TITRATION ERROR PREVENTION:
SMART PUMP TECHNOLOGY AND BEST PRACTICES

DESIGNED TO HELP REDUCE TITRATION PROGRAMMING ERRORS

The Dose/Rate Change Alert is designed to help reduce titration programming errors even within the drug library’s soft limits. The Dose/Rate Change Alert feature is only available with the Sigma Spectrum Infusion System.
Importance of Drug Dose Titration

High-alert medications carry a significant patient safety risk if not administered correctly, especially when given intravenously (IV). These medications, which may include antithrombotics, antihypertensives, neuromuscular blockers, opioids, sedatives, analgesics, and vasopressors, are typically given to critically ill patient groups and are often titrated to achieve a therapeutic effect. Due to their potential for harm, careful monitoring and titration of these medications is essential. For example, it has been estimated that 80% of deaths due to medication errors are correlated with just 20 high-risk drugs.

Correct dosing and titration of high-alert medications, especially in the ICU setting, is critical to avoid severe complications.

Of 64,260 ICU patient encounters involving high-alert medications identified in a US electronic health record (EHR) database covering 114 hospitals from 2008 to 2013, the most commonly administered high-risk medications class in the ICU were sedatives and analgesics (including opioids). These drugs, if not administered correctly, may cause adverse events. high-alert medications (Figure 1).

Titration Errors: Scope of the Problem

The prevalence of medication errors is well-known and the administration stage of medication delivery is particularly prone to error — especially incorrect dosing of titratable drugs in critically ill patients.

The most important risk factor for ADEs in ICU patients is the higher number of medications ICU patients receive, including more high-alert medications. A retrospective medical record review by Nuckols et al., published in 2007, analyzed two hospitals for adverse events with IV medications both before and after implementing smart pump technology. The analysis included 4,604 ICU patients and 20,559 bed days. The study found that 44% of the adverse events that occurred were associated with four titratable high-alert IV medications. Critically ill patients are particularly susceptible to ADEs and frequently receive potent intravenous drugs with narrow safety margins that require careful titration of dosage. This could mean that this patient population is often exposed to multiple opportunities for medication errors, and that there is an opportunity for infusion technology to help address this source of medication errors.

Error Rates and Potential Adverse Drug Events; An Ongoing Concern. Despite implementation of safety related technologies, including smart pump technology, medication error rates and rates of preventable IV pump-related ADEs are still unacceptably high.

In the 2007 retrospective medical record review, by Nuckols et al., only 4% of the preventable IV-ADEs could be intercepted by the smart pumps’ features included in the study (detecting duplicate and continuous infusion doses outside of hospital defined ranges). The authors concluded that “expanding smart pump capabilities might prevent more IV-ADEs.”

One reason for titration errors may be the need to perform several tasks at once (i.e. programming doses for several IV medications). As explained in a set of 2012 guidelines created by the San Diego Patient Safety Council for the administration of high-risk medications, “The action of programming an infusion pump is complex. Humans performing complex behavior with many interruptions have a higher rate of failure.”

High-alert medications are often titrated multiple times throughout an infusion. The risk of programming errors and IV infusion pump-related adverse drug events (IV-ADEs) increases as the number of changes increases. In patients receiving more than one high-alert medication, the risk is compounded with each additional medication.

In the ICU patient encounters covered in the EHR database examined, 83% of patients receiving a high-alert medication (53,002) received two or more such medications over the course of their ICU stay, and 41% (26,038) received six or more high-alert medications (Figure 1).

Correct dosing and titration of high-alert medications, especially in the ICU setting, is critical to avoid severe complications.

Number of high-alert medications

- 1: 9,397 (15%)
- 2: 11,258 (17%)
- 3–5: 8,701 (14%)
- 6–10: 16,641 (26%)
- >10: 18,263 (28%)

Figure 1. Distribution of high-alert medication use (number of drugs/patient) in ICU patients from a US EHR database covering encounters from 114 hospitals from 2008 to 2013.
Titration alerts may help minimize this problem. As stated in these same guidelines, “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.”

A smart infusion pump that could recognize potential titration errors would represent significant value to clinicians and could help support infusion safety.

**Titration Error Prevention**

**Importance of Titration Error Prevention.** IV Pump-ADEs occurring when inaccuarately changing a dose or rate can potentially be avoided with the use of a titration error prevention feature that provides alerts when defined limits are exceeded. Some high-alert medications, such as opioids, have the potential to cause harm even within common soft dosing limits. For example, a vasopressor can have varying effects depending on the dose: at lower doses the vasopressor can cause vasodilation, at higher doses the effect is vasoconstriction. An incorrect adjustment of the infusion rate could therefore lead to serious unintended consequences. This is especially important in the ICU, where many patients receive high-alert, titrated medications, and in many cases receive more than one such medication. As stated by Dennison, in the ICU “many drug dosages are titrated based on the patient’s changing condition, and the more dosage changes a nurse keys in, the greater the risk of error and patient harm.”

**Baxter’s Sigma Spectrum Infusion Pump: Novel Dose/Rate Change (Titration) Error Prevention Safety Feature.**

Baxter’s Sigma Spectrum Infusion Pump is the only smart pump that alerts the clinician to potential programming errors in dose or rate changes. The titration error prevention feature can help identify potential titration programming errors within the facility-defined soft dosing limits. This feature alerts the clinician if the percentage change exceeds limits set to match the facility’s titration protocols. These alerts are configurable for all medications to meet each Care Area’s clinical practice. For example, the default alerts will warn the clinician programming the change if the programmed increase is greater than 101% (or the decrease is greater than 51%) of the previously programmed dose. These percentage limits are editable by drug (exception Anesthesia and OR Care Areas where percentage increase limit is 500%). In the case of the example shown in Figure 2, the Dose/Rate Change Alert would alert the user of the programming error (25 instead of 2.5 mcg/kg/min).

**Conclusion**

Despite advances in smart pump technology, medication errors still occur frequently in the hospital setting. Errors in titrating high-alert medications can be particularly dangerous due to their prevalence in the ICU and usage in vulnerable patient groups. The importance of accurate titration has been described in several articles and guidelines. Though all smart pumps...
Dose/Rate Change (Titration) Error Prevention Feature

Employ best practices to maximize the patient safety feature of titration error prevention.

Hospitals with the Sigma Spectrum Infusion System can customize single step rate change/titration alert thresholds based on the IV medication and care area — this safety feature can be adapted to your hospital’s IV medication policies. This feature enables an additional safety check during doses/rate change (titration).

The Sigma Spectrum Infusion Pump with Master Drug Library is intended to be used for the controlled administration of fluids. These may include pharmaceutical drugs, blood, blood products and mixtures of required patient therapy. The intended routes of administration consist of the following clinically accepted routes: intravenous, arterial, subcutaneous, epidural or irrigation of fluid space.

The Sigma Spectrum Infusion Pump with Master Drug Library is suitable for a variety of patient care environments such as, but not limited to, hospitals and outpatient care areas.

Rx Only. For the safe and proper use of this device, refer to the appropriate operator’s manual. Refer to manufacturers’ Package Insert for full Prescribing Information for Sodium Chloride Injection.

References

www.sigmapumps.com
www.baxter.com

Baxter Healthcare Corporation
Route 120 and Wilson Road
Round Lake, IL 60073

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