Safe Use of Smart Pumps

Smart pumps were introduced to improve the safety of IV medication administration.[1] These pumps have customizable drug libraries (i.e., a list of meds along with parameters such as concentrations and dose).[1,6] They also incorporate "dose error-reduction systems" (DERS) to identify problems (e.g., potentially unsafe dosing and infusion rates), allowing for prevention of miscalculation or programming errors.[5,6] In fact, the goal for hospitals, as per ISMP best practices, is to have a 95% or better compliance rate for the use of DERS for infusions, and for this compliance to be monitored on a monthly basis.[13] (Note that exceptions to the use of DERS may include instances where gravity infusions are needed, such as to infuse an IV fluid at a rate higher than a pump will allow.)[15] But even when used as intended, smart pumps can't catch all mistakes and may actually create new types of errors (e.g., due to workarounds).[4] Understanding limitations of smart pumps and consistent use of their drug libraries can allow users to take full advantage of safety features.[1,4,6,15] The chart below reviews possible smart pump limitations, common programming errors and how to prevent them, and best practices to improve safe use for infusing meds intravenously (e.g., bolus, continuous infusion, intermittent infusion) or by the epidural route.

Topic/Issue	Pertinent information/actions to recommend for smart pump users

Potential smart pump **limitations**	Smart pump dose error-reduction systems rely on the accuracy of information provided by users.[4,6] Smart pumps may still be **UNABLE to identify certain errors,** including:
	• Programming of incorrect medications, such as dobutamine being selected from the library instead of dopamine.[1-3,6,7,15]
	• Incorrect pump library selected, resulting in wrong med concentration or infusion rate limits being programmed.[1,6,7,15]
	  ○ For example, the nurse accidentally chooses the correct drug, but from the ICU library for a floor patient.
	• Clamped tubing that could result in too little drug being delivered to the patient.[1]
	• Dosing errors that are within pre-programmed limits, but wouldn't be safe for a specific patient.[2,6]
	  ○ For example, vancomycin 1 g IV over 60 minutes programmed for a patient with a critically high vancomycin level.
	• Drug programmed correctly but for the wrong patient or using the wrong dosing weight.[1,6,7]
	• Administration delays or omission errors, which can't be identified without EHR-smart pump interoperability.[1,6,7]
	• Errors with secondary infusions, or piggybacks, which are meds infused through a primary line with a secondary set.[15]
	  ○ For example, a piggyback that isn't positioned physically higher than the primary infusion (in order to increase fluid pressure of the secondary infusion) may infuse at an unpredictable rate or not at all.[15]
	• Administration of discontinued meds.[15]
	• Infusion line or channel mix-ups.[15]

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Smart pump **error prevention** strategies	• Use a pump library whenever possible. It has pre-programmed guardrails (e.g., maximum dose, maximum and/or minimum rate) to ensure dose and rate errors can be identified.[4-8]
	  o Ensure the correct pump library (Anesthesia, ED, ICU, PACU, etc) is selected for the ordered med or IV fluid.[1]
	• Reserve use of manual settings (e.g., custom, drug calc, wildcard) for drugs not listed in the pump library, such as for a med new to your formulary or a med that's being used instead of another med that's on shortage.[4,5,6,8]
	  o Be aware that manual settings cannot detect programming or miscalculation errors.
	  ▪ For example, incorrect manual programming with mcg/kg/**min** instead of mcg/kg/**hr** would be missed.[8]
	  o Get a double-check for any manual pump programming, to verify correct drug, concentration, and rate have been entered.[6,8]
	• Be especially careful when programming secondary infusions, IV bolus doses, and titration of continuous infusions.[5,13,14]
	  o For example, if an IV bolus dose is misprogrammed, too much or not enough drug could be delivered.
	  o If possible, when administering an IV bolus or loading dose from an IV bag, use a smart pump that allows separate programming of the bolus and continuous infusion rates.[15]
	• Be alert for possible drug concentration differences that may affect pump settings for transferred patients.[9,14]
	  o This applies to level of care transfers, such as ICU to floor, and for admissions from an outside institution.
	• Use bar-code scanning whenever possible to help prevent patient-drug mismatches and other potential errors.[6,15]
	• Ensure smart pumps that may be malfunctioning are removed from use.[15]

Smart pump **library optimization**
 	
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	• Be aware of limitations of drug libraries so that they can be addressed.[12]
	• Dedicate resources to review the medical literature and actual clinical practice to determine appropriate limits.[12]
	  o Examine overridden alerts to identify need to change.[12]
	  o Pump library soft- and hard-stop alert settings may need to be reassessed and updated to avoid use of dangerous work-arounds.[6,12]
	  o Require approval of the library by a multidisciplinary team.[12]
	• For titratable meds, ensure that the dose limits encompasses the potential titration range.[12]
	• Work to achieve a reasonable dosage/infusion rate ranges for meds without absolute upper dosage limits (e.g., opioids, benzodiazepines) or variable rates.[12]
	  o A range that is too narrow may require mistake-prone manual programming; setting it too wide could permit a dosage error to sneak through.[12]
	• For drugs with different indication-specific library options, match the indication-specific option to the area in which it is used, or make users aware that there is more than one option.[12]
	• Ensure that the most current library is available on all pumps. Update the library if a standard drug concentration changes.[12]
	  o Use technology or other methods to keep track of each infusion pump.[12]
	• Test the library before it is released.[12]

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Library optimization, continued	• Put alerts in the EHR so that prescribers know if a dose is outside the usual range or is too small to be administered on the infusion pump and may require a change in concentration.[12] • Use the same drug name in the EHR and the library.[12] • Use bolus dose features and include a bolus in the library so that the nurse does not need to remember to reset the rate after the bolus is administered; otherwise, consider dispensing/administering boluses separately.[12] o Use the EHR to communicate how the bolus dose should be dispensed or administered.[12]

Smart pump **library troubleshooting s**trategies	• Keep in mind that a pump library is designed to include dosing guidelines and alerts specific for your hospital. However, library settings may still differ by patient type (e.g., by weight, by acuity) or clinical care area.[1,6,9,10,15]
	• Report problems with pump library settings or when excessive alerts are encountered.[6] These problems may include:
	  o Medication bolus and/or infusion parameters missing from library despite searching by generic name.[10]
	  o Hard-stop alerts encountered for commonly used med and infusion combinations.[12]
	  o Inconsistencies between the pump library and drug information or names in your EHR.[13]
	• Ensure that an appropriate person is alerted about a med omission from a pump library, to evaluate if the med needs to be added to the pump library.

Best practices that assist with safe use of smart pumps
 	
Continued…
	• Program infusions using smart pump library settings whenever possible.[4-8]
	• Use a "stop/check" procedure to reduce potential for pump programming errors:[17]
	  o Make sure the dose on the IV bag matches the med order and the programmed infusion rate.[17]
	  o Verify the correct infusion channel has been programmed to deliver the infusion.[17]
	  o Do not automatically bypass DERS alters.
	  ▪ Evaluate soft-stop alerts before acknowledging and overriding them.[5]
	  ▪ Think through possible mistakes that may have prompted a soft-stop alert, such as a keystroke error.[1] A keystroke error could have caused a "dropped" decimal point, resulting in a 10 to 100-fold error.[1]
	  o Pause to re-confirm correct drug, dose, and infusion for hard-stop alerts before entry reprogramming.[17]
	• Confirm correct dosing weight is being used and avoid making adjustments unless a significant change occurs.[17]
	  o Weight adjustments aren't necessary after weight-based infusions have been titrated to effect. This could result in dangerous under- or over-dosing of meds (e.g., heparin, norepinephrine) until goal parameters are re-attained.
	• Continue to adhere to standard safety practices that smart pumps may not be able to take the place of:
	  o Assuring correct positioning of roller clamps.[6]
	  o Checking drip chamber flow.[6]
	  o Taking precautions to prevent errors with secondary infusions, or piggybacks, such as by:[10,16]
	  ▪ Appropriately positioning the secondary infusion bag above the primary infusion bag.
	  ▪ Avoiding secondary infusion of continuous infusions of high-alert meds. (This is dangerous because pumps often automatically switch back to primary infusion settings after the programmed volume of a secondary infusion ends. If

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Best practices, continued	there is volume left in the secondary infusion bag, it could continue to be infused at the programmed rate for the primary infusion.) ▪ Avoiding putting a secondary infusion into a primary line that's being used for continuous infusion of a high-alert med. (This is dangerous because the secondary infusion could push a bolus of the high-alert med through the line.) • Scan patient identification bands and medications whenever possible to provide an added layer of safety.[1,6] • Look for more hospitals to incorporate smart pump "interoperability." o Be aware that smart pump interoperability enables EHR-to-smart pump wireless communication. This means med orders are auto populated into the pump, to help prevent wrong med or patient errors. Plus, information from the pump is auto populated into the MAR, which helps ensure accurate documentation of med administration (e.g., when a rate was adjusted, when an infusion was interrupted or stopped).[3,10,11,13] o Interoperability allows automatic documentation in the EHR for titratable meds, which may alleviate the need for charting about dosage changes during urgent situations.
Titration of infused medications	• Orders for titratable meds should include: drug name, route, initial infusion rate, incremental rate change, frequency of titration, max dose or infusion rate, and an objective clinical measure(s) to guide dosage changes.[12] • When titrating a medicine, make sure that the infusion pump setting is being changed on the correct medication.[16] • Know what to do when a med may need to be paused, such as if the patient no longer meets criteria for administration based on assessed physiological parameters (e.g., upon stabilization of blood pressure).[18,19] (Pausing differs from discontinuing a med. Discontinuing a med should only be done in response to a prescriber's order or criteria described in hospital policy [e.g., a med that's been paused for more than 24 hours]).[18] Ensure that if an infusion is paused, there is an order or a policy indicating how to restart.[18] Options may include: o restarting at the last infusion rate. o restarting at the original infusion rate. o restarting at a new rate, as ordered by the provider.
Safe administration of IV piggybacks *Continued…*	• IVPB should not be administered through a primary IV set because up to 25 mL of IV fluid can remain the in tubing, leading to underdosing.[20] • Position secondary infusion bags (IVPB) at the proper height above the primary infusion bag.[10] If the IVPB is not positioned physically higher than the primary infusion (in order to increase fluid pressure), the IVPB may infuse at an unpredictable rate or not at all.[15] (Some pumps don't require a height difference but many do.[15]) After the IVPB infuses, the primary infusion restarts and will push any residual med in the tubing from the IVPB to ensure the full dose is delivered.[16] • Consider adding alerts to labels, the EHR, or automated dispensing cabinet for drugs that should only be given as secondary infusions.[20]

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IVPB, continued	• The IVPB should NOT be connected to a **high-alert** primary infusion, a physically incompatible primary infusion, or a critically important primary infusion (e.g., Lactated Ringer's in a septic patient).[10,16,20] In these situations, use a compatible "flush bag," "carrier infusion," or "chaser" as the primary infusion to administer the IVPB.[16,20] o A secondary infusion could push a bolus of the high-alert primary infusion med (the volume in the primary tubing downstream from the secondary infusion) through the line.[16] o Some drug libraries can be used to restrict high-alert drugs to primary only, with interruption by a secondary not allowed.[10] • Avoid secondary infusion of continuous infusions of high-alert meds (e.g., morphine drip). Pumps may automatically switch back to the primary infusion settings after the programmed volume of the secondary infusion (IVPB) ends. But if the IVPB is still hanging at the higher height and there is volume in the secondary infusion bag, it could continue to be infused at the programmed rate for the primary infusion.[16]

Abbreviations: ED = emergency department; EHR = electronic health record; ICU = intensive care unit; IV = intravenous; IVPB = IV piggyback; MAR = medication administration record; PACU = post-anesthesia care unit.

Users of this resource are cautioned to use their own professional judgment and consult any other necessary or appropriate sources prior to making clinical judgments based on the content of this document. Our editors have researched the information with input from experts, government agencies, and national organizations. Information and internet links in this article were current as of the date of publication.

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