using a smart pump. The entire lidocaine 2 g bag was infused. The patient became bradycardic and arrested. A pharmacist who was responding to the code questioned why the bag was empty and identified the error. The prescriber ordered a lipid rescue infusion, which the nurse administered. The patient experienced a return of spontaneous circulation with improvement in hemodynamics and was transferred to an outside hospital for further care.*

During event investigation, the organization found that lidocaine was available in the code cart in both an infusion bag (for continuous infusion) and a syringe (for bolus administration). The drug library did not have an option to administer a bolus dose from the lidocaine infusion or to administer a separate bolus dose. The organizational protocol was for the nurse to administer the bolus dose from a syringe without using the pump, but the nurse did not have experience with this process.

Safe Practice Recommendations: Consider the following recommendations to address these commonly reported challenges when programming smart infusion pumps.

Plan for interoperability. Implement bidirectional smart infusion pump interoperability with the EHR to reduce the risk of infusion pump programming errors. To learn more about infusion pump and EHR interoperability, see the ISMP Guidelines for Optimizing Safe Implementation and Use of Smart Infusion Pumps.

Establish and approve dose limits. Establish and/or evaluate minimum and maximum dose limits for each medication infusion and bolus dose that requires administration via a smart infusion pump. Determine if the dose limits should be weight-based or non-weight based, aligning the dose limits with organizational protocols, dosing references, literature, and clinical practice. Be aware that continuous infusion units are generally dosed per hour, while boluses may be dosed per minute. Also consider the full range of titration when setting dose limits for titratable infusions. Smart infusion pump dosing limits should not cause nuisance alerts or prevent the programming of incremental doses. Once the drug library parameters have been determined, require approval by an interdisciplinary committee before updating or creating the drug library. Also, determine and communicate a process for practitioners to request changes to the set limits.

Create drug libraries. Set soft dosing limits in the drug library that reflect the minimum and maximum expected dose and rate prescribed, as well as a buffer for patients who may require more or less than the typical default doses and rates. Set hard dosing limits as a forcing function to prevent catastrophic errors, while considering patients who may clinically require atypical doses, to prevent end users from needing to program the infusion without engaging the DERS. Incorporate a quality control process into the drug library build prior to releasing it onto the pumps. Communicate changes to end users.

Use the EHR to drive safe practice. Establish dose range checking in the EHR to notify prescribers and pharmacists with an alert if it is likely that a medication dose has been prescribed outside of a safe dose range. Require all titratable medication orders to include the medication name, diluent, route, initial or starting rate, incremental units in which the rate can be increased or decreased, frequency of dose titrations, maximum rate of infusion, and an objective clinical measure(s) to guide changes. Ideally, medication names and corresponding dosing units listed in the smart pump should match exactly with those listed on drug labels, the MAR, and the automated dispensing cabinet (ADC) screen.

continued on page 3 — Smart Pump Challenges Persist >

>SAFETY briefs cont'd from page 1

To reduce the risk of inadvertent IV push administration, the organization removed all procainamide prefilled syringes from automated dispensing cabinets (ADCs) and eliminated their storage outside the central pharmacy. Until the shortage is resolved, all procainamide syringes will be stored in the pharmacy in clearly labeled bins indicating that they are for IV infusion preparation only. Organizations should proactively evaluate packaging and labeling risks when alternative products are introduced due to drug shortages and restrict access to products that increase the likelihood of unsafe administration. Use barcode scanning during stocking, pharmacy preparation, and prior to administration.

Problematic B. Braun Pump Configuration. A pharmacist reported concerns about not receiving an alert when exceeding a hard dose limit in the B. Braun Infusomat Space pump. When increasing the dose rate field, if the hard rate limit is exceeded, the pump will automatically change the displayed value to the maximum allowed limit (i.e., the hard limit), without any associated warning. The pharmacist provided an example using phenylephrine from their drug library, which has a hard dose limit of 600 mcg/min. If the phenylephrine dose is set at 550 mcg/min, and the practitioner, intending to select the tens unit to increase the dose to 560 mcg/min, inadvertently selects the hundreds unit and programs 650 mcg/min, the pump display will modify the dose to 600 mcg/min (the hard maximum limit). If the drug library has a soft maximum dose limit set, and the dose exceeds it, the practitioner will receive an alert for exceeding the soft limit; however, they will **not** receive an alert for exceeding the hard limit. Only if the practitioner tries to increase the dose a second time (e.g., from 600 to 650 mcg/min) will they receive an alert that they have reached the hard maximum limit.

The B. Braun Infusomat manual states, "IMPORTANT: if a value increase or decrease is not possible due to a hard limit....the value of the hard limit is displayed as the highest acceptable value." However, the reporting organization told us

continued on page 3 — SAFETY briefs >

> Smart Pump Challenges Persist — continued from page 2

Limit multiple indication-based options. If different indication-based library entries are needed for certain medications, determine if the infusion is only used for a single indication in a specific location, and limit the drug library for that location to only one option, when possible. Otherwise, let end users know about the infusions that have multiple indication-based options and communicate if these options have different dosing units. If possible, clearly include the indication in the drug name selection on the pump and make it obvious to the end users which option to select.

Communicate how end users should administer bolus doses. Ensure order sentences and order sets for medication infusions that may include a bolus have been built and tested by end users. On the EHR/MAR, clearly show the route and rate of administration of the bolus, and whether the pharmacy will dispense a separate bolus (or verify a bolus dose from an ADC), or if the practitioner should administer the bolus from the continuous infusion via a bolus infusion feature.

Safeguard bolus doses. Ensure bolus doses can be safely administered using the pump. Only allow practitioners to administer a bolus dose from a continuous infusion if your infusion pump has a bolus feature that automatically resumes the continuous infusion rate once that bolus dose has been administered, and if your drug library includes bolus dose range limits.

Test the drug library. Evaluate the drug library to ensure that soft and hard stops will capture a variety of prescribing and programming errors. For medication infusions with two options in the drug library based on the indication, test to see if this could lead to unintended programming errors. Gather feedback from end users to ensure it is intuitive to select between the two options. Consider conducting a usability study to observe end users as they program the pump under simulated conditions.

Communicate doses safely. Limit verbal orders to true emergencies. However, if a medication is urgently needed, practice closed-loop communication where the receiver repeats back a verbal order, stating the exact dose of medication including the units of measure and dosing units. Ensure the prescribed medication and dose make sense in the context of the patient's condition. Encourage practitioners to clarify any medication-related concerns prior to order execution.

Educate practitioners. Provide initial and annual competency assessments for practitioners who use smart infusion pumps. Provide practitioners with simulation-based education using scenarios (such as reported events published in ISMP newsletter articles) to achieve specific learning objectives, focusing on safe pump option selection and programming practices. Include education about internally and externally reported errors and safety concerns.

Review pump data. Have the smart infusion pump team regularly monitor drug library usage and alerts, including overridden soft alerts, and adjust the dose limits as needed based on current practice and the literature. Also review interoperability data to determine how often it is used for starting a new medication and for dose change adjustments.

Report errors. Emphasize that the organization values a culture of safety and encourages medication error reporting and sharing lessons learned. If there are any safety reports related to the use of the smart pump, notify the smart pump team for follow-up. Continuously monitor and reevaluate the data to determine warranted adjustments to the drug library and possible hospital dosing protocols.

Work with pump vendors. Collaborate with your smart pump vendor and provide them with feedback for consideration for future upgrades. Smart pump vendors must consider human factors to enhance the physical design of the pump and drug library, and to improve the programming experience for end users.

>SAFETY briefs cont'd from page 2

that this is not intuitive when practitioners are programming the pump, and that some nurses expect an alert to display when the hard limit value is exceeded.

The pharmacist noted that another safety concern is the way that the dose is entered. The pump requires a user to click left or right to a desired place value, then up or down to change that place value to the desired number. They must take care not to confuse the tens and hundreds place values. Also, it is easy to "over-click" to the wrong place value. This risk applies to any medication but may be particularly problematic for drugs with wide dose ranges, such as vasopressors and insulin. An additional concern with this design is that organizations may be unable to gather data on how often a practitioner has attempted to exceed a hard limit, as the pump automatically converts the entered dose to the hard limit maximum dose.

We have reported this concern to B. Braun. Organizations that use this pump should evaluate which medications in their drug library may be impacted by this risk and develop a mitigation plan if changes are needed. Ensuring that all medications have both soft and hard limits is an important first step. Notify end users of this risk and any mitigation strategies you have taken. Encourage practitioners to report errors and safety concerns with smart infusion pump drug libraries to the vendor and to ISMP.

Survey Highlights Ongoing Need to Report and Learn from PN Errors. A new *Journal of Parenteral and Enteral Nutrition* article describes results from the American Society for Parenteral and Enteral Nutrition's (ASPEN) national survey of parenteral nutrition (PN) practice involving 1,160 US clinicians.[1] Although the survey identified greater adoption of safety technologies, it also highlighted persistent gaps across the PN-use process, including prescribing, compounding, administration, oversight, and quality improvement efforts. These findings reinforce that PN remains a complex, high-alert medication requiring standardized processes, interdisciplinary oversight, and ongoing learning from errors and close calls.

continued on page 4 — SAFETY briefs >

Special Announcements

Apply for a JUST CULTURE Scholarship

Applications are now being accepted for the **Judy Smetzer Just Culture Champion Scholarships**. Qualifications to apply include the following: currently working in the healthcare field, having at least 5 years of full-time postgraduate experience, and a commitment from executive leadership within your organization. Achieving Just Culture certification helps advance fair accountability and system improvements. The deadline to apply is **September 30, 2026**. For more information and to submit an application, click here.

Last Call for CHEERS Nominations

If you have not submitted your nomination for an **ISMP CHEERS AWARD**, please do so now! The completed packet must be emailed to cheers@ismp.org by 11:59 PM ET on **August 15, 2026**. For more details and to submit a nomination, click here.

Free On-demand CE and Frontline Conversations from ASHP

The American Society of Health-System Pharmacists (ASHP) is offering four **FREE** on-demand activities related to USP Chapter <797>. The first is an on-demand webinar: Making USP <797> as Easy as 123: Overcoming Sterile Compounding Insourcing Challenges and Adult Versus Pediatric Considerations. There is also an interactive CE module: Level Up Your BUD Game: An Interactive, Choose Your Own Adventure Activity on Beyond Use Dates in Sterile Compounding. Continuing education (CE) credit is available for pharmacists and technicians for both activities. Additionally, there are two on-demand Frontline Conversations sessions: Frontline Conversations: USP <797> in Practice—Resources, Risk, and Readiness, and Frontline Conversations: USP <797> Considerations for Safe Sterile Compounding in Adult and Pediatric Patients.

Your Reports at Work

Fresenius Kabi Morphine Recall. Our July 30, 2026 article, Morphine 2 mg/mL Prefilled Syringes Contain **HYDRO**morphone 0.5 mg/0.5 mL, discussed how a nurse removed a prefilled syringe of what they thought was morphine 2 mg/mL from an automated dispensing cabinet (ADC) and identified that while the syringe packaging contained a tamper-evident seal labeled "Morphine 2 mg/mL," the syringe was labeled **DILAUDID** (**HYDRO**morphone) 0.5 mg/0.5 mL. The hospital found 6 impacted syringes, made by Fresenius Kabi. The **HYDRO**morphone prefilled syringe had an NDC of 76045-009-96, lot number 6402813, and expiration date 12/31/28. The syringe was removed from a carton labeled morphine 2 mg/mL, with an NDC of 76045-004-11, lot number 6402820, and expiration date 12/31/28.

Based on this report, Fresenius Kabi recalled this lot number (6402820) of morphine, as it may contain a prefilled syringe of **HYDRO**morphone. Fresenius Kabi is notifying its distributors and customers and is arranging for return of the recalled product. If your organization purchases this product, review all inventory to ensure you do not have impacted syringes, or if found, contact Fresenius Kabi to arrange for return. Notify staff to be vigilant when checking the prefilled syringe labels for Fresenius Kabi's **HYDRO**morphone and morphine injection, regardless of the lot.

We want to thank you for reporting this to us. We cannot emphasize enough how important it is to report errors to ISMP. ***Please keep the reports coming!***

>SAFETY briefs cont'd from page 3

The survey found that 69.4% of respondents reported that PN-related errors are evaluated at their organization, while 26.9% were unsure whether such evaluations occur. Among organizations that evaluate PN-related errors, respondents reported one or more errors per month during prescribing, transcribing, and/or verification (34.9%); compounding (17.3%); and administration (37.1%). About one-third (33.8%) of respondents had cared for a patient affected by a PN-related error in the previous 12 months, including errors associated with temporary harm, permanent harm, life-sustaining intervention, or death. Similar to other medication errors, it is known that these events occur and may be underreported for a variety of reasons. The survey results also showed that some practitioners may not consider PN errors as medication errors or may not know how to report these events externally. If your organization experiences a PN-related error or close call, please report it to ISMP. Sharing these events enables organizations to identify system weaknesses, strengthen safeguards, and prevent similar harm.

Reference

1. Ayers P, Boullata JI, Canada TW, et al. Parenteral nutrition practice in the United States: a cross-sectional survey with gap analysis. *J Parenter Enteral Nutr.* Published online March 28, 2026.

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Editors: Shannon Bertagnoli, PharmD; Rita K. Jew, PharmD, MBA, BCPPS, FASHP; Editor Emeritus, Michael R. Cohen, RPh, MS, ScD (hon), DPS (hon), FASHP. ISMP, 500 Virginia Drive, Suite 501, Fort Washington, PA 19034. Email: ismpinfo@ismp.org; Tel: 215-947-7797.