

Patient Care Issues in Acute Care Settings

Enhancing patient safety with intelligent intravenous infusion devices: Experience in a specialty cardiac hospital

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ABSTRACT

OBJECTIVE: The study objective was to evaluate patient safety, increase nursing satisfaction, and affect economic factors through implementation of intelligent intravenous (IV) infusion devices in a specialty cardiac hospital. Intelligent IV infusion devices have been shown to decrease medication errors associated with inpatient infusions.

METHODS: Intelligent IV infusion device evaluation and drug library creation were conducted by a multidisciplinary team within the hospital. Devices were then implemented into patient care, and the impact was analyzed over a 9-month period.

RESULTS: Post-implementation data showed that compliance was approximately 100%. A total of 494 critical catches occurred over the study period, resulting in an estimated annual savings of \$7,513,333. End-users became familiar with the new technology and recognized the increase in safety measures and time spent with patients.

CONCLUSION: This evaluation suggests that intelligent IV infusion devices resulted in decreased costs and a safer environment for patients.

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In today's healthcare environment, most patients admitted to an acute care hospital will receive medications by the intravenous (IV) route. Although lifesaving in many patients, IV medication administration can be associated with adverse drug events (ADEs), producing substantial patient morbidity and mortality.

Approximately one third of all medication errors in US acute care hospitals are due to administration of IV medications.^{1,2} These IV infusion-related ADEs are costly to patients, their families, employers, healthcare

facilities, and payers. Each preventable ADE in a hospital adds, on average, approximately \$8750 (in 2006 US dollars) to the cost of a hospital stay.³

Technologic advancements and complexities of today's medications have made it even more difficult to administer IV medications without error.⁴ There has been a dramatic increase in high-risk IV medications with narrow safety margins (ie, "high alert" medications) that are associated with a large potential for patient harm. Often these drugs involve complicated protocols and procedures that in turn carry an

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increased risk of drug, dose, and route errors in the administration stage.⁵

In today's environment, hospitals are searching for methods to decrease or eliminate administration medication errors through a new generation of IV infusion pumps, known as "intelligent" or "smart" pumps that use wireless medication safety software.⁶ The intelligent pump will alert the nurse if institution-defined parameters (ie, drug dose, dosing unit, dosing rate, or drug concentration) are outside of preestablished limits.⁷ In addition, intelligent pumps have free-flow protection that prevents unintentional over-delivery of fluids or medications.

Several studies have strongly suggested that the use of intelligent IV infusion pump technology can reduce ADE rates.⁸⁻¹¹ In 2008, the American Society of Health-System Pharmacists organized an IV Safety Summit that recommended a suggested timeline for intelligent pumps implementation in 1 to 3 years.¹² Acting on these recommendations, the leadership at St Vincent Heart Center of Indiana (SVHCI), a specialty cardiac hospital located in Indianapolis, decided to incorporate intelligent IV infusion technology into the redesign of its hospital work environment. This article describes the implementation process and findings of interest since its implementation.

MATERIALS AND METHODS

Implementation

A multidisciplinary committee was involved in the evaluation, subsequent selection, and implementation of the new IV administration technology. Program leaders were identified and responsible for overall organization and keeping the program on schedule. The committee was charged with creation of a drug library. Drug libraries are assigned to the major patient care areas or specific patient populations who receive "high alert" medications administered by IV infusion within that institution. These specific areas are referred to as clinical care areas (CCAs). Ultimately, a well-constructed library will support efficiency, effectiveness, and appropriate use of the drug library at the bedside.

The pharmacy department was charged with developing the initial draft library using multiple reference sources to establish hard and soft dosing limits. The completed draft library was then distributed for review and comment. As end-users, nurses ensured that the library reflected current practice and patient treatment protocols.

Unit directors identified super-users (ie, clinicians trained on the equipment to be "hands-on" instructors for individuals needing assistance) in specific areas. Each super-user reviewed the draft drug library contents line-by-line for accuracy. Challenges in the library

development process included agreeing on specific drugs, concentrations, and selection between existing drug protocols (eg, units/hour, weight-based dosing calculations), and meeting the specific department needs. It was decided to adopt national recommendations where available, for example, propofol dosing was switched from milliliters/hour to microgram/kilograms/minute. Consistent standards would likely avoid confusion and decrease the potential for errors.

To minimize disruption of patient care and to gain support of staff, a detailed implementation plan was devised for the switchover to the new infusion pumps, which included the set-up and testing of 200 pumps. The implementation proceeded from unit to unit on a strict schedule. The process was uneventful and required only 3 additional nursing staff members and vendor staff. Total switchover was completed within 8 hours.

RESULTS

End-users initially experienced some difficulty with adapting to the new pump technology. However, within 6 months, as end-users became more familiar with the software and adept at its use, the technology was embraced. Compliance with use of the safety software was virtually 100% across the 3 CCAs that were responsible for 91.4% of all IV infusions. Unlike previous intelligent pumps, this new generation of infusion pumps mandated use of the safety software. In the 3 CCAs, 3.3% to 4.3% of all infusions resulted in a soft or hard limit alert.

Hard limit alerts constituted 11.8% to 33.0% of all alerts. By definition, hard limit alerts could not be overridden and required an edit of the pump entry parameters. Most edits of hard limit alerts involved alterations of the dosing rate (80.7%-96.2%), whereas the balance involved alterations in bolus dosing (3.8%-19.3%).

Soft limit alerts constituted the majority of all alerts (67.0%-88.2%) and could be overridden. In most cases, soft limit alerts were overridden (40.4%-70.9%) with the balance resulting in edits of pump entry parameters (29.1%-59.6%). When edits were made in response to soft limit alerts, most involved alterations in the dosing rate (89.8%-96.7%), with only a minority involving alterations in bolus dosing (3.3%-10.2%).

A total of 644 infusions had dosing parameters outside of normal ranges as established by lower and upper soft and hard limits. There were 47 (7.3%), 103 (16.0%), and 494 (76.7%) infusions that had dosing parameters below lower soft, above upper soft, and above upper hard limits, respectively.

Dopamine, propofol, dobutamine, heparin (dosed on the basis of body weight), and heparin (cardiovascular surgery, dosed as units/hour) exhibited the greatest ranges of percentage deviations followed by vasopressin,

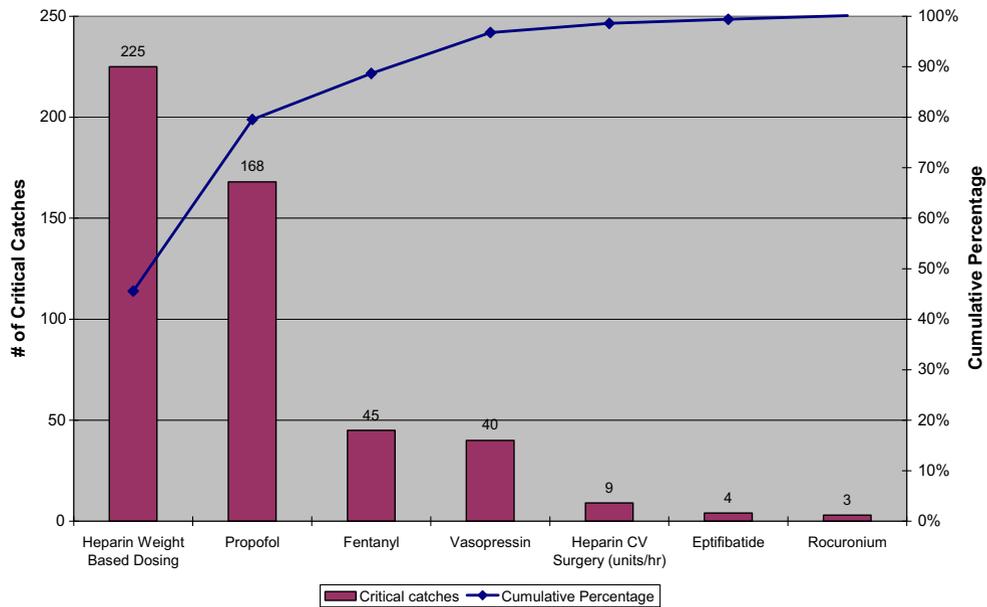


Figure 1 – Pareto chart of critical catches.

Table 1 – Potential cost savings⁵

	Critical catches (N)*	Potential savings (\$)*	Potential savings (\$)†
Hard limit	494	\$4,322,500	\$5,763,333
Soft limit	150	\$1,312,500	\$1,750,000
Total	644	\$5,635,000	\$7,513,333

* Nine-month data.
† Estimated annual.

fentanyl, and the remainder of the agents in the drug library.

Critical catches (defined as adverse medication events that could result in significant patient harm and triggered hard limit alerts) were a function of drug selected and varied over a wide range of doses. Overall, 494 infusions resulted in critical catches. Drugs could be divided into 3 categories based on hard limit alert critical catch incidences: negligible frequency (dobutamine, dopamine, epinephrine, norepinephrine, all 0%; rocuronium, .6%; eptifibatide, .8%; and heparin-cardiovascular surgery dosing, 1.8%); low frequency (fentanyl, 9.1%; vasopressin, 8.1%); and high frequency (heparin using weight-based dosing, 45.5% and propofol, 34.0%). Figure 1 illustrates the number of critical catches for each drug. Heparin (dosed on the basis of body weight) and propofol contributed the majority of critical catches (393/494 or 79.6%) followed by fentanyl, vasopressin, and the remainder of the agents.

Cost Savings

In addition to the clinical benefits, use of intelligent IV pump software has potential financial benefits

(Table 1). By using a dollar cost estimate for each critical catch of \$8750 as per the Institute of Medicine,³ the 494 critical catches made over a period of approximately 9 months potentially saved \$4,322,500. This amount can be extrapolated to an annualized cost savings of \$5,763,333 for our institution. There were also a substantial number of soft limit alerts resulting in edits that were considered critical catches because of the high-risk nature of particular medications. If these programming soft limit edits (150 in total) had not been made, they could also have resulted in patient harm. Assigning the Institute of Medicine cost of \$8750 to each of these 150 additional catches would have resulted in a potential additional saving of \$1,312,500 (annualized amount, \$1,750,000). The overall net result was an overall potential saving for SVHCI of \$5,635,000 (annualized amount, \$7,513,333).

Ongoing Procedures

Currently, changes to the drug library are made quarterly. They are instituted by the pharmacy department, based on comments received from nurses and physicians using the pumps. Only significant changes are reviewed by the Pharmacy and Therapeutics Committee. Most changes are minor and do not affect current protocols. When library changes are implemented, fliers are distributed, e-mails are sent to all users, scrolling bar reminders are incorporated on nursing documentation computers, and other communications are sent from unit directors to end-users. These methods ensure that end-users are made aware of all library changes in a timely manner. Also, the pharmacy department process leader monitors soft limit alerts, which could indicate that limits have been set too tight.

Monthly reports are automatically downloaded from the safety software server for review by Clinical Directors. Data are reviewed for compliance rates, types and frequencies of limit alerts and the drug(s) involved, and frequencies of overrides and edits.

CONCLUSIONS

At SVHCI, it has been recognized that supporting nurses is key to maintaining a vibrant, dynamic, patient-centered institution that provides optimal patient care. One important step has been the implementation of intelligent IV infusion technology, which has improved efficiency and accuracy in IV medication administration allowing nurses to spend more time in direct patient care. Although not formally studied, anecdotal reports indicate that the nurses at SVHCI think that intelligent IV infusion technology has enhanced their comfort level in IV medication administration because they know there is now another powerful check system in place to ensure that drugs are being administered properly and safely. This process is characterized by superior safety software, an enhanced library data transfer process, and continuous quality improvement initiatives through the use of reporting via wireless technology. This has been an important step for the institution and its staff, and with the ability to collect data from the software, it is anticipated that benefits will continue to be realized well into the future.

KEY POINTS

1. Intelligent infusion pumps that mandate the use of safety software (ie, cannot be bypassed) are available.
2. Use of safety software reduces the opportunity for both minor and major dosing errors.
3. Different medications can have widely varying risks for dosing errors.
4. Dosing errors create adverse clinical and financial outcomes.
5. Adaptation by nursing staff to intelligent infusion pump use is usually rapid as familiarity is gained.

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