Drugs for Selected Medication Overdoses and Poisonings

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Hospitals may not be prepared to treat poisonings or overdoses due to unavailability of antidotes. Unavailability of enough antidote to treat a patient until more of the antidote can be procured can also be a problem. Hospitals should stock type and quantity of antidotes based on geographic location, type of hospital, referral base, risk of more than one victim, etc.[1] For example, snake bites are not uncommon in rural areas, or local industry might increase the risk of exposure to certain chemicals. Cost can be a concern; avoid stocking excessive amounts or using antidotes inappropriately.[1] Some states have suggested par levels of antidotes, so check with your state's poison control center, which can be reached at 800-222-1222 (US). In Canada, check with the Canadian Association of Poison Control Centres (http://www.capcc.ca/provcentres/centres.html). **For management of specific patients, consultation with poison control center staff helps ensure the right antidote, right frequency, right dose, etc is given. Plus, these experts will make follow-up calls to ensure that the patient's treatment remains optimal throughout their hospital stay**.[2] See our FAQ, *Managing Bleeding with Anticoagulants* for information on anticoagulant reversal agents.

—Doses in chart can vary according to the reference used. Doses may also vary depending on patient-specific characteristics and clinical considerations. This chart is **NOT meant to replace consultation with poison control center** staff or use of appropriate resources. (Also see footnotes at end of chart.)—

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Acetylcysteine* (Available as injection and inhalation solution for oral use.)	• Acetaminophen[1]	• Regimens vary. A regimen that provides acetylcysteine ≥300 mg/kg (PO or IV) over the first 20 to 24 h of treatment is recommended.[4] • See **footnote d** for examples.	30 g	• Errors include delayed treatment, dose miscalculation, treatment interruption, wrong infusion rate, and prolonged infusion.[4,28] • Do not stop treatment before discontinuation criteria are met.[4]
Atropine sulfate** *Continued…*	• Beta-blockers[30] • Calcium channel blockers[30] • Clonidine[29] • Digoxin[30] • Local anesthetics[30]	• IV: 0.5 to 1 mg every 3 to 5 min PRN for bradycardia (max total dose 3 mg)[29,30]	---	• Commonly used first-line for bradycardia.[29,30] • Use based on case reports; efficacy varies.[30]

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Atropine sulfate, continued	• Organophosphate pesticides or nerve agents[1] • Carbamate insecticides[1]	• IV loading dose: 1 to 2 mg doubled every 5 min PRN.[30] • Infusion: 10% to 20% of the total loading dose/h, up to 2 mg/h.[30]	165 mg	• Used to treat muscarinic effects.[30] Titrate to control bronchorrhea, bronchospasm, bradycardia, and blood pressure.[30] • Does not treat paralysis (does not block acetylcholine at the neuromuscular junction or nicotinic ganglia).[30]
Calcium chloride 10%**	• Beta-blockers[33] • CCBs[1] • Fluoride[1]	• For **CCB** overdose, 2 g IV over 5 min, then 20 to 40 mg/kg/h.[22,30]	10 g	• Titrate to blood pressure.[30] • Central line administration preferred.[30] • Monitor serum ionized calcium. Max level 1.5 to 2 x ULN.[30]
Calcium disodium versenate (edetate calcium disodium)	• Lead[1]	• Dose differs according to BSA, SCr, and blood level of lead. See product information for specific doses.	2.25 g	• Also called calcium disodium EDTA.[22]
Calcium gluconate 10%**	• Beta-blockers[33] • CCBs[1] • Fluoride[1]	• For **CCB** overdose, 6 g IV over 5 min, then 60 to 120 mg/kg/h.[22,30]	30 g	• Titrate to blood pressure.[30] • Monitor serum ionized calcium. Max level 1.5 to 2 x ULN.[30]
Calcium trisodium pentetate	• Americium[1] • Curium[1] • Plutonium[1]	• 1 g IV over 3 to 4 min.[22]	1 g	• Also called calcium DTPA, Ca-DTPA, and pentetate calcium trisodium.[1,22]
Charcoal	• Several medications and poisons[31]	• 50 to 100 g PO x 1.[22] Multiple doses are not routinely indicated.[5,31]	100 g[22]	• Most benefit if given within 1 h.[5] • Avoid formulation with sorbitol.[5]

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Centruroides Antivenin* (*Anascorp* [US])	• Scorpion[1]	• 3 vials IV in 50 mL NS over 10 min.[20]	3 vials	• Additional doses may be needed.[20]
Crotalidae Polyvalent Immune Fab, ovine* (*CroFab* [US])	• North American pit vipers (rattlesnake, copperhead, water moccasin, or cottonmouth)[1,22]	• 4 to 6 vials IV in 250 mL NS (total volume) over 60 min.[22] Monitor for one hour.[22] Follow poison control's recommendation regarding need for additional doses.[7]	18 vials	• Some patients may need up to 12 vials initially, depending on severity of envenomation and clinical judgement.[22] • For the first 10 min, infuse at 25 to 50 mL/h, then increase rate to 250 mL/h if no allergic reaction.[22] • *Anavip* (crotalidae immune f[ab]2, equine) is also available.
Cyproheptadine	• Serotonergic drugs[1]	• Initial (first 24 h): 4 mg PO TID, **or** 12 mg x 1, then 2 mg Q1-2H.[21] • Maintenance: 2 mg TID to 8 mg QID based on efficacy and tolerability.[21] • Continue for 1 to 4 weeks, with tapering over ~2 weeks.[21]	36 mg	---
Dantrolene** (e.g., *Dantrium*, generics; *Ryanodex* [US])	• Anesthetic agents that cause malignant hyperthermia in susceptible people.[24]	• 2.5 mg/kg IV, repeated PRN for continued symptoms, with a **suggested** max dose of 10 mg/kg.[23]	36 vials of dantrolene 20 mg (*Dantrium* etc), or 3 vials of dantrolene 250 mg (*Ryanodex* [US])[34]	• Ensure availability where general anesthesia is administered.[1] • The Malignant Hyperthermia Association of the United States (www.mhaus.org) has information on preparedness and a hotline for emergency help (800-644-9737).

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Deferoxamine mesylate* (*Desferal*, generics)	• Iron[1]	• Acute iron intoxication: 15 mg/kg/h IV infusion until iron level and symptoms have normalized.[22]	36 g	• Can be given IM, but IV is preferred because of more reliable absorption.[22] • Total dose determined by clinical response.[22]
Dextrose (D50)**	• Hypoglycemic agents[1]	• IV: 10 to 25 g (20 to 50 mL) repeated PRN.[22] • Initial treatment is usually followed by a continuous infusion of D10.[1,22]	250 g	---
Digoxin Immune Fab** (*DigiFab*)	• Digoxin[1]	• Dose varies by amount ingested. See product information for details.	15 vials	---
Dimercaprol* (*Bal* [US])	• Arsenic[1] • Gold[22] • Lead[1] • Mercury[1]	• Dose differs by heavy metal and severity of poisoning. See product information for details.	2.4 g	---
Ethanol*	• Ethylene glycol (antifreeze)[1] • Methanol[1]	• PO: 1g/kg, then 0.5 g/kg hourly, titrated to an ethanol target level of 1 to 1.5 g/L.[6,8] • Continue until ethylene glycol or methanol level is <20 mg/dL[9]	360 g	• Fomepizole is preferred because it is easier to use and has fewer side effects.[1,6] • Injectable dehydrated alcohol is not FDA-approved as an antidote.[39]
Flumazenil**	• Benzodiazepines[1]	• IV bolus regimen: 0.2 mg x 1, then 0.3 mg 30 sec later if needed. Additional 0.5 mg doses can be given every min to a total dose of 3 to 5 mg. If resedation occurs, regimen can be repeated every 20 min to a max of 3 mg each h.[22] • IV infusion: 0.1 to 4 mg/h titrated to level of sedation.[22]	12 mg	• Flumazenil half-life is shorter than that of benzodiazepines, so resedation can occur.[22] • Used for sedation, not hypoventilation.[22] • Can precipitate seizures, especially in patients taking benzodiazepines chronically.[22] • Could precipitate anxiety or a panic attack.[22]

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Fomepizole*	• Ethylene glycol (antifreeze)[1] • Methanol[1]	• IV: 15 mg/kg x 1, then 10 mg/kg Q12H x 4 doses, then 15 mg/kg Q12H until ethylene glycol or methanol levels are <20 mg/dL.[22]	4.5 g	• Fomepizole is preferred over ethanol because it is easier to use and has fewer side effects.[1,6] • During hemodialysis, doses should be given Q4H.[22]
Glucagon** (*GlucaGen*)	• Beta-blockers[1] • CCBs[1]	• IV: 2 to 10 mg, then 1 to 15 mg/h continuous infusion.[30]	250 mg	• In Canada, IV administration is off-label.[10] • Used for bradycardia and hypotension.[30] • Vomiting is common.[30] • Tachyphylaxis may develop quickly.[30] • Efficacy varies.[30] • Not a preferred treatment for CCB toxicity due to limited/mixed evidence.[30]
Glucarpidase (*Voraxaze* [US])	• Methotrexate[1]	• IV: 50 units/kg/dose over 5 min x 1 dose[22]	5 vials	• Indicted to treat toxic levels in patients with slow methotrexate clearance due to kidney impairment.[22] • Separate from leucovorin by ≥2 hours.[22]
Hydroxocobalamin hydrochloride** (*Cyanokit* [US])	• Cyanide[1]	• IV: 5 g in 200 mL NS (preferred diluent) over 15 min x 1 dose. Repeat the 5 g dose if necessary, infusing it over 15 to 120 min.[22]	10 g	---

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Insulin, regular	• Beta-blocker[33] • CCB[33]	• 1 unit/kg IV bolus, then 0.5 units/kg/h IV infusion.[33] • Titrate every 15 to 30 min.[36]	---	• Administer with D10 at 0.5 g/kg/h. If glucose is <200 mg/dL, start with a bolus of 50 mL of D50.[35] • Target HR (50 bbm), MAP (65 mm Hg), and glucose (e.g., 125 to 250 mg/dL).[36,37]
***Latrodectus mactans* antivenin**	• Black widow spider	• IV: 2.5 mL (6,000 units) in 10 to 50 mL NS over 15 min.[22] • A second dose may be nessessary.[22]	1 vial	• Perform skin or conjunctival sensitivity testing before administration; serum sickness and/or death could occur in patients allergic to horse serum.[22] • Dose can be given IM, but IV is preferred in severe cases, and in children.[22]
Leucovorin*	• Methotrexate[1] • Methanol[1]	• IV, IM, or PO: 15 mg (10 mg/m^2) Q6H until serum **methotrexate** level is <0.05 micromol/L. If SCr has increased ≥50% above baseline 24 hours following methotrexate administration, or if serum methotrexate is >5 micromol/L, use leucovorin 100 mg/m^2 IV or IM Q3H until serum methotrexate level is <0.05 micromol/L.[22]	1,000 mg	• Role in **methanol** poisoning is unclear.[25]

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Levocarnitine* (*Carnitor*, generics)	• Valproic acid[1]	• IV: 100 mg/kg x 1, then 50 mg/kg (max 3 g) Q8H (if tolerated) until ammonia levels are dropping and patient is improving.[26]	15 g	---
Lipid emulsion**	• Local anesthetics[1]	• See our checklist, *Safe Use of Local Anesthetics*.	1,250 mL	• Our checklist, *Safe Use of Local Anesthetics*, provides information on strategies to prevent and manage toxicity.
Methylene blue**	• Methemoglobinemia[1] • CCB[30]	• IV: 1 to 2 mg/kg, repeated hourly if necessary.[22,30] • IV infusion (for treatment-resistant vasodilatory shock due to **CCB** overdose): 1 mg/kg/h.[30] • Max dose 5 to 7 mg/kg.[30]	600mg	• For methemoglobinemia, consider alternate treatment if no resolution after two doses.[22] • Efficacy for CCB overdose is unclear.[30]
***Micrurus fulvius* antivenin** (US)*	• North American coral snake (Eastern and Texas)	• IV: 3 to 5 vials (30 to 50 mL when reconstituted). • Administer in 250 to 500 mL NS.[19]	10 vials	• Consider skin testing before treatment.[22] • Consider reconstituting one vial to withdraw test dose from before reconstituting the remaining vials to minimize waste in case patient has anaphylaxis to test dose.
Naloxone** (*Narcan*)	• Opioids[1]	• See our FAQ, *Meds for Opioid Overdose*. • An IV maintenance infusion starting with 2/3 of the effective dose per hour can be titrated to maintain respiratory drive and airway protection.[30]	40 mg	---

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Octreotide* (*Sandostatin*)	• Sulfonylureas[1]	• SC: 50 to 100 mcg Q6-12H[11]	225 g	• Used to reverse hypoglycemia.[11]
Physostigmine salicylate**	• Anticholinergics[1]	• IV: 0.04 mg/kg (2 mg), then 1 to 4 mg every 20 minutes. Repeat previously effective dose if symptoms recur.[12] • Administer slowly (e.g., in 50 mL NS over 10 to 15 min).[12]	4 mg	• Unapproved drug[12] • Used to target mental status changes.[12] • Contraindicated with cholinesterase inhibitors for dementia (e.g., donepezil). • Use caution in tricyclic antidepressant ingestion.[12]
Potassium iodide* (*Iosat*, *ThyroSafe*, tablets; oral solution [US]; *RadBlock* [Canada])	• Thyroid radioiodine protection[1]	• PO: 130 mg x 1[13]	130 mg	• Product is OTC.
Pralidoxime chloride* (*Protopam* [US])	• Organophosphate[1]	• Follow poison center dosing recommndations.[14]	18 g	• Can be given IM but IV is preferred.[14]
Prussian blue (*Radiogardase*)	• Radiocesium[1] • Thallium[1]	• PO: 3 g TID[15]	25 g	• Also called ferric hexacyanoferrate.[15] • Treatment duration dependent on level of internal radioactivity.[15]
Pyridoxine hydrochloride**	• Isoniazid[1] • Hydrazine[1]	• IV: Give g per g for the amount of **isoniazid** taken.[16,17] If isoniazid dose unknown, give pyridoxine 5 g over 30 to 60 min.[16] If seizing, administer over 3 to 5 minutes.[16] May repeat if needed.[16]	24 g	• Consider similar dosing for **hydrazine** toxicity.[18]

Drug or Antidote[c]	Used For Poisonings or Overdoses with:	Adult Dosing Information[a]	Amount to Treat a 100 kg Adult for 24 h[1,b]	Comments
Sodium bicarbonate**	• Tricyclic antidepresants[1] • Cocaine[1] • Local anesthetics[1]	• IV Bolus: 50 to 150 mEq (50 to 150 mmol).[30] • Maintenance: 150 mEq (150 mmol)/L infused at 1 to 3 mL/kg/h.[30]	84 g (1,000 mEq)	• For wide-complex tachyarrhythmias (cocaine: or cardiac arrest).[30] • Do not exceed blood pH 7.55, or sodium 155 mEq/L.[30] • Monitor for hypokalemia.[30]
	• Salicylates[1]	• IV: 132 to 150 mEq (132 to 150 mmol) in 850 mL D5W with 20 to 40 mEq (20 to 40 mmol) KCl, at 2 to 3 mL/kg/h.[22]		• For salicylate toxicity, target urine output 2 to 3 mL/kg/h and urine pH 7.5 to 8.
Thiamine**	• Ethylene glycol toxicity • Ethanol (chronic alcohol misuse)	• Ethanol misuse: See our FAQ, *Management of Inpatient Alcohol Withdrawal*. • Ethylene glycol toxicity: thiamine 100 mg IV.[27]	1,500 mg	• Our FAQ, *Management of Inpatient Alcohol Withdrawal* addresses common questions about the pharmacotherapy of alcohol withdrawal in acute care patients. • Thiamine is typically given as part of the treatment for ethylene glycol toxicity because it is a cofactor in its metabolism.[27]
Uridine triacetate (*Vistogard* [US])	• Fluorouracil • Capecitabine	• PO: 10 g Q6H x 20 doses.[32]	40 g	---

Abbreviations: BSA = body surface area; CCB = calcium channel blocker; ED = emergency department; h = hour; IM = intramuscular; IV = intravenous; min = minutes; NS = normal saline; PO = by mouth; PRN = as needed; SC = subcutaneous; SCr = serum creatinine; sec = seconds; TID = three times daily; ULN = upper limit of normal

*Expert Consensus Guidelines for Stocking of Antidotes in Hospitals That Provide Emergency Care recommends that these antidotes be available **within 60 min**.[1] These can be stocked in the pharmacy if the antidote can be delivered to the emergency department quickly.[1]

Expert Consensus Guidelines for Stocking of Antidotes in Hospitals That Provide Emergency Care recommends that these antidotes be available **immediately (e.g., stocked in the emergency department).[1]

a. Doses may vary according to resource used. Some doses may differ from manufacturer product labeling. Doses may also vary depending on patient-specific characteristics/clinical considerations and **should not be used without consultation of appropriate resources and/or consultation with a poison control center**.
b. Information provided to aid in determining appropriate product par levels to stock. **Doses are an approximation** and in most cases will vary depending on patient-specific characteristics and clinical considerations (e.g., weight, amount drug/poison ingested, kidney function, etc). This information should **NOT** be used to guide treatment.
c. In Canada, some drugs (e.g., black widow antivenin, hydroxocobalamin) are available through Health Canada's Special Access Programme.[3]
d. **Acetylcysteine** dosing example:[38]
    - Three-bag method (patients ≥5 kg):
        - Bag 1: 150 mg/kg (max 15,000 mg) infused over one hour.
        - Bag 2: 50 mg/kg (max 5,000 mg) over four hours.
        - Bag 3: 100 mg/kg (max 10,000 mg) infused over 16 hours.
    - Two-bag method (better-tolerated option for lower-risk patients ≥41 kg):
        - Bag 1: 200 mg/kg (max 20,000 mg) infused over four hours.
        - Bag 2: 100 mg/kg (max 10,000 mg) infused over 16 hours.

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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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]

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

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**
 	
Continued…
	• 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]

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

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

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