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Reduction of Medication Errors in a Pediatric Cardiothoracic Intensive Care Unit

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Medication errors resulting in patient harm were reduced from 33 in 2010 to 3 in 2011, 6 in 2012, and 4 in 2013 by initiating the following quality improvement interventions: multidisciplinary cardiothoracic intensive care unit quality committee, nursing education, shift change medication double check, medication error huddles, safety systems checklist, distraction-free zone to enter orders, and medication bar coding. **Key words:** *administration errors*, *intensive care unit*, *medication errors*, *pediatrics*, *quality improvement*

A *MEDICATION ERROR* is defined as an error that occurs with the prescribing, transcribing, dispensing, administering, adherence, or monitoring of a drug regardless of whether it results in patient harm or has the potential to result in patient harm. Patient harm is the need for additional testing or medical intervention, hemodynamic compromise, prolongation of hospital stay, end-organ compromise, or death. Medications errors resulting in patient harm occur most frequently at the prescribing and administration stages.[1,2]

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Up to 27% of all pediatric medication orders result in a medication error.[3–5] Hospitalized pediatric patients encounter 3 times more medication errors than hospitalized adult patients.[3] Kaushal et al[3] reported that 1% of all medication errors were potentially harmful in children and that 0.24 per 100 orders written resulted in patient harm. In a more recent study, Cousins et al[6] reviewed all medication errors reported to the National Reporting and Learning System in England and Wales from 2005 to 2010. They found that 16% of all medication errors resulted in patient harm ranging from low harm (13%) to death (0.05%).[6]

Errors are complex and often the result of faulty systems design that either induce errors or make them difficult to detect.[1,7] Modification of these system breakdowns have been shown to be successful in reducing errors.[7] A recent review of studies aimed at the reduction of medication errors in the pediatric population revealed 34 relevant articles.[8] The interventions implemented to reduce medication errors most commonly used were computer order entry, automated intravenous systems with programmed alerts and prepackaged standardized solutions, educational modalities, institution of protocols or guidelines, pharmacist involvement, and

support systems for clinical decision making.[8] Computerized order entry, automated intravenous systems with programmed alerts, and education were suggested as the most useful in reducing medication errors.[8] In 2010, the pediatric cardiothoracic intensive care unit (CTICU) documented 33 medication errors that resulted in patient harm. Our institution already had computerized order entry, prepackaged standardized solutions, pharmacist involvement, and automated intravenous systems with programmed alerts in place. Therefore, the aim of this quality initiative was to develop and implement additional interventions to reduce the number of medication errors that resulted in patient harm in the pediatric CTICU.

METHODS

Setting

The pediatric CTICU is a 20-bed unit with an average of 540 admissions per year. In 2013, the median length of pediatric CTICU stay was 1.7 days; the mean was 6.1 days. The top 5 most common admission diagnoses were postoperative ventricular septal defect repair, hybrid palliation stage I, hybrid palliation comprehensive stage II, pulmonary valve replacement, and Fontan procedure. The pediatric CTICU staff include a multidisciplinary team of critical care and cardiology physicians (n = 8), advanced nurse practitioners (n = 10), a dedicated clinical pharmacist (n = 1), registered nurses (n = 61), respiratory therapists (n = 14), physicians in fellowship training in critical care and cardiology, clinical dieticians, physical therapist, occupational therapist, child life specialist, and social worker. The current electronic medical record (EMR) system has been in place for approximately 5 years and integrates the inpatient and outpatient medical records into a single record for each patient. The computerized practitioner order entry system also allows for reminders of best clinical practices, quality measures, and documentation reminders.

Medication error collection and measurement

The severity of harm by medication errors is measured at the institution by a clinical severity-level score 1 to 9 based on the 2005 National Coordinating Council for Medication Error Reporting and Prevention.[9] A clinical severity-level score of 1 represents a minor error not reaching the patient. Clinical severity 4 indicates the need to monitor the patient; a score of 5 indicates temporary harm and the need for intervention; and a score of 6 results in an increased hospital stay. A severity score of 7 indicates long-term patient harm, an 8 would be a near-death event, and 9 would be a patient death. The hospital reports only medication errors that result in patient harm, clinical severity of 4 or more. Therefore, this quality initiative was directed at medication errors that resulted in patient harm: severity 4 to 9. Each medication error is reviewed by hospital-wide and unit-based quality leaders. Severity is designated by the hospital-wide quality committee following discussion of the event. The members of the hospital-wide quality committee receive training in the science of quality initiatives using an organizational improvement approach, based on the Institute for Healthcare Improvement Breakthrough Series[10] and the Model for Improvement.[11] Didactic sessions include how to form multidisciplinary microsystem-based teams, the use of rapid improvement Plan-Do-Study-Act cycles, and the interpretation and use of statistical process to drive change.

Potential medication error review is prompted by pharmacist review of orders, trigger tools, and hospital-wide event reporting via an online voluntary reporting system. Pharmacists review all orders for appropriate drug, appropriate dose by weight, appropriate interval between doses, and sound-alike, look-alike medications.[12,13] The ordering provider is called for clarification if the pharmacist notes a potential issue with the order, and a voluntary event reporting form is completed by the pharmacist and

addressed by the hospital-wide and unit-based quality committees. A trigger tool is a retrospective review of patient records using cues to prompt further investigation for possible medication error as formulated by the Child Health Corporation of America.[14] For example, a trigger tool would be identification of administration of a reversal agent to treat oversedation due to opioid or narcotic use.[14] This trigger would then prompt further investigation. For every event that was triggered, a voluntary event reporting form was completed and addressed by the hospital-wide and unit-based quality committees. Each error was only counted once regardless of how many ways it was captured as ensured by the quality committee review.

The median monthly hospital-wide event reporting submissions between September 2010 and August 2012 were 540 events per month (range, 480-632). The median hospital-wide patient days per month were 10 038 (range, 9090-11 079) over the same time frame. Although the culture is one of supporting safe, nonthreatening, blameless, nonpunitive event reporting, the voluntary reporting system is still likely to result in the underreporting of errors. Each event reported was reviewed by the hospital-wide quality committee along with the individual unit-based quality committees to classify the event as appropriate (ie, catheter-associated blood stream infection, catheter-associated urinary tract infection, medication error, etc).

Total medications dispensed each month were the sum of the doses recorded as dispensed in the EMR and those dispensed from the automated dispensing stations. The medication error rate is the number of medication errors resulting in patient harm per 1000 dispensed doses.

Planning the intervention

Creation of a pediatric CTICU multidisciplinary quality committee with accountability for guiding improvement and quality process education was instituted. This committee reviewed pediatric CTICU medication errors resulting in patient harm from January to June 2010 that were identified by the hospital-wide medication error collection and measurement tools described earlier. Twenty-two medication errors were reviewed in detail using the EMR. The primary cause of the medication error was administration errors rather than prescribing, monitoring, or dispensing errors. Most were described according to the "5 rights."[15] Root-cause analysis focusing on personnel, system, and technical issues identified the following factors: culture change and defined quality process, attention to detail, and improved communication. The hospital already had computerized physician order entry and a unit-based clinical pharmacist, shown previously in the literature to reduce medication errors resulting in patient harm.[8,16,17] Therefore, additional unit-specific interventions were sought to address medication administration errors. Supplemental Digital Content, Figure 1 (available at: http://links.lww.com/JNCQ/A133, annotated run chart of results), provides a timeline of the intervention implementation.

CTICU quality vision and action plan

The first step was the creation of a pediatric CTICU vision and action plan that encouraged the staff to question if one is correct rather than assume one is correct. This philosophy of questioning was achieved by reinforcing the hospital's "Zero Hero" philosophy of reducing patient harm.[18] "Zero Hero" is the institutional goal of striving for zero preventable harm events.[18] The philosophy is based on the belief that system failures require corrective action plans including an "owner," a timeline, and a monitoring plan.[18] An institutional "safety coach" program was implemented to train frontline staff in coaching their peers on the effective use of error prevention techniques.[18] Institutional quality improvement measures were posted on the intranet as a marker of internal and external transparency. Unit-based measures were posted on bulletin boards in a prominent public place in every unit.

Quality process education

Mandatory nursing staff quality process education included lectures and study guides, followed by tests for new employees and "5 rights" of medication use[15] individual training, followed by peer-to-peer auditing. For auditing, individual nurses were assigned the task of monitoring their peers to ensure adherence with the "5 rights." This was accomplished by bedside observance and direct questioning. Finally, every employee in the hospital was required to attend institution-wide "Zero Hero"[18] education including basic error prevention training and training in leadership methods focused on techniques to reinforce the high-reliability organization concepts.[18] This educational process introduced the quality concepts and process measures that the institution was using.

Nursing medication independent double check

Nursing medication independent double check was implemented at shift change, with all medications given throughout the shift, by 2 individual nurses independently being responsible for a medication double check using the "5 rights" of medication use. For all continuous infusions, the incoming nurse validates correct patient, allergies, and dosing weight; correct medication, dose, route, rate, and site; there are no expired medications, clamped tubing, and leaks in the tubing or connectors; and all catheters are labeled correctly. For all scheduled or as-needed electrolyte replacements, insulin, heparin, narcotics, or benzodiazepines, the bedside nurse must have a second nurse to double check the medication using the "5 rights" before giving the medication.

Hands-free communication

Hands-free communication was implemented for all staff members, including physicians. The institution instituted a lightweight, wearable voice-controlled device that enables instant 2-way or 1-way to many conversations using intuitive and simple commands. This hands-free device allowed for easier communication to perform bedside medication double checks. The bedside nurse was now able to use the device to call for a second available nurse to come to the bedside to perform the medication double check instead of leaving the room to physically find a second available nurse.

Medication error huddles

Physicians, advanced practice nurses, pharmacists, nurses, respiratory therapists, and quality staff worked together to review events and suggest interventions in a nonthreatening environment in a "huddle." It was beneficial to have multiple disciplines involved in the review process, as each discipline looked at the event from a different standpoint. Huddles are organized by the clinical nurse leader with the goal to occur within 1 week of the event. The huddle process started with a medical record review of events leading to the medication error and caregiver input regarding contributing clinical or situational factors. The goal of each huddle was to identify factors that resulted directly in the error and interventions aimed at preventing recurrence of the event with consensus agreement of the huddle participants.

The most common causative factors leading to the medication errors that were identified by the huddles included errors in "5 rights" of medication use, nursing stressors, nursing double-check errors, and individual human factors. Action plans were initiated as a result of the huddles. Representatives from the huddle would then discuss their findings and proposed interventions with the pediatric CTICU staff via e-mail and staff meetings. The CTICU quality committee would then assist the staff in implementation of the interventions as appropriate.

Several months after institution of the first set of these interventions, the quality committee evaluated the interventions and found that medication errors that reached the patient continued to occur. The majority of errors were still with medication administration, and it was also discovered that it was difficult to measure compliance with many of the

interventions. Staff attendance at mandatory education and the huddle following adverse drug events was well documented, but there was no method of measuring the nursing medication independent double check or hands-free communication usage. Therefore, the following additional interventions with specific measurable compliance were identified.

Safety systems checklist

The safety systems checklist (see Supplemental Digital Content, Figure 2, available at: http://links.lww.com/JNCQ/A134) was designed by the nursing staff as a tool that enhanced the medication double-check process and ensured independent checks. It was used for all continuous infusion medications at shift change by incoming and outgoing nurses at the beginning of each shift. This process is different from the medication double check, which was performed just prior to the medication being given. The checklist was collected by the charge nurse at the end of each shift and reviewed for completeness, thus allowing for a way to measure compliance with the intervention and ensure accountability.

Distraction-free zone

A distraction-free zone for all staff members whenever medications were involved (administration and prescribing) and time allotment to enter orders into the EMR during rounds was implemented. The distraction-free zone was a physical mat placed on the floor in front of the PYXIS as well as signs placed on the computers throughout the unit. When staff members were in the distraction-free zone, they were not to be bothered until their task was completed. The distraction-free zone was intended to heighten awareness of the staff to the importance of concentration and limit distraction when dealing with medications. The distraction-free zone was not only addressing administrative errors but potentially also prescribing errors. Before moving to the next patient during morning or night shift rounds, the nurse practitioner was given distraction-free zone time to complete the order entry process. After all of the orders were entered, the bedside nurse read back all of the orders that were discussed as an additional double check. Compliance was randomly audited during rounds by the quality information service representative who was present during rounds at an average of 7 days per month.

Medication bar coding

Hospital-wide medication bar coding was implemented in April 2011. After administering the medication, the bedside nurse signs off the medication in the medical record. Administration of medication without bar code scanning by the bedside nurse may occur in emergency situations and in medications that are bolused from continuous infusions. This is audited monthly and reported to the hospital-wide adverse drug events committee.

RESULTS

The pediatric CTICU demonstrated a reduction in medication errors that resulted in patient harm from 33 events in 2010 to 3 events in 2011, 6 events in 2012, and 4 in 2013. Harm-causing medication errors were reduced from 0.43 to 0.05 per 1000 doses administered ($P < .0001$) over the same time period. Overall results are documented in the Figure using an interrupted time series that demonstrates changes over time, with annotations showing the time frame of the aforementioned interventions.

The most frequent medication error causing patient harm in 2010 was medication administration errors (22 of 33 total medication

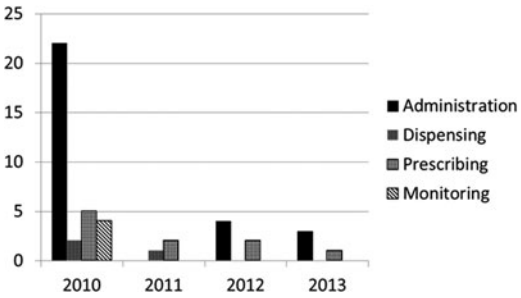

Figure. Medication errors that caused patient harm per year.

errors) shown in the Figure. Seventeen of the 22 administration errors were described according to the "5 rights" shown in Supplemental Digital Content, Figure 3 (available at: http://links.lww.com/JNCQ/A135). Hence, the interventions were tailored toward reducing medication administration errors and were successful (Figure).

Compliance with interventions

Compliance with the safety systems checklist was monitored from December 2010 to April 2011 and increased from a low of 8% to 85%. Compliance increased secondary to staff awareness and buy-in of the importance and engagement in the process. The most common error identified with the safety systems checklist was a discrepancy between the order in the EMR and what the patient was actually receiving (71%), catheters labeled incorrectly (11%), expired medications or fluids (8%), and other (10%).

Compliance with medication bar code scanning was consistently between 81% and 86% (hospital target 90%) from introduction in April 2011 to June 2012. Reasons for being below the hospital's goal include emergency situations, EMR downtimes, and the inability to use bar coding on bolus doses from a continuous infusion. In the pediatric CTICU, the most frequent admission is postoperative cardiac surgery. Pain control in this patient population is managed by nurse controlled analgesia, which consists of a continuous infusion with bolus doses delivered as needed via the continuous infusion pump.

In 2010, 11 huddles for 33 harm-causing medication errors (33%) were performed; 1 huddle for 3 harm-causing medication errors (33%) was performed in 2011; and 6 huddles for 6 harm-causing medication errors (100%) in 2012. Compliance with huddles improved to 100% in 2012.

DISCUSSION

Interestingly, the most common medication error resulting in patient harm in the pediatric CTICU was errors in medication administration rather than in prescribing, dispensing, or monitoring. The increased administration errors were attributed to the onboarding of many new nurses following the move to the new pediatric CTICU with increased beds and increased average daily census; an inexperienced nursing staff, with more than half having less than 2 years of nursing experience; and the lack of specific policies and procedure guidelines at the beginning of this quality initiative. While still a relatively young unit, administration errors have remained at a low rate for the past several years.

Interventions

Reinforcement of quality process education, nursing medication independent double check, hands-free communication, and reinforcement of medication error huddles were all introduced around the same time frame in late summer 2010. Hands-free communication allowed the nurse to call for a second nurse without leaving the bedside of the patient. However, this independent double check had no accountability measure, as it was easy to document without actually going through the process. Hence, ongoing education, continual real-time feedback during peer-to-peer auditing, and transparency with quality process measurements during staff meetings and e-mails with the goal of engagement of the staff were instituted. The nonpunitive huddle process was also important in staff engagement. Review of medication errors resulting in patient harm in the first several months following the first set of interventions resulted in robust discussions of the situation related to the medication error, possible confounding factors, and additional potential interventions.

The safety systems checklist, distraction-free zone, and continued huddle reinforcement were implemented in late 2010. The safety systems checklist was intended to enhance the nursing medication independent double-check process. This form was collected and reviewed for completion and accuracy by the charge nurse. If deficiencies were found, real-time feedback was given by the safety coach. Following the significant

reduction in medication errors, this form was transitioned to an electronic form that is no longer audited for every patient.

Introduction of the distraction-free zone was an effective visual marker of when a nurse or provider should not be disturbed if possible. Admittedly, the distraction-free zone was slow to catch on, as each individual believed that his or her specific need was important and needed to be addressed immediately. As overall situational awareness throughout the CTICU improved, so did the effectiveness of the distraction-free zone. Without the visual cues as a constant reminder, mat on the floor and sign on the computers, the intervention might not have been as effective. Of note, medication bar coding, documented in the literature to reduce medication errors,[19,20] was implemented hospital-wide in April 2011 after the initial reduction of medication errors in the CTICU.

Limitations

Multiple interventions were undertaken simultaneously, with no attempt made to ascertain which intervention was most or least effective. This quality initiative was performed in a single unit using interventions designed to address specific areas of weakness. Therefore, this may not be fully extrapolated to other units. However, the quality improvement methodology is valuable to all.

Opportunities for improvement include the voluntary reporting system, which currently does not have a method of system analysis, and the labor-intensive validation of the process. The continued review and validation process as well as the event huddles are labor-intensive and time-consuming. At times, medication error huddles occurred later than desired or were not attended by everyone who should attend. Distraction-free zone and hands-free communication unfortunately remain without robust compliance measures.

CONCLUSIONS

Education and process improvement strategies directed specifically at reducing medication administration errors and staff engagement were successful in reducing medication errors causing patient harm. While achieving the objective for 2011 and sustaining through 2013, next steps include continued vigilance with reporting events and event huddles to strive for continued improvement in quality patient care.

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