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Implementation of intelligent infusion technology in a multihospital setting

The current medication-use process encompasses several steps[1]; however, the administration step is the most vulnerable for errors, excluding wrong-time errors, reported at a rate of 11% in hospitals.[2] High-risk i.v. medications with narrow safety margins (i.e., "high-alert" medications) are associated with a large potential for patient harm.[3,4]

Of the seven goals identified in the 2004 National Patient Safety Goals of the Joint Commission on Accreditation of Healthcare Organizations, five relate to medication administration.[5] These goals may be positively affected by implementing an intelligent infusion system, but only if a high rate of compliance is achieved. For example, the third goal is to improve safety when high-alert medications are used. The other goals relate to improving the safety of infusion pumps and the effectiveness of clinical alarm systems, which include infusion pump alarms. We describe the successful implementation of wireless intelligent pump technology across a five-hospital system and focus on the strategies used to achieve a high compliance rate with safety software, as well as specific results in intercepting medication administration errors.

Background. Health Alliance of Greater Cincinnati (Health Alliance) is an integrated health care delivery system that includes teaching, acute care, and rehabilitative hospitals. These facilities offer a range of medical and surgical services, including a level I trauma center, cardiac care services, a level III perinatal center, neurologic services, oncology services, blood and bone marrow transplant services, orthopedics and behavioral medicine, and primary care services. Health Alliance is affiliated with the University of Cincinnati's colleges of medicine, pharmacy, and nursing. Each acute care hospital operates 24-hour pharmacies with clinical pharmacy support.

A fleet of approximately 2000 various i.v. pumps within the Health Alliance system were in need of replacement due to their constant necessity for repair. A systemwide, multidisciplinary expert task force comprising clinical leaders from nursing from each hospital and pharmacy, information technology, bioengineering, and supply chain staff was convened to perform an assessment of possible replacement technologies.

A clinical pharmacist reviewed the published literature and presented the findings to the task force. Special consideration was given to the Emergency Care Research Institute's recommendations, which suggested that facilities use only infusion devices that incorporate dosage-error-reduction systems.[6] The task force determined that the fleet of i.v. pumps across the health system should be replaced at once with i.v. pumps with intelligent technology. The task force supported the project through presentations at multiple forums and set criteria for pump

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The Informatics Interchange *column gives readers an opportunity to share their experiences with information technology in pharmacy.* AJHP *readers are invited to submit their experiences and pertinent lessons-learned related to pharmacy informatics. Topics should focus on the use of information technology in the medication-use process, informatics pearls, informatics education and research, and information technology management. Readers are invited to submit their ideas or articles for the column to ajhp@ashp.org or* ASHP, *c/o Karl Gumpper at 7272 Wisconsin Avenue, Bethesda, MD 20814 (301-657-3000).*

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selection, including considerations for a wireless platform (appendix). A return-on-investment analysis was completed to support the large capital expense of purchasing pumps with safety technology. The leadership fully supported the implementation of this safety technology and was involved throughout the selection and implementation process.

Implementation and resources. A medication administration team (MAT), with representatives from nursing, pharmacy, and information technology from all hospitals, was appointed and charged with implementing the intelligent i.v. infusion pump system. Several standardized systems and processes relating to medication administration were already in existence across all hospitals, which facilitated the implementation procedure (i.e., clinical information system, computer-generated medication administration record, pharmacy compendium, and systemwide formulary). A website was created to list materials relevant to i.v. drug administration. The MAT conducted a failure modes and effects analysis to identify high-risk situations that could hinder a successful switch to the new technology. A plan for i.v. pump report generation and review was outlined before implementation, and expectations were set. The goal for adherence to safety software use for each hospital was established as 85% to exceed the adherence rates reported in previously published studies.[4,7,8]

The MAT was charged with decision-making related to the drug library. Drug libraries were assigned to the major patient care areas or specific patient populations who receive high-alert medications administered by i.v. infusion within that institution. These specific areas were referred to as clinical care areas (CCAs). The number and specific conditions or categories for the CCAs were selected for each hospital. Next, pump default settings were determined (e.g., i.v. piggyback versus continuous infusion). Using preestablished standardized concentrations, continuous-infusion grid tables, and reports generated by our existing clinical information system, the pharmacists developed CCA-specific drug libraries. These libraries were then reviewed by the MAT and presented at the systemwide drug policy development committee for approval. By developing a systemwide drug library, a standard of care was established for i.v. drug administration. Drug libraries were updated according to the implementation plan for each hospital so that identified problems could be corrected before subsequent implementations. Wireless capability was mandatory to allow this to occur smoothly and in a timely manner while ensuring the adequate security of the existing network (appendix). After implementation, the drug library is updated twice each year, in April and November, unless additional updates are required due to a safety reason. Notification about the drug library updates, including the changes made to the drug library and the process of how to update the library, was sent to all nursing and bioengineering staff. Bioengineering staff were tasked with monitoring the drug library updates and identifying devices that had not updated the library within a two-week time frame, which they then updated.

Training and adherence. A vital realization was that there are no shortcuts to using the safety software. All nursing and pharmacy personnel were required to attend pump training inservice education to learn the benefits of the safety software and that it will be worth the additional time required to program the pumps.

During implementation, reports were generated to identify i.v. pumps whose safety software was not in use (i.e., nurses administering infusion with no limits). Individuals from the implementation team would then proceed to the locations of these i.v. pumps and use this as an educational opportunity with the nurse responsible for programming the pump. Adherence reports were prepared daily for the first week after implementation and then weekly thereafter if nursing leaders were satisfied with the results. Once the implementation phase was completed, reports were generated monthly and as needed. Nurses with additional training using the pumps were identified on each unit to assist with questions and perform "walking rounds" to review i.v. pumps and ensure that safety software was being used. Retraining was always available, when requested.

Issues concerning the drug library were forwarded to the department of pharmacy services and added to the agenda for the next scheduled meeting of the MAT. Monthly reports were shared at a number of meetings (e.g., pharmacy and therapeutics, nursing leadership, medication safety, drug policy development). When significant edits, changes that may have averted serious adverse events associated with high patient morbidity and mortality, were identified, they were forwarded to the nursing staff to present at staff meetings. The drug library was updated four times during implementation. Compliance rates and significant edits continue to be monitored, and the monthly reports have been incorporated into the system's "quality dashboard."

Follow-up. Initial compliance with the intelligent pump software across all hospitals was 68–88%. During the six-month evaluation, compliance ranged from 73% to 93%. Though initially compliance rates did not meet the 85% goal across all hospitals, they were well above other compliance rates reported in the literature.[9] Hospitals compared their compliance rates with each other, and CCAs compared their compliance rates to other CCAs within the same hospital and to similar CCAs in sister hospitals. Each month, the data are analyzed and reported to the MAT. From these data, significant edits were determined, reported to patient care nurses each month, and discussed during staff meetings.

During the six-month evaluation period, the intelligent pumps averted 303 significant medication alerts, 70 (23%) of which were triggered by heparin, insulin, propofol, and lorazepam. Heparin administration generated 27 alerts, including 7 (26%) "dose above maxi-

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mum" alerts and 20 (74%) "dose below minimum" alerts. For all of these alerts, the users either reprogrammed the device or canceled the infusions. Intelligent pumps also averted significant errors in 21 patients receiving insulin infusions, 25 patients receiving propofol infusions, and 7 patients receiving lorazepam infusions. All alerts were related to overdose errors. The number of significant errors intercepted did not decrease considerably over time, as the number of errors intercepted is a function of the compliance rate with the intelligent pumps and safety software. As the compliance rate stays high, the number of intercepted errors will most likely remain constant.

Conclusion. Implementation of wireless intelligent infusion pump technology occurred transparently in our multihospital setting. The real-time monitoring increased compliance with the use of the drug library and resulted in improved i.v. medication administration, potentially prevented patient harm, and demonstrated areas for quality and safety improvement.

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Appendix—Wireless technology considerations

Near real-time transfer of infuser event and alarm data

Capable of downloading information on up to 2000 devices simultaneously

Provides bidirectional communication from server to pump and pump to server

- Allows the transfer of hospital-specific drug libraries and operating values from a remote location
- Allows the pump to upload and report all events (e.g., program start or stop, drug limit alerts, power-state changes) and alarms to the server as they occur
- Provides prospective and concurrent continuous quality-improvement information and allows real-time review and intervention

Current technology has enhanced security features for patient information

Tracks idle and infusing pumps throughout the system

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