

San Diego Patient Safety Council

High-Risk IV Medications Dosing Limits Guidelines of Care

Tool Kit

2012

HOSPITAL ASSOCIATION
of San Diego and Imperial Counties



SHARP



Tri-City Medical Center



UNIVERSITY of CALIFORNIA, SAN DIEGO
MEDICAL CENTER



FALLBROOK
HOSPITAL



Scripps
A World of Healing

PALOMAR
POMERADO
HEALTH



Salinas Valley Memorial Healthcare System

About This Document

The purpose of this tool kit is to provide evidenced-based recommendations and best practices on setting and managing high-risk IV medications limit settings for adult patients in intensive and acute care units.

Intended Audience

The document is intended for clinical leaders involved in caring for adult intensive care and acute care patients.

Organization of This Document

The document is organized into the following sections: 1) introduction, 2) improvement project, 3) voice of the customer, 4) dosing limits recommendations, and 5) guidelines for implementing dosing limits in your institution.

Acknowledgement

The San Diego Patient Safety Council wishes to acknowledge the financial grant provided by CareFusion, as well as each of the institutions listed on the cover that contributed the valuable time of its expert clinicians in the creation of this document.

Palomar Pomerado Health

Michael Kruse, PharmD

Rady Children's Hospital

Bill Murray, PharmD

Salinas Valley Memorial Healthcare System

Larry Dolph, PharmD

UCSD Health System

Sally Rafie, PharmD

Scripps Health

Julie Moon, PharmD

Mark Parmenter, PharmD

Pamela Richter, PharmD

Sharp HealthCare

Cheryl Dailey, RN, MSN

Brett MacLaren, MBA

Nancy Pratt, RN, MSN

Albert Rizos, PharmD

VA San Diego Healthcare System

Katie Bordonaro, RN, CCRN

Richard Gibson, RN

Jennifer Howard, PharmD

CareFusion

Gail Berglund, RN, MSN

Sachin Naker, MBA

Monica Obsheatz, RPh, MPM

Tim Vanderveen, PharmD, MS

This document is in the public domain and may be used and reprinted without permission provided appropriate reference is made to the San Diego Patient Safety Council and the authors of the included tools and documents. The information and tools in this document are also available in electronic format at: www.carefusion.com, www.hasdic.org, www.patientsafetycouncil.org, and www.sharp.com

All SDPSC member health care organizations use the CareFusion Alaris® system, which made it is easy to acquire and compare countywide alert data. Guidelines presented in this tool kit can be used with other smart pumps. This document is not an endorsement of the CareFusion Alaris® system. CareFusion does not accept any responsibility for the information contained in this document.

Contents

Introduction.....	4
Method.....	6
Dosing Stops Recommendations: High Risk IV Medications	11
Dosing Limits Recommendations	15
Implementing Dosing Limits Guidelines.....	19
Appendices	22

Glossary

This is an alphabetical glossary of terms related to smart infusion pump technology used in this tool kit.

Bolus Feature - The optional infusion pump feature that invokes and controls the rapid infusion of a defined drug dose of a drug.

Cancel Feature - The infusion pump feature that stops the current infusion and allows re-entry of infusion order parameters.

Custom Concentration - Blank settings for concentration in the infusion pump that require the clinician to enter patient-specific dose or nonstandard drug formulation.

Dose Error Reduction System (DERS) - A hospital-defined drug library with limits for dosing range, infusion rate, infusion duration, units, concentration, and administration methods (e.g., bolus).

Dosing Limits - The dosing range (lower and upper limits) for safe medication administration.

Dosing Limit Alerts Settings - Settings in the infusion pump that trigger an alert for any dosing outside the predefined dosing limits and identified as soft minimum, hard minimum, soft maximum, and hard maximum limits.

Hard Stop Alert - A forced stop, including an audible and visual alert, produced by the pump indicating to the clinician the programmed medication parameters (dose, rate, etc.) are outside the hospital's safe limits as defined in the drug library. The drug will not infuse unless the clinician reprograms the pump within the set limits.

Profile - A customized set of drug infusion parameters specific to a patient population (e.g., modality like epidurals, indication, location, acuity, or weight).

Override Soft Stop Alert - The infusion pump feature that provides the clinician the opportunity to proceed with an infusion after a soft stop alert is reached and allows the infusion to begin with entered parameters.

Reprogram or Reset Feature - The infusion pump feature that is triggered when the clinician exceeds the maximum recommended dosage in the drug library and requires the clinician to re-enter the infusion parameters within the limits.

Soft Stop Alert - A forced stop, including an audible and visual alert, produced by the pump indicating to the clinician the programmed medication parameters (dose, rate, etc.) are out of the acceptable range as defined in the drug library. The clinician can either override the soft stop and the medication is infused without changing the pump settings or reprogram the pump within the set limits.

Therapy - Options for dosing that exist in the drug library as a subset once the drug is selected, such as heparin protocol for post-stent anticoagulation.

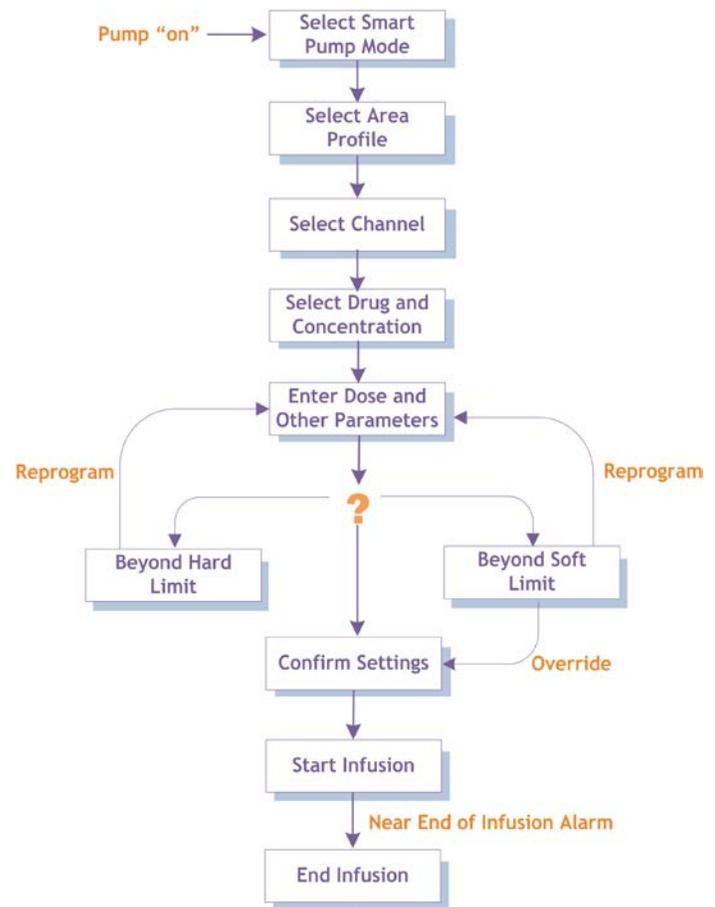
Introduction

Background

Today, the use of computerized or “smart” infusion pump technology that alerts bedside clinicians to potential intravenous (IV) programming medication errors is integral to the hospital’s strategy for reducing risk in IV drug administration. Based on results from 2011 ISMP Medication Safety Self Assessment for Hospitals, approximately half of the respondents use smart pump technology throughout their organizations to intercept and prevent errors due to mis-programming or miscalculation of doses or infusion rates.¹ Smart infusion pumps can offer bedside clinicians a state-of-the-art check-and-balance solution when administering IV drugs² (Figure 1.0). Key features of smart infusion pumps might include the following:³

- Dose Error Reduction System (DERS): A hospital-defined drug library with limits for dosing range, infusion rate, infusion duration, units, concentration, and administration methods (e.g., bolus). Hospitals can further customize these libraries by patient location, acuity, therapeutic profile, or body weight.
- Best practice guidelines and additional administration information per drug are noted for clinicians, such as advisories or protocols.
- Validation of manual calculations and dosing formula appropriateness are available for the medication and the patient (e.g., mcg/kg/hr vs. mcg/kg/min).
- A report of the programming alerts, including clinicians’ responses to alerts. These medication administration data afford hospitals valuable retrospective insight into bedside medication administration practices and areas for improvement.
- Dosing limit alerts and infusion stops notify the clinician that the programmed dosage is outside the hospital-defined medication’s administration parameters. Dosage alerts can be “soft” (can be overridden) or “hard” (must be reprogrammed) and are triggered before the infusion can begin. These alerts are based on settings established in each hospital’s drug library.

Figure 1.0: Smart Infusion Pump Programming Steps for Limit Alerts



One component of smart pump technology that lacks a standard, evidence-based approach is dosing limit alert settings in the pre-defined medication libraries. When set appropriately, high and low dosage limits and alerts offer a measure of dosing error prevention. However, clinicians too often view these limits and alerts as arbitrary hurdles, interruptions, and delays to providing patient care. Additionally, there is limited evidenced-based literature to guide hospitals in standardizing and optimizing their settings.

In 2009, the San Diego Patient Safety Council (SDPSC) IV Safety Task Force developed a tool kit identifying standardized high-risk IV drug concentrations and dosage units within and across area hospitals to reduce the likelihood of adverse drug events⁴. SDPSC members pursued implementation of these recommendations in their hospitals to facilitate safer practice as care providers and patients travel between facilities.

¹ Institute for Safe Medication Practices. *Medication Safety Alert!* February 23, 2012 issue.

² ECRI Institute. *Infusion Pumps, Large Volume Product Comparison*. www.ecri.org. 2010.

³ Institute for Safe Medication Practices: *Proceedings from the ISMP Summit on the Use of Smart Infusion Pumps: Guidelines for Safe Implementation and Use*. 2009.

⁴ San Diego Patient Safety Council. *The Safe Administration of High-Risk IV Medications: Intra- and Inter-Hospital Standardization: Drug Concentrations and Dosage Units Tool Kit*. 2006, revised 2009. www.patientsafetycouncil.org.

In 2011, as an extension of the original work, SDPSC recommended taking a closer look at countywide infusion pump comparison data on alert limits for IV infusions, particularly in high-risk medications.

Dosing Limits Improvement Project

SDPSC consists of countywide representatives from acute care facilities across multiple disciplines, including nurses, pharmacists, physicians, and respiratory therapists. Members reviewed literature, consulted institutional, thought leaders, applied process improvement and facilitation tools, and shared experience and best practices to obtain consensus in building a comprehensive set of recommendations for safe and effective management of high-risk IV drug dosing limits in acute and ICU patients. This tool kit contains these recommendations to assist hospitals in setting limits and alerts.

Problem

The SDPSC's smart infusion pump alert performance data requested of CareFusion, noted there was a prevalence of high variability in dosing limits and alerts with high-risk continuous infusion medications. In fact, SDPSC members determined no common systematic process or guidance existed in setting infusion pump dosing limits (hard and soft stops) for high-risk infusion medications specifically the medications identified in the 2009 tool kit. Furthermore, members determined this inconsistency results in rework, conflicting practice across facilities and environments, no evidenced-based standardized settings, and sub-optimal application of smart infusion pump technology as a safety tool.

Goals

The goal of this SDPSC improvement project was to provide evidenced-based community standards and best practices on setting and managing high-risk IV drug dosing limits. This standardization would facilitate safety in the administration of high-risk IV medications by:

- Decreasing percentage of clinician “cancel” actions which exit the smart pump library,
- Decreasing number of clinician “overrides” actions,
- Decreasing number of overall alerts (reducing alert fatigue),
- Increasing percentage of DERS system usage versus basic mL/hour programming,
- Increasing number or percentage of reprogramming the infusion pump after an alert,

- Managing alerts systematically, and
- Standardizing smart pump settings and alert behavior within a community, facilitating safe practice across facilities.

Scope

The scope of this SDPSC improvement project included:

- High-risk continuous infusion medications used in the care of adult patients in intensive and acute care units (see Table 2.0: High-Risk Infusion Medications). Twenty (20) high-risk IV medications were selected from the 2009 SDPSC tool kit's list of 34 high-risk IV medications (see Appendix A);
- Analyzing smart infusion pump comparison data focused on the 20 high-risk IV drugs for compliance of current SDPSC member hospitals with 2009 recommendations; and
- Standardizing minimum and maximum dosage limits for the selected 20 high-risk infusion medications.

This improvement project excluded the dosage limits for neonatal and pediatrics patients and the remaining 14 high-risk IV medications from the 2009 project.

Table 2.0: High-Risk Infusion Medications By Therapeutic Class

Antithrombotics: <ul style="list-style-type: none"> ▪ Abciximab (Reopro) ▪ Argatroban ▪ Bivalirudin (Angiomax) ▪ Eptifibatide (Integrilin) ▪ Heparin (Unit/h and Unit/kg/h)
Opioids (PCA or IV): <ul style="list-style-type: none"> ▪ fentaNYL (Sublimaze) ▪ HYDROMorphone (Dilaudid) ▪ Morphine
Hypertonic Saline (3% NaCl) (<i>not in 2009 tool kit list</i>)
Insulin
Sedatives: <ul style="list-style-type: none"> ▪ Dexmedetomidine (Precedex; <i>not in 2009 tool kit list</i>), LORazepam (Ativan) ▪ Midazolam (Versed) ▪ PENTobarbital ▪ Propofol (Diprivan)
Magnesium Sulfate
Neuromuscular Blockers: <ul style="list-style-type: none"> ▪ Rocuronium ▪ Cisatracurium ▪ Vecuronium ▪ Pancuronium

Method

SDPSC met ten times over two years using an abbreviated and facilitated version of GE's Change Acceleration Process as its methodology to reach consensus, devise dosing limit standards, and share best practices.

Step 1: Created a Shared Vision and Commitment

SDPSC members determined the improvement project charter: problem statement, project scope, customers, goal, potential benefits, and deliverables. Additionally, the council evaluated the SDPSC 2009 high-risk adult IV medications and standardized medications listings and identified the 20 medications for further data gathering and study.

Step 2: Obtained Countywide Aggregated Data

Seven SDPSC member health care organizations using the CareFusion Alaris® smart pump with available data agreed to have CareFusion data analytic experts aggregate their pump data from the previous 15 months. Data elements pulled from each organization's smart infusion pump library included:

- Infused medication name
- Concentration
- Bolus dose, units, duration, and rate
- Continuous infusion dose, units, and rate
- Infusion device serial number (patient ID surrogate)
- Pumps per patient day usage
- Override, Cancel, and Reprogram functions usage, including number and distribution of dosages attempted and overridden
- Number of infusion starts with the denominator being doses infused and total infused (for the basis of the analysis).

All instances of continuous dose limits for the identified high-risk IV medications in the ICU Care Area profile were studied as well. In cases where a hospital had two instances of a drug (but different concentration, therapy, etc.), both instances were included in the data set analyzed.

For a sample of data slides studied, see websites listed on page 2.

Step 3: Established Rationale for Recommendations

Prior to collecting and analyzing the comparison data, SDPSC members agreed on the glossary of definitions and purposes of the various infusion pump DERS limits (e.g., soft minimum, soft maximum, and hard maximum) and consented on the rationale for dosage limits. For a summary of the rationale applied by SDPSC members when establishing dosage limits, bolus usages, and profiles for the identified high-risk IV medications, see Table 3.0 Rationale Summary: High Risk IV Medications.

Step 4: Analyzed the Data

SDPSC studied the compiled, comparison data slides for each high-risk IV medication, which consisted of the following aggregated data:

- Number of alerts by care area profiles
- Percentage of alerts beyond limits
- Clinician response to the alerts as indicated by percentage of overrides versus cancels versus reprogramming
- Number of pumps including the top five pumps with the most alerts (distribution)
- For each dosage limit alert, the following were studied:
 - Number of alerts by dosage that caused the clinician to cancel, override, or reprogram the alert
 - Alert limit type (percentage above maximum and below minimum alerts)
 - For the top ten doses, the number of alerts by dosage that were overridden, cancelled, or reprogrammed
 - Top ten overridden doses above and below soft maximum limit
 - Top ten doses above the soft maximum limit that were cancelled
 - Top ten doses above the limit that were reprogrammed
 - Top ten doses reprogrammed after alert and the cumulative frequency percentage
 - Top ten final doses reprogrammed after soft maximum alerts and after hard maximum alerts
 - Top ten doses causing soft minimum limit alerts, soft maximum limit alerts, and hard maximum limit alerts
 - Number of alerts by dosage by soft minimum, soft maximum, and hard maximum limit.

High Risk IV Medications Dosing Limits Guidelines of Care

Rationale Summary: High Risk IV Medications

Table 3.0 summarizes the rationale used by SDSPC members for setting infusion pump safety parameters after reviewing countywide usage data:

Table 3.0: Rationale Summary: High Risk IV Medications

Alert	Purpose	When To Use	When Not Use	Data Review Findings
Soft Minimum Dose Limit	<ul style="list-style-type: none"> Prevents inadvertent “under” dosing in drugs needed to maintain a therapeutic blood level 	<ul style="list-style-type: none"> Use to prevent sub-therapeutic drug levels (e.g., anticoagulants) Use for drugs in which dose is defined Potentially use as reminder to consider stopping therapy 	<ul style="list-style-type: none"> Avoid using in drugs commonly titrated off (to minimize alert fatigue) 	<ul style="list-style-type: none"> Appears soft minimum dose limits are not needed on most drugs In pump systems that require a minimum dose limit, it is recommended to use the lowest value accepted in the pump to minimize alert fatigue (so that soft minimum alerts are experienced in drugs that have minimum requirement for therapeutic use)
Soft Maximum Dose Limit (Soft Stop)	<ul style="list-style-type: none"> Acts as a audible and visual cue to prevent human programming errors Increases risk awareness while offering some latitude in dosing variations 	<ul style="list-style-type: none"> Use to alert clinician to potential risk, “Are you sure?” (double-check entry and order) Use for drugs with large therapeutic dosage ranges where an upper limit for a hard stop is lacking or difficult to define for the patient Use for drugs identified as high risk 		<ul style="list-style-type: none"> Appears a high majority (60-70%) of soft maximum dose alerts are overridden because limits are not set properly set Appears hospitals did not invest in determining what is clinically relevant or what risk-adverting settings were needed
Hard Maximum Dose Limit (Hard Stop)	<ul style="list-style-type: none"> Prevents adverse patient effects from overdosing the drug therapy Protects patient from human errors, inadvertent actions, such as data entry errors (e.g., pushing IV keypad button twice; decimal point errors), dose vs. rate errors, dosing unit calculations mistakes, and “knee-jerk” overrides from alert fatigue Serves as a “forcing” function to require the clinician to double-check order, dose, rate, etc. 	<ul style="list-style-type: none"> Use for drugs identified as high risk Use for drugs with clear upper limits in which overdosing causes harm Use for drugs with defined dosing and narrow dosage range (e.g., Reopro) Use for drugs in which harm is not readily apparent via monitoring the patient at the bedside (e.g., Insulin) 	<ul style="list-style-type: none"> Avoid using in drugs without a clear upper limit of safe dosing 	<ul style="list-style-type: none"> Appears hard maximum dose limits in pumps prevent overdosing by enforcing delivery of the established dose and rate Appears if hard maximum dose limits are too narrowly defined, clinicians don’t comply, avoid use, and develop workarounds

High Risk IV Medications Dosing Limits Guidelines of Care

Table 3.0: Rationale Summary: High Risk IV Medications

Alert	Purpose	When To Use	When Not Use	Data Review Findings
Bolus Dose Limit	<ul style="list-style-type: none"> Enables safe bolus dose and rate of infusion using the existing infusion (eliminates potential calculation errors) Reduces the necessity for another supply of the drug Ensures safe end of bolus and return to safe continuous infusion settings 	<ul style="list-style-type: none"> Use for drugs in which rapid rate infusion is ordered to eliminate the risk of not returning to setting and recalculating dosage 		<ul style="list-style-type: none"> Appears clinicians employ creative methods to bolus due to time constraints, inconvenience, patient demand, etc., such as adjusting rate to simulate a bolus from the main infusion bag Appears bolus limit alerts are not being enabled Appears that the use of high rates (e.g., over 500-999 mL/hour) suggests staff bolus in continuous mode without hard limit alerts enabled
Concentration Limit	<ul style="list-style-type: none"> Identifies and intercepts dose concentration programming errors when using custom concentrations 	<ul style="list-style-type: none"> Use for drugs where dose is individualized based on patient weight or body surface area Use when standard concentration is not available in drug library May also be used for drugs that are infrequently concentrated at very high concentrations for specific patient needs 	<ul style="list-style-type: none"> Avoid using wildcards; offer only fixed drug selections with no wildcards and no concentration options 	<ul style="list-style-type: none"> Appears custom concentrations are used with limited or no established concentration limits for prevention of adverse effects from dosing errors Appears soft low concentration limits can be overridden and result is large overdoses Strongly recommended that every custom concentration have hard minimum concentration limits
Profiles	<ul style="list-style-type: none"> Facilitates requisitioning medications with limit settings to their appropriate population or care area (e.g., vasoactive drips kept within ICU) 	<ul style="list-style-type: none"> Use for drug that require a dedicated infusion device for certain high risk situations (e.g., epidurals) Use for outlier patients needing specific medication and dosage Use for appropriate and familiar medications in a dedicated care area (e.g., oncology or infusion center) 	<ul style="list-style-type: none"> Avoid using where levels of acuity are insufficiently distinct to merit the potential error risk when switching profiles during patient transfers 	<ul style="list-style-type: none"> Appears variation in profile composition makes benchmarking between hospitals challenging Appears some hospitals use the profile to identify specific patient types, such as bariatric patients; others use the therapies to identify the patient type

SDSPC members' thought process in analyzing the data set was as follows:

- The override action implied the dose was either intended or was overridden in error.
- The cancel action implied that the clinician either did not intend to proceed or was unsure what caused the alert and cancelled to start over.
- Often, the clinician reprogrammed to a different dose suggesting that the alert stopped an error, and the reprogrammed dose was the intended dose.
- High frequency on a specific dose suggested this dose was intended and settings too narrow or was seen decimal point error or common error.

After analyzing each organization's soft and hard alert limits and the community's alert responses, SDSPC members then:

- Determined safe, but not overly restrictive limits to minimize "noise" alerts appropriately overridden, as supported by evidence, and
- Proposed dosage limit alert settings for the specific drug, designed to produce a lower override to reprogramming alerts ratio.

Step 5: Obtained Voice of the Customer

SDPSC asked member hospitals to engage staff critical care nurses to share insight on nursing practice and provide "voice of the customer" input related to dosing limits for high-risk IV medications. The council was interested in learning why nurses responded to IV pump hard and soft stops with overrides or cancellations and understanding what clinical situations stimulated these responses. ICU nurses representing hospitals from across the county participated in the focus group session. This section describes nursing's insight on medication errors with smart infusion pumps.

Canceling

Many distractions (e.g., patient family, end-of-shift demands) occur at the bedside, which introduce the potential for human error when calculating infusion dosage and/or programming the pump. The nurses stated the main reason they pressed the infusion pump's Cancel key was to re-enter the programming when faced with an alert where the problem was unclear.

Other cancellation scenarios included:

- **Reach dose soft stop** – they often pressed the Cancel key and re-entered the dose information.
- **Correct programmed information** – they needed to correct a wrong entry they were aware of, such as incorrect drug, wrong IV line, too many zeros entered, or wrong row entry (e.g., volume instead of dose).
- **Change pump information** – they needed to change an entry (or became stuck when responding to screen prompts), so they turned off the module to get out of the screen and re-entered the pump information.
- **Remove air in line** – they needed to remove an air bubble in the line by flushing volume out of a port. This involved running volume through the pump and then cancelling, reprogramming, and re-connecting the line to the patient.
- **Change module configuration** – they needed to move around multiple modules/lines on the infusion pump unit, such as accessing an unused module on the inside of the unit.

Other conditions identified as contributing to increased cancellations included poor room lighting, rushing through the steps when programming a pump, changing the pump for a Code situation, not reading the screen messages, pressing keys too fast, and over familiarity with confirmation prompts ("confirmation basis").



High Risk IV Medications Dosing Limits Guidelines of Care

Reprogramming

If a nurse reaches a dosage hard stop, the infusion pump requires the nurse to reprogram the pump with acceptable dosage parameters to start the infusion. When this happened, the nurse reviewed the order, validated the patient ID and drug information on the bag, and re-entered the infusion dosage information. Interestingly, when the nurses were asked about their experience with a reprogramming/reset function after a hard stop alert, a majority stated they had little to no experience with hard stops and were not familiar with using a reprogram feature.

Overriding

Soft stops are intended to alert the user that the programmed infusion may be out of the drug's usual dosage range, as determined by the hospital. The user can change the infusion settings or proceed to beginning the infusion. When polled on soft stops, the common reason given why nurses override soft stops is due to patient need, such as a patient's blood sugar increases and the soft stop is set too low. Another reason nurses override soft stops is a programming error, such as entering 15 instead of the desired 1.5 dosing unit. The nurse can re-enter the dosage and begin the infusion with minimal steps if the error is realized.

Bolusing

Some clinicians use the bolus functionality on the pump to administer a bolus dose from a continuous infusion, while others administer bolus doses of a drug using a separate injection. In general, most SDPSC member hospitals are underutilizing the bolus feature of the infusion pump.



Step 6: Determined and Documented Recommendations

Collaboratively, SDPSC members analyzed the comparison data set for each high-risk IV medication and reviewed alert response behaviors (overrides, cancels, and reprogramming), alarm occurrence with possible explanation (e.g., wrong unit of measure, double-key error), and compliance with SDPSC 2009 tool kit recommendations. Members discussed the need for limits on a drug-by-drug basis, depending on therapeutic index, weight/non-weight based dosing, weight-capped dosing (i.e., beyond a maximum patient weight, the dosage is fixed, no longer increased), ease and rapidity of evaluating effectiveness, fixed dosing, renal dosing, and alert performance.

Collective experience, voice of the customer feedback (see *Voice of the Customer* section in this document), literature research, and shared general practices by hospitals identifying differences in smart infusion pump usage contributed to the council's discussions and decision-making. SDPSC's facilitator polled each member using the "Fist to Five" technique to achieve consensus on each high-risk medication's dosage limit. Table 4.0 summarizes SDPSC's standardization recommendations on hard and soft dosage limits for 20 high-risk IV medications. *NOTE: This information is a collection of experience and learning from SDPSC members along with the use of evidence-based literature and the analysis of countywide alert data.*

Dosing Stops Recommendations: High Risk IV Medications

The following table provides recommendations on standardized limits for the following high-risk IV medications:

Table 4.0: Dosing Stops Recommendations: High Risk IV Medications

Medication	Minimum	Soft Stop	Hard Stop	Safety Recommendations
Anticoagulants				
Abciximab (Reopro)	See safety notes below	See safety notes below	11 mcg/min	See safety notes below
	1.) Need pharmacy to publish on drug label the weight used to calculate the drug mixture 2.) To account for weight discrepancies between pharmacist and nurse, set dose calculation 20% over/below patient weight; ideally reconcile weight before dispensing 3.) If drug entered in infusion pump drug library, consider creating two library items: one for average patient (up through 80 kg is weight based at 0.125 mcg/kg/minute) and one for large patient (above 80 kg, dose is fixed at 10 mcg/minute, no longer weight based) 4.) Consider using drug as intermittent and run bag over 12 hours. NOTE: Pharmacy calculates the dose for this use. If used as intermittent, recognize learning curve for clinicians to view drug as “continuous infusion” and implement a change process. San Diego county standard is to run every bag as a continuous infusion (not intermittent) at 21 mL/hour, with the bag containing only enough drug for 12 hours for that patient			
Argatroban	0.1 mcg/kg/min	10 mcg/kg/min	12 mcg/kg/min	<ul style="list-style-type: none"> Need safety measures upstream from infusion pump settings Need protocol for titration of Hepatic patient, including monitoring liver function and coagulation state Consider different dose for patients with liver impairment
Bivalirudin (Angiomax)	0.1 mg/kg/hr	1.8 mg/kg/hr	2 mg/kg/hr	May consider two varieties (e.g., standard therapy and renal therapy)
	Renal Dose: 0.1 mg/kg/hr	Renal Dose: 1 mg/kg/hr	Renal Dose: 1.1 mg/kg/hr	Renal dosage 1 mg/kg/hour
	Bolus: 0.2 mg/kg	Bolus: 0.75 mg/kg	Bolus: 0.8 mg/kg	Bolus for PCI and medically treated
Eptifibatide (Integrillin)	0.5 mcg/kg/min (patients less than 120 kg)	2.2 mcg/kg/min (patients less than 120 kg)	2.4 mcg/kg/min (patients less than 120 kg)	Need proper ordering and pharmacy administration to ensure safety. Max of 20 mL/hour for > 120 kg if std 75 mg/100 ml
	Renal Dose: 0.5 mcg/kg/min (patients less than 120 kg)	Renal Dose: 1.1 mcg/kg/min (patients less than 120 kg)	Renal Dose: 1.2 mcg/kg/min (patients less than 120 kg)	<ul style="list-style-type: none"> Renal dosage is 1 mcg/kg/minute vs. 2 mcg/kg/minute otherwise Need proper ordering and pharmacy dispensing to ensure safety Max of 10 mL/hour for > 120 kg if std 75 mg/100 ml

High Risk IV Medications Dosing Limits Guidelines of Care

Table 4.0: Dosing Stops Recommendations: High Risk IV Medications

Medication	Minimum	Soft Stop	Hard Stop	Safety Recommendations
Heparin				
Heparin (Unit/h)	100 unit/hr	2800 unit/hr	3999 unit/hr	Require bolus per injection from vial
Heparin (Unit/kg/h)	2 unit/kg/hr	30 unit/kg/hr	40 unit/kg/hr	See safety notes below
	Consider possible Look Alike, Sound Alike errors resulting from the units/kg/hour and mL/hour numbers being in the same general range for the usual standard concentration of 50 units/mL, especially lighter patients (most similar around 50 kg). A standard of 100 units/mL results in the greatest error risk around 100 kg (when using kg based dosage units)			
Heparin Bolus – Facility with loading dose out of the bag	Bolus: 100 units	Bolus: 10,000 units	Bolus: 12,000 units	
Heparin Bolus – Titration during infusion (e.g., dose changes)	Bolus: 100 units	Bolus: 4,500 units	Bolus: 5,000 units	
Hypertonic Saline (3% NaCl)	<ul style="list-style-type: none"> Limited amount of data to characterize limits accurately. Usual rate: 0.5-1 mL/kg/hour with caution to avoid excessive durations. Smart pump administration requires mL/hour units and control of the infusion duration Need to specify rate limit and volume over a specific duration (with ongoing monitoring); this would enable setting limits and provide bolus function Must be able to specify infusion duration in hours - set max rate of 100 ml/h and not to exceed 8 hours in duration Infusion units are always mL/hour wherever displayed, not mEq/hr 			
Insulin	0.1 unit/hr ^(a)	Insulin Normal: 20 unit/hr Insulin Resistant: No SDPSC consensus	Insulin Normal: 30 unit/hr Insulin Resistant: 50 unit/hr (check q1 hr)	<ul style="list-style-type: none"> For continuous infusion outside ICU, do <u>not</u> allow a bolus dose For ICU use, allow bolus, assumes insulin resistance
	Bolus: 0.01 unit	Bolus: 15 units	Bolus: 20 units	
Neuromuscular Blockers				
<i>(Be sure to employ Train of Four to monitor the amount of muscle paralysis for upper limit of dosage; see Appendix B)</i>				
Cisatracurium (Nimbex)	0.01mcg/kg/min or 1 mg/hr	8 mcg/kg/min or 19 mg/hr	11 mcg/kg/min or 19 mg/hr	<ul style="list-style-type: none"> Limited use within San Diego area hospitals due to little data except recent ACURASYS trial; increased use during shortages Some hospitals traditionally use non-weight based dosage units (e.g., mg/hr, such as these recommendations from University of California, San Diego Medical Center [UCSD])
	Bolus: 0.01 mg/kg or 2 mg	Bolus: 0.1 mg/kg or 19 mg	Bolus: 0.2 mg/kg or 26 mg	
Pancuronium (Pavulon)	0.01 mcg/kg/min(a) or 0.5 mg/hr	2 mcg/kg/min or 15 mg/hr	3mcg/kg/min or 20 mg/hr	<ul style="list-style-type: none"> Limited use within SDPSC county hospitals Some hospitals traditionally use non-weight based dosage units (e.g., mg/hr, respected in these recommendations from UCSD)
	Bolus: 0.05 mg/kg or 1 mg	Bolus: 0.1 mg/kg or 10 mg	Bolus: 0.15 mg/kg or 15 mg	

Dosing Stops Recommendations: High Risk IV Medications

Table 4.0: Dosing Stops Recommendations: High Risk IV Medications

Medication	Minimum	Soft Stop	Hard Stop	Safety Recommendations
Rocuronium (Zemuron)	0.01 mcg/kg/min(a) or 2 mg/hr	16 mcg/kg/min or 50 mg/hr	24 mcg/kg/min or 99 mg/hr	<ul style="list-style-type: none"> Very limited use within SDPSC county hospitals due to no data; increased interest during shortages; extrapolated limits from combination of comparative ED95s and durations of action Some hospitals traditionally use non-weight based dosage units (e.g., mg/hr, respected in these recommendations from UCSD)
	Bolus: 0.5 mg/kg or 10 mg	Bolus: 1 mg/kg or 50	Bolus: 1.5 mg/kg or 100 mg	
Vecuronium	0.01 mcg/kg/min(a) 0.5 mg/hr	1.6 mcg/kg/min 15 mg/hr	2.5 mcg/kg/min 20 mg/hr	<ul style="list-style-type: none"> Some hospitals traditionally use non-weight based dosage units (e.g., mg/hr, respected in these recommendations from UCSD)
	Bolus: 0.05 mg/kg or 1 mg	Bolus: 0.1 mg/kg or 10 mg	Bolus: 0.15 mg/kg or 15 mg	
opioids				
fentaNYL (Sublimaze)	0.01 mcg/hr ^(a)	300 mcg/hr	No SDPSC consensus	For bolus safety, see opioid Recommendations in this document
	Bolus: lowest possible	Bolus: 100 mcg	Bolus: 250 mcg	
HYDROmorphone (Dilaudid)	0.01 mg/hr ^(a)	5 mg/hr (basic concentration)	<ul style="list-style-type: none"> No SDPSC consensus due to mix of opioid-tolerant patients Recommend hard stop for opioid-naïve patients Recommend separate hard stops for ICU and non-ICU units 	<ul style="list-style-type: none"> For opioid-tolerant patients, implement a different profile with an alternate <u>soft</u> stop and hard stop (see Dosing Limits Recommendations in this document) Recommend an order/policy that allows nurse to use the opioid-tolerant profile (can be standard for oncology patients)
	Bolus: lowest possible	Bolus: 2 mg	Bolus: 4 mg	
Morphine (PCA or IV)	0.01 mg/hr ^(a)	25 mg/hr	No SDPSC consensus	Use a different profile for opioid-tolerant patients with no upper limit
	Bolus: lowest possible	Bolus: 10 mg	Bolus: 25 mg	
PENTobarbital	0.2 mg/kg/hr	10 mg/kg/hr	10 mg/kg/hr	
Perinatal				
Magnesium Sulfate	0.01 gram/hr	2 gram/hr (covers 90% of patients)	3.5 gram/hr	<ul style="list-style-type: none"> Use only one standard concentration Limit to no more than 10-13 grams in a bag in case it is given off pump in error Follow hospital protocols to minimize human error and eliminate free flow infusions to decrease human error; follow hospital protocols
	Bolus hard stop: 6 gram over 20 minutes of (effectively a rate of 18 grams/hr) If over 18.1 grams/hr, then go to Eclampsia therapy to allow infusion over as little as five minutes			

High Risk IV Medications Dosing Limits Guidelines of Care

Table 4.0: Dosing Stops Recommendations: High Risk IV Medications

Medication	Minimum	Soft Stop	Hard Stop	Safety Recommendations
Oxytocin -- Induction	None or 0.01 milliunit/min ^(a)	20 milliunit/hour	40 millinunit/hour	<ul style="list-style-type: none"> Includes Augmentation profile Do not bolus until postpartum
Oxytocin – Postpartum (Bolus)	Bolus: lowest possible	Bolus: 10 unit (500 milliliters in 30 minutes)	Bolus: None	<ul style="list-style-type: none"> Includes hemorrhage and fetal demise Bolus immediately after delivery
	Bolus: 0.01 mg ^(a)	Bolus: 10 mg	Bolus: 20 mg	
Sedatives				
Dexmedetomidine (Precedex)	0.01 mcg/kg/hr	1.5 mcg/kg/hr	1.9 mcg/kg/hr	Do not bolus this drug due to bradycardia, hypotension, possible hypertension
Lorazepam (Ativan)	0.01 mg/hr ^(a)	6 mg/hr	10 mg/hr	<ul style="list-style-type: none"> Bolus to control agitation, maintain with drip, rather than titrating drip to control without bolus Not after 48 hours – no more than 6 mg/hr for 48 hours Adjuvant therapies should be considered Slow onset considered Filter required
	Bolus: 0.01 mg ^(a)	Bolus: 5 mg	Bolus: 10 mg	
Midazolam (Versed)	0.01 mg/hr ^(a)	10 mg/hr	20 mg/hr (if have Bolus)	<p>If patient at high dose (beyond hard stop limit):</p> <ul style="list-style-type: none"> Consider another drug, because it is not working or patient needs change For patients resistant, may supplement order with IV push
	Bolus: 0.01 mg ^(a)	Bolus: 10 mg	Bolus: 15 mg	
Propofol (Diprivan)	0.01 mcg/kg/min ^(a)	80 mcg/kg/min	100 mcg/kg/min	<ul style="list-style-type: none"> Bolus doses given outside OR are beyond nursing scope and not recommended If bolus doses allowed, must: <ul style="list-style-type: none"> Use pump's bolus mode Have order to Bolus with Bolus frequency, interval, and wait period Limit doses as recommended

(a) or lowest programmable value accepted by infusion pump in cases where no limit is wanted, yet required by the infusion pump

Dosing Limits Recommendations

SDSPC members and frontline nurses identified key strategies to help organizations reduce variability in practice and improve patient safety with the administration of high-risk continuous infusion medications in intensive and acute care units.

Address Common Infusion Issues

Throughout SDSPC's discussions on standardizing the high-risk medication dosage limits, common infusion issues related to body weight calculations, opioid-tolerance, renal clearance, bolus dosing, and weaning were identified. This section describes recommended safety practices related to these issues.

Body Weight Issues

After analyzing county data, most recorded alerts for weight-based IV drugs appeared to be weight discrepancies. SDSPC members suggest the following to address common body-weight infusion issues:

- Establish one measured patient weight in the chart for all dosage calculation, which is then used throughout the patient's stay, adjusted only for significant weight changes. SDPSC recommends using this *drug-calculation weight* for dosing.
- Implement ISMP recommendations that patient weight is measured and expressed in kilogram, not pounds, to ensure proper dosing.⁵
- Publish on the drug label the weight used by the pharmacist to calculate the drug mixture.
- For drugs not dosed on total body weight, use the appropriate body scalar versus total weight to calculate the dosage.
- For weight-capped drugs, consider a separate weight-based library in the infusion pump drug dataset for heavy patients. Common drugs included TPA/Stroke (90 kg), Integrilin (120 kg), and Reopro (80 kg). For example, with Reopro, consider implementing average and a heavy patient weight profiles or drug library items, such as:
 - Patients up to 80 kg: weight-based 0.125 mcg/kg/minute dose
 - Patients over 80 kg: use a fixed 10 mcg/minute dose

⁵ Institute for Safe Medication Practices. *ISMP Statement on Use of Metric Measurements to Prevent Errors with Oral Liquids*. October 2011.

- For Heparin therapy, consider establishing a separate library item if weight-based infusions will be allowed as an option (see recommendations in Table 6.0). Most SDSPC members use the weight-based Heparin for initiation (e.g., 18 units/kg/hour), then absolute units/hour for continuous infusion and titration (units/hour).

Opioid Tolerance Issues

Opioid Screening

Opioids by their nature pose inherent risks to the patient when delivered intravenously. In 2008, SDPSC conducted an improvement project focused on reducing errors with opioid infusion and patient controlled analgesia (PCA) therapy (see SDPSC's 2008 *Patient Controlled Analgesia Guidelines of Care for the Opioid Naïve Patient tool kit*). A critical safety factor uncovered in the 2009 project, as well as this improvement project, was accurately characterizing if a patient is opioid-naïve or opioid-tolerant. An effective process does not exist for separating opioid-naïve patients from opioid-tolerant patients at the bedside in the acute care setting. Although screening processes do exist that support certain patient populations (e.g., palliative care, oncology), the current mix of opioid-tolerant patients in the acute care setting stretch practice. Some suggestions to address this screening hurdle include:

- An organization must agree on the definition of an opioid-tolerant patient. SDPSC recommends using the U.S. Food and Drug Administration's definition of opioid-tolerant:

"Patients who are considered opioid-tolerant are those who have been taking, for a week or longer, at least 60 mg of morphine daily, or at least 30 mg of oral oxycodone daily, or at least 8 mg of oral HYDROMORPHONE daily, or an equianalgesic dose of another opioid."
- An organization should select an opioid screening tool and make the tool available to bedside acute care clinicians for determining tolerance.

Opioid-Tolerance Recommendations

For Opioid-Naïve Patients

In general, for opioid dosage limits, SDSPC members recommend hard stops exist for opioid-naïve patients (i.e., not tolerant). However, due to the mix of opioid-tolerant patients in the acute care setting and the lack of an effective narcotics screening process, SDSPC members were not able to gain consensus on establishing an upper dosing limit (hard stop) for HYDROMORPHONE, fentaNYL, and Morphine (PCA or IV).

High Risk IV Medications Dosing Limits Guidelines of Care

For Opioid-Tolerant Patients

SDPSC recommends instituting a separate opioid-tolerant profile for dosing. Pain management experts familiar with the specific patient population should be consulted in determining these dosing limits.

Additionally, it is recommended hospitals implement an organization-wide policy defining a patient as opioid-tolerant and establishing related protocols and order sets (e.g., the order to assess the patient). These are necessary for providers to order and clinicians to use the opioid-tolerant profile. Other such profiles and related policies and protocols can then be instituted as a standard for other patient areas (e.g., oncology).

Other Opioid Dosing Recommendations

Other recommended protocols to prevent overdoses when infusing opioids include:

- Consider administering opioids via syringe, not in bags. This delivery method provides added security via a PCA device, which hinders diversion. (The Alaris® module uses a safety feature that prevents infusion of more than 30% of the syringe per hour. This is helpful in the event of an incorrect concentration programming error.)
- Use the infusion module for PCA administration
- Avoid Look Alike, Sound Alike concentrations in the drug library
- If using the bag to infuse opioids:
 - Implement a hard stop at an upper dose limit, because the hard stop will require the clinician to bolus the drug (preferably using the smart pump's Bolus feature).
 - Ensure clear labeling of the infusion pump and line with the IV opioid infusion for additional safety.

Insulin Resistance

SDSPC members identified insulin resistance as a significant complication when setting dosage limits for infusing insulin. For example, bedside clinicians must balance the challenge of dosing to sliding scale orders and boluses for glucose control. Members recommend the following insulin dosing practices:

- Establish a separate insulin resistance profile or therapy in the IV drug library for clinicians to select.
- Implement an assessment for clinicians to evaluate the patient for normal insulin versus insulin resistance that is correlated with the profile, order sets, etc.

- Deploy regular refresher education and related competencies, including instructions on using the dose-rate calculator on the infusion pump.
- Consider instituting supplemental boluses via a syringe.

Renal Clearance

SDPSC members recommend the following dosing practices to address patients with compromised renal function:

- Establish Integerrin therapies for renal failure patients and those greater than 120 kg, because of prescribing requirements.
- If two therapies exist (e.g., standard therapy and renal therapy), ensure proper ordering, appropriate definition of renal clearance patient and protocol, and separated listing of therapies in the drug library.

Bolus Dosing

Hospitals should identify guidelines and protocols for when to use the bolus dose mode/feature on infusion pumps. For several of the high-risk medications, SDPSC members recommend the following:

- Restrict bolus delivery methods to the infusion pump for Midazolam, Insulin, and opioids. Doses of any opioid infusion should only be administered using the bolus mode/feature on the syringe pump.
- Ensure Propofol bolusing is based on an order, which includes how often to bolus and the interval between bolus. SDPSC members engaged in a lively discussion on whether this was appropriate in the ICU or should be limited to the operating room. SDSPC members came to no consensus and no conclusion.

Weaning a Drug

The issue of weaning a patient off a drug and running into alerts each time the dose went below the soft limit was identified as an annoyance factor, which creates a risk of alert fatigue for bedside clinicians. For this reason, SDSPC members recommended against having an alert for soft minimum, unless used to prevent sub-therapeutic drug levels (e.g., anticoagulants), drugs with hard concentration limits, and drugs in which recommended doses are clearly defined. Most of the high-risk IV medications dosing limits identified in this tool kit are set to use the lowest programmable value accepted by the infusion pump for the soft minimum dosing limit.

Expand Existing Smart Infusion Pump Technology Safety Features

The action of programming an infusion pump is complex. Humans performing complex behavior with many interruptions have a higher rate of failure.⁶ Over the past ten years, smart infusion pump technology has become an invaluable safety tool for hospitals. SDPSC members identified technology enhancements that could be useful in reducing the risk of medication errors and improving overall administration safety.

Drug Library

- **Drug Selection Display Order** – When the alphabetized IV drug library is presented to the clinician for selection, some high-use medications may display at the bottom of the selection list and not readily accessible to the user. It is suggested that the ability to re-order how medications are listed for selection in an infusion pump (e.g., displaying commonly used drugs at the top of the selection list versus the alphabetical display). However, SDPSC members also recommend conducting a usability study in real clinical settings to validate this concept.
- **Search Engine** – As the library of available medications expands, additional features could be made available for clinicians to search for the desired medication when programming the IV pump, such as text string, trade or generic drug name, and aliases.
- **Override Rationale** – Although it may be useful and interesting to capture in real-time via the smart infusion pump the reason why clinicians’ override, any confirmation prompt/additional feedback would create significant workflow issues. Therefore, it is suggested that infusion pump vendors perform additional research and carefully conducted trials to understand the rationale for overrides, without restricting workflow.
- **Dosage Limits Around Titration Dose and Time Increments** – Titration increment limits could be used in medications with standard protocols and provide additional safety benefits. In circumstances when a clinician is titrating a drug up, yet has entered an incorrect dose into the infusion pump, limits to the titration increment could exist and trigger an alarm. For instance, with a Heparin order started at 800 units/hour titrated to a total of 1700 units/hour, the

infusion pump could alert the clinician if the wrong increment (e.g., 1000 instead of 100 units/hour) is unintentionally entered.

- **Weight-Based Dosing Calculations** – While the dose is calculated per kg/hour, clinicians tend to run the infusion in units/hour even if they base the dose on the patient’s weight. It may be helpful for the infusion pump to do the calculations and display the final dose per hour to reduce errors in mathematics.
- **Bolus Feature** – SDPSC members noted that there was an underutilization of the Bolus function among SDSPC member hospitals. It may be useful for infusion pumps to facilitate clinicians in the direction of the Bolus option when they enter values detected as a bolus (e.g., bolus deliveries are often given in volume rather than dose).
- **Code Override** – In Code situations, it may be helpful for clinicians to have an infusion pump option to override all settings (e.g., “Code Override” feature).

Confirmations

- **Entry Validation** – It is important to display all infusion pump drug information back to the clinician at the time of programming for order validation to happen. This full display for optimum data validation is consistent with closed loop communication
- **Concentration Validation** – A recurring problem is accidentally mis-selecting the concentration from the drug library when several are available (e.g., 1x, 5x). This can happen when replacing a bag or syringe. It should be an intentional and infrequent change that requires confirmation to prevent errors of 2-5 x in dosages. Infusion pump could request, “Are you sure this is a concentration change?” whenever changing from the previous relative or absolute concentration.
- **Second Verification** – Considering the inherent challenge of categorizing patients for opioid administration, it is suggested a second verification in lieu of a hard stop is available for opioids. Another clinician can agree that the override is appropriate. This could be helpful for some weight-based drips that have a maximum patient weight beyond which the dose is fixed (e.g., mg/hour).

Failure Feedback

- **Meaningful Failure Feedback** – When clinicians reach a hard stop, it is important for them to understand why the stop was reached, what alternatives are available, and a prompt to modify the order.
- **Alert/Prompt Language** – It is suggested that the language used in concentration alerts/prompts reflect “nursing speak,” such as “too dilute.”

⁶ Westbrook JI, Woods A, Rob MI, Dunsmuir WT, Day RO. Association of interruptions with an increased risk and severity of medication administration errors. Arch Intern Med. 2010 Apr 26;170(8):683-90.

High Risk IV Medications Dosing Limits Guidelines of Care

Alerts

- **Distinguishable Alert Sounds** – It is suggested an audible alert for the hard stop that is distinguishable from the soft stop could better help the clinician differentiate importance.
- **Significant Dosage Percentage Changes** – If a significant percent change (of relative and absolute numeric value) in dosing is detected by the pump (e.g., clinician enters 15 instead of 1.5), it may be helpful for the infusion pump to alert the clinician to re-enter the dose as a way to validate the entry. Such a change in dose is often an indication of human error.
- **Soft Maximum Limit** – When a soft stop is reached, it is suggested that the infusion pump display all information for comparison, prompt the clinician to re-enter the dose, and check that the doses match.

Technology Integration

To reduce serious medication errors, it is suggested that hospitals integrate the following bedside technology for single path medication administration:

- Computerized physician order entry system,
- Electronic medical record- and barcode-assisted infusion administration, and
- Clinical decision support systems.⁷

Increase Effective Monitoring of Smart Infusion Pump Use

SDPSC members identified the following monitoring strategies as important practices to reduce the frequency of high-risk IV medication errors at the bedside.

Stop/Check Practices

When programming the infusion pump, implement “stop/check” practices with clinicians, such as:

- Verify the dosage written on the infusion bag matches the medication order.
- Verify the programmed infusion entries match the medication order and infusion bag.
- When selecting a medication, check for a profile matching the medication order.

- Be sure to program the correct channels carrying the medication.
- If a soft stop alert is reached, pause and consider:
 - Was there a keystroke mistake?
 - Is the dosage correct and within hospital practice?
- If a hard stop alert is reached, pause and do the following:
 - Check the entry and note why alarmed
 - Check the dosage entered matches the infusion bag and medication order
 - Reprogram the entry.

Independent Verification

San Diego area hospitals employ independent verification appropriately as follows for Heparin, Insulin, and PCA orders at: 1.) initiation/set-up of the infusion pump; 2.) every dose change (i.e., increase or decrease in rates or parameters); and 3.) each replacement of a new bag or syringe.

Line Reconciliation

It is recommended clinicians perform the following line reconciliation at change-of-shift for each infusion, including maintenance fluids:

- Trace the line from the bag to the infusion site (i.e., map the line),
- Trace and label all lines above and below the infusion pump module,
- Verify route selection and placement, and
- Check concentration.

Improve Frontline Education

Advancing safety at the bedside starts with ensuring clinicians are competent and comfortable with delivering high-risk IV medications using smart infusion pump technology. SDPSC members recommend the following education practices:

- Institute regular infusion pump competency training.
- Provide off-floor practice time for clinicians to work with equipment using realistic scenarios and quizzes to validate competency and comfort with equipment.
- Instruct on how to recover from errors in programming the infusion pump, such as what to do when soft stop or hard stop alert is reached or when a wrong entry is made. For sample education handouts, see websites listed on page 2.

⁷ Benoit E, Beney J. Can new technologies reduce the rate of medications errors in adult intensive care?. J Pharm Belg. 2011 Sep;(3):82-91.

Implementing Dosing Limits Guidelines

This section provides a description of the methodology used by SDPSC to develop guidelines in this tool kit. It is recommended that hospitals use this same methodology to develop and implement IV dosage limits.

Mobilize Commitment

To start, form a hospital task force and manage resistance by identifying stakeholders:

- Critical Care Nurses
- Acute Care Nurses
- Clinical Pharmacists
- Pharmacy Leadership
- Pharmacy Buyers/Wholesaler Supplier
- Process Improvement Department
- IS/IT Pharmacy-IT Department
- Nursing Leadership
- Service Line Experts: Pain, Oncology, Diabetes
- Intensivists
- OB-Gyn Nurses
- OB-Gyn Physicians
- Anesthesia
- Pharmacy and Therapeutics Committee
- Nurse Educators
- Policy and Procedure Committee
- Those responsible for standard order sets
- Others, as needed

Identify Patient Population

The scope of the improvement project should include IV medication settings for adult patients in intensive and acute care units. For the neonatal and pediatric populations, it is recommended that the task force use alerts data from a broad spectrum of children's health organizations (e.g., Children's hospitals) when determining dosage limits.

Define and Evaluate Current State

The task force must identify current state to target change effectively. To do so, the task force should compile available smart infusion pump data and prepare the data (e.g., data slides) for sharing and discussing (see *Methods section*). Additionally, the task force should consider holding focus group sessions with bedside nurses from various acute care settings to better characterize frontline practices.

Key recommendations to consider when reviewing smart infusion pump data:

- Identify discrepancies (e.g., concentrations, dosage)
- Analyze alert data for patterns:
 - What doses triggered alerts?
 - What were the reprogrammed doses?
 - Could outliers indicate double-digit mis-entries (e.g., 20 vs. 200)?
 - What were the number of reprograms to overrides?
- Identify infrequently administered high-risk IV medications
- Compare organization's data with SDSPC's infusion pump drug/fluid limits recommendations. If recommendations were implemented, look at performance, such as increased alerts and overrides to reprogramming
- Be aware that tightly set alerts contribute to an increase in alert override.

Create a Shared Need

The case for standardization must be based on evidence, best practice, participants' experience, literature reviews, etc. Additionally, facilitation should be encouraged to allow for discussion and clarification to ensure that the task force aligns fully on what is included and excluded in the project. The outcome should be a concise description of the case for dose limit standards. Furthermore, it is important to work with all stakeholders to obtain agreement on suggested standards for the hospital.

Elevator Speech

An "Elevator Speech" can be used to quickly convey key elements of the improvement project to staff, such as:

- **What:** The goal of this project is to implement evidenced-based community standards and best practices on setting and managing high-risk IV drug dosing limits.
- **Why:** This is important because too restrictive dosing limits cause unnecessary alerts, which increase the risk of overriding legitimate medication alarms.
- **Success:** We will have achieved success with this project when we have implemented a safe, effective dosage limits across our hospital, as evidenced by a reduction in infusion errors.
- **Need:** We need your support and commitment in developing and adopting these standards and facilitating this change to all applicable areas and individuals.

High Risk IV Medications Dosing Limits Guidelines of Care

Standardize, Simplify, and Clarify

A standard approach to IV dosing limits across hospitals within a region should extend beyond defining the soft and hard stop settings. It is recommended policies and procedures, standard orders, labeling, and education are standardized as well to simplify and clarify high-risk drug infusions for improved patient safety.

Policies, Procedures, and Process

Standard policies, procedures, and work processes are effective methods that provide a margin of safety in minimizing variance with medication administration. When developing these practices, be sure to engage in active listening and learning with bedside clinicians.

The following are recommended:

- Establish when to use infusion pump limits versus employing other tools for safety (e.g., computerized physician order entry, barcoding, electronic health record, order sets).
- Establish ordering practices that eliminate the use of custom, non-standard concentrations (or wildcards) (which have no limits) and ordering by concentration. *If using wildcards, SDSPC recommends instituting limits to prevent errors.*
- Ensure the hospital's IV drug library complies with The Joint Commission's "Do Not Use" abbreviation list and the Federal Drug Administration and ISMP TALL MAN lettering conventions.
- Ensure appropriate hand-off order and infusion pump information are communicated from pharmacist/technician to nurse and between nurses at shift change.
- Establish policies on the following:
 - Elimination of free flow infusions of Magnesium Sulfate to decrease human error,
 - Ordering protocol for opioid-tolerant patients,
 - If authorized, nursing ordering protocol for bolus of Propofol, and
 - Process to manage running up against hard stops for outlier patients.

Documentation

SDPSC recommends the task force conduct a comprehensive and careful analysis of documentation to identify changes to any documentation forms, both paper and computerized, based on the recommended standards. For example, nursing assessment and MAR documentation should be updated to include the new drug dosage units.

Reports

SDPSC recommends establishing a systematic method for evaluating alert data and systems. The task force should consider employing standard reports and establishing practical guidance on what is important to review (e.g., how many times a high dose is used) and how often to analyze for trends and underlying issues.

Standard Order Sets

Standard order sets ensure consistent and accurate product ordering, delivery, and use, thereby reducing potential medication errors. SDPSC recommends that each hospital establish standard order sets for the following drug profiles:

- Opioid-tolerant and opioid-resistant,
- Lipid-based IV drugs,
- Insulin resistance, and
- Renal clearance.

It is important that physicians participate in all discussions related to order set standardization. Also, Pharmacy and therapeutics committees should be kept apprised of any planned changes in medication use.

Labeling

SDPSC recommends the following labeling practices to reduce potential patient safety mistakes:

- Make the information on the label match how the nurse will program the pump
- Make the formatting of the order set match the infusion pump programming fields, and their sequence within the pump
- Ensure syringe/bag label is consistent with programming settings on the pump
- Publish clearly all order information on the bag's label for the nurse (including total volume and amount of drug)
- Use different font family, size, and color to differentiate pharmacist instructions on bag labeling
- Identify clearly the body weight calculated by pharmacy on the bag's label
- Label the bag with dosing of the entire package as well as the dose intending to be administered
- Use Tall Man lettering on all syringe product labels (e.g., HYDR**O**morphine)

- Comply with The Joint Commission's "Do Not Use" Abbreviations List
- Use Dose per ml in large font and Total dose per syringe in small font to communicate dosage information (e.g., 1 mg/mL, 50 mg/50 ml).
- If custom concentrations must be used, change the container label to a different color to distinguish the concentration from the standard syringe/bag label.
- Implement bedside technology, such as barcoding, to program the pump. This would eliminate concentration keystroke errors during programming.
- Provide "concentration alerts" that distinguish concentration orders. These alerts need to be written for the nurse administering the drug (not the pharmacist).

Appendices

Appendix A – 2009 Revised SDPSC Tool Kit High Risk IV Medications

From 2009 Revised SDPSC Tool Kit

Standardized List of Adult IV Infusions – High-Risk Medications

HIGH-RISK MEDICATIONS Antithrombotics, Electrolytes, Insulin, opioids, Neuromuscular Blockers			
DRUG	MIXTURE(S)	STANDARD FINAL CONCENTRATION (Single Strength)	STANDARD INFUSION RATE UNITS
Abciximab (Reopro)	Standardized rate and duration, with variable concentration being weight-based and patient specific	12 hr bag, with variable concentration per patient specific, weight-based standard infusion of 0.125 mcg/kg/min (max 10 mcg/min)	Flat rate 21 ml/hr; dosing units are mcg/kg/min
Eptifibatide (Integrilin)	Standard pre-mixed products (i.e., 75 mg/100ml)	75 mcg/ml	Mcg/kg/min
fentaNYL (Sublimaze)	Varies	IV: 10 mcg/ml (0.01 mg/ml) Non-OB epidural: 5 mcg/ml Epidural OB: 2 mcg/ml (0.02 mg/ml) (+/- bupivacaine 0.125%)	IV: Mcg/hr OB: Mcg/hr
Heparin (Warning: look-alikes: 2 units/ml vs. 50 units/ml 500 ml bags vs. Hesperan)	25,000 Units/500 mL	50 units/ml	Units/hr
HYDRomorphone (Dilaudid) PCA or IV	10 mg/50ml, 20 mg/100ml	0.2 mg/ml	Mg/hr
Insulin	100 units/100ml	1 Unit/mL	Unit/hr
Magnesium Sulfate	20 gm/500 ml (4%) LVP OB only Otherwise, IVPB as 1 or 2 gm/50 ml, or 4gm/100ml	4% LVP solution for OB use only Otherwise, IVPB as 0.02 gm/ml (2%) or 0.04 gm/ml (4%)	Gm/hr
Morphine PCA or IV	Volume variations on a theme, depending upon device and patient needs: 50 mg/50ml, 100 mg/100 ml, 250 mg/250 ml, 300 mg/300 ml	1 mg/ml	Mg/hr
Vecuronium	100 mg/100ml	1 mg/ml	Mcg/kg/min

From 2009 Revised SDPSC Tool Kit

Standardized List of Adult IV Infusions – Other Medications

OTHER MEDICATIONS			
DRUG	MIXTURE(S)	STANDARD FINAL CONCENTRATION (Single Strength)	STANDARD INFUSION RATE UNITS
Amiodarone	Load: 150 mg/100ml Drip: 900 mg/500 ml	IVPB Load: 1.5 mg/ml LVP Drip: 1.8 mg/ml	Mg/min
Bumetanide	Undiluted 25 mg/100 ml	Undiluted 0.25 mg/ml	Mg/hr
DOBUTamine	500 mg/250 ml	2 mg/ml	Mcg/kg/min
DOPamine	400 mg/250 ml	1.6 mg/ml	Mcg/kg/min
EPI/CAL	2 mg epi + 1 Gm CaCl ₂ /250 ml	8 mcg/ml	Mcg/min
EPINEPHrine	2 mg/250 ml	8 mcg/mL	Mcg/min
Esmolol (Brevibloc)	2500 mg/250ml	10 mg/ml	Mcg/kg/min
Furosemide	250 mg/250ml	1 mg/ml	Mg/hr
Isopreterenol	1 mg/250 ml	4 mcg/ml	Mcg/min
Labetalol	100 mg/100 mL	1 mg/mL	Mg/min
Lidocaine	2 gm/250 ml pre-made	8 mg/ml	Mg/min
LORazepam	1 mg/ml D5W; std volume not determined	1 mg/ml	Mg/hr
Midazolam	1 mg/ml D5W; std volume not determined	1 mg/ml	Mg/hr
Milrinone	20 mg/100ml pre-made	200 mcg/ml	Mcg/kg/min
Neosynephrine	50 mg/250 mL	200 mcg/ml	Mcg/min
Nesiritide	1.5mg/250ml	6 mcg/mL	Mcg/kg/min
niCARDipine	25 mg/250 mL	0.1 mg/mL	Mg/hr
Nitroglycerin Glass Only	50 mg/250 mL pre-made	200 mcg/mL (0.2 mg/ml)	Mcg/min
Nitroprusside	50 mg/ 250 ml	200 mcg/ ml (0.2 mg/ml)	Mcg/kg/min
Norepinephrine (levophed)	4 mg/250 ml D5W	16 mcg/ml	Mcg/min
PENTobarbital	2.5 gm/500 ml	5 mg/ml	Mg/hr
Pitressin (vasopressin)	100 units/100ml	1 unit/ml	Unit/min
Procainamide	2 gm/ 250 ml	8 mg/ ml	Mg/ min
Propofol	Undiluted	Undiluted 10 mg/ ml	Mcg/kg/ min
Theophyllin	800 mg/500mL (pre-mixed) (1,000 mg/500 ml aminophylline)	1.6 mg/ml theo (2mg/ml aminophylline)	Mg/kg/hr

High Risk IV Medications Dosing Limits Guidelines of Care

Appendix B - Neuromuscular Blockers Dosing Guidelines

	ED95 ³ dose (mg/kg)	ED95 Ratio	Initial dose (mg/kg)	Infusion dose (mcg/kg/min)	Duration (min)	Recovery (min)
Cisatracurium	0.05	1	0.1-0.2	2.5-3	90	90
Pancuronium	0.05	1	0.08-0.1	0.5-2	90-100	50+
Rocuronium ²	0.3	6	0.6-1	10-12	30	33
Vecuronium	0.05	1	0.08-0.1	0.8-1.2	35-45	50

1. Murray MJ et al (SCCM): Clinical practice guidelines for sustained neuromuscular blockade in the adult critically ill patient. Crit Care Med 2002; 30 (1): 146-147
2. A PubMed search for “rocuronium” and “ICU” clinical trials, reviews, and guidelines found nothing since 2002 related to ICU infusions other than immediate post CT surgery.
3. ED95 – The dose of a neuromuscular blocking drug required to reduce twitch height by 95%. (source: Miller, RD et al. Miller’s Anesthesia, 7th ed, Churchill Livingstone: Chapter 29. 2009 (ISBN 9780443069598))