CASE STUDIES

Origins of and solutions for neonatal medication-dispensing errors

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Purpose. Five cases of sound-alike, look-alike, neonatal medication-dispensing errors and their resolution are reviewed.

Summary. In 2008, there were five cases in which look-alike or sound-alike neonatal medication-dispensing errors occurred at our institution. A mix-up between neonatal and adult or pediatric products occurred in four of the five cases. Three of the five errors resulted in near misses with the potential to cause harm. The other two errors reached the patients but did not cause harm. The medication mix-ups involved adult and neonatal phytonadione injectable emulsion, sodium citrate injection and vancomycin–heparin combination injection, adult tetanus–diphtheria–acellular pertussis and infant diphtheria–tetanus–acellular pertussis (DTaP) vaccines, Haemophilus B and DTaP vaccines, and cisatracurium and vecuronium. Each error exposed weaknesses in the system of neonatal medication storage, labeling, delivery, knowledge, and administration documentation at our institution. Resolution of system problems was made possible by a collaborative approach and involved reorganizing shelving used to store neonatal medications; using a differently colored labeling scheme for products whose syringes were nearly identical; implementing changes to the infant vaccine ordering, storage, dispensing, and documentation systems; and instituting centralized and decentralized pharmacist review of pharmacy technician automated dispensing cabinet-filling activities.

Conclusion. An institution providing services to both neonatal and adult patients experienced five cases of medication-dispensing errors with look-alike or sound-alike medications. Multidisciplinary collaboration within the system helped the pharmacy identify, resolve, and prevent errors related to medication storage, labeling, delivery, knowledge, and administration documentation.

Index terms: Dispensing; Documentation; Drug administration; Errors, medication; Labeling; Nomenclature; Pediatrics; Personnel, pharmacy; Pharmacists, hospital; Pharmacy, institutional, hospital; Storage

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Medication errors with the potential to cause harm are eight times more likely to occur in neonatal intensive care units (NICUs) compared with hospital patient care areas for adults.[1] When neonates receive pharmacy services from a hospital pharmacy department that also serves older children and adults, look-alike and sound-alike medication-dispensing errors are always a possibility. Such errors can be considered system errors, caused by the wide variety of dosage forms and concentrations the hospital pharmacy is required to stock to meet all its patients' needs and by the different concentrations of the same medication that are manufactured in very similar-appearing packages.[2] The widely publicized heparin dispensing errors that occurred in 2007[3] and 2006[4] are notorious examples of such system errors. Providing safe pharmacy services to hospitalized neonates requires drug distribution procedures and standards designed to prevent adult–neonatal medication mix-ups.[5]

Problem

Our institution is a 386-bed academic hospital and medical center that provides a number of specialty

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adult and pediatric services. Women and infants services (WISs) include high-risk obstetrics and perinatology, fetal surgery, and a 40-bed level IIIB NICU. In 2008, 2633 births occurred in our institution, 18% of which were preterm. Pharmacy distribution services are centralized. Decentralized pharmacists provide clinical services in specialty areas, including neonatal–perinatal care. Providers order medications for inpatients using a computerized prescriber-order-entry (CPOE) system. A point-of-care bar-code-assisted medication administration (BCMA) system is used by nurses for checking medications before administration and for recording data in electronic medication charts.

In 2008, there were five cases in which pharmacy-dispensing errors occurred with look-alike or sound-alike medications in NICU at our institution. A mix-up between neonatal and adult or pediatric products occurred in four of the five cases. Three of the five errors resulted in near misses with the potential to cause harm. The other two errors reached the patients but did not cause harm. In each case, an investigating pharmacist was made aware of the error through direct communication by the patient's nurse or nurse manager shortly after the error occurred. An electronic quality variance report was filed in each case, alerting other investigating pharmacists from the pharmacy's performance improvement department of the error. Collaborative review of these errors by four investigating pharmacists (authors) resulted in the discovery of pharmacy system deficiencies that had heretofore been underappreciated.

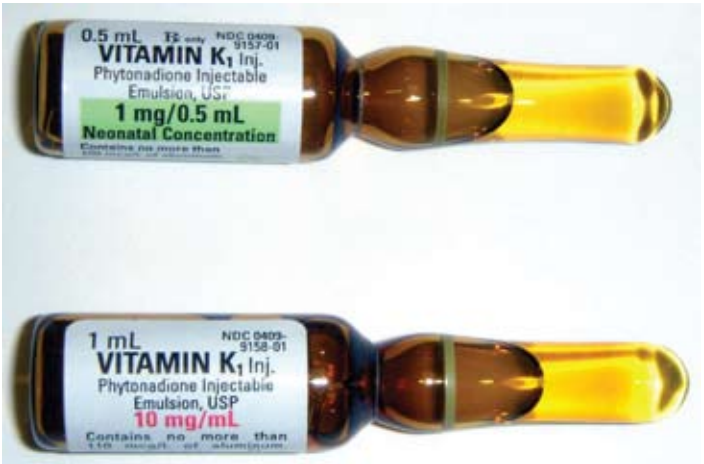
Analysis and resolution

A search of our health system's electronic quality variance reporting system from 2006 through 2007 revealed no documented cases similar to the five reported in 2008. To our knowledge, none of these specific errors has been previously reported in the biomedical literature.

Case 1. A healthy, term, newborn boy erroneously received adult-strength phytonadione injectable emulsion 10 mg/mL at a dose of 5 mg/0.5 mL administered intramuscularly into his right thigh at 3 hours of life (HOL). The automated dispensing cabinet (ADC) on the baby's nursing unit had been refilled with the adult-strength product instead of the neonatal phytonadione injectable emulsion 1 mg/0.5 mL product. The initial error was made by a pharmacy technician and a pharmacist in the central pharmacy before the medication was put in the ADC on the nursing unit. The adult and neonatal strengths of phytonadione injection were stored in the central pharmacy adjacent to one another, and both products have similar packaging and appearance (Figure 1). Before orders for the phytonadione injection and other routine medications for newborns were entered in the CPOE system by the patient's provider, the nurse removed the phytonadione from the ADC using an override function. The incorrect concentration was not noticed by the nurse. Because there were no active CPOE orders at the time of administration, the institution's inpatient point-of-care BCMA system was also bypassed by the nurse.

The nurse realized the error within 20 minutes of administration. The newborn's parents, the pediatrics service resident physician, and a hospital pharmacist were informed immediately by the nurse upon discovery of the error. Because of a theoretical risk of hemolytic anemia and hyperbilirubinemia resulting from the overdose,[6] the baby's total serum bilirubin concentration was monitored. His total serum bilirubin concentration was 4.3 mg/dL at 10 HOL, 9.7 mg/dL at 25 HOL, and 9.3 mg/dL at 32 HOL. The latter two values put the baby at high to high-intermediate risk of developing severe hyperbilirubinemia.[7] Therefore, phototherapy with a BiliBed (Medela, McHenry, IL) was initiated and discontinued after approximately 4 hours of treatment when the total serum bilirubin concentration decreased to 8.6 mg/dL at 40 HOL. According to the attending pediatrician on the newborn service, the baby appeared and acted healthy and normal after phytonadione administration and throughout his hospitalization. The newborn was never jaundiced and had normal bowel movement, voiding, and

Figure 1. Ampuls of phytonadione injectable emulsion for neonates (top) and for adults.



breastfeeding patterns. A toxicology service consultation recommended no special treatment or follow-up because the erroneous single overdose was not significantly high enough to likely cause harm. The baby was discharged home at 48 HOL in good condition with his parents.

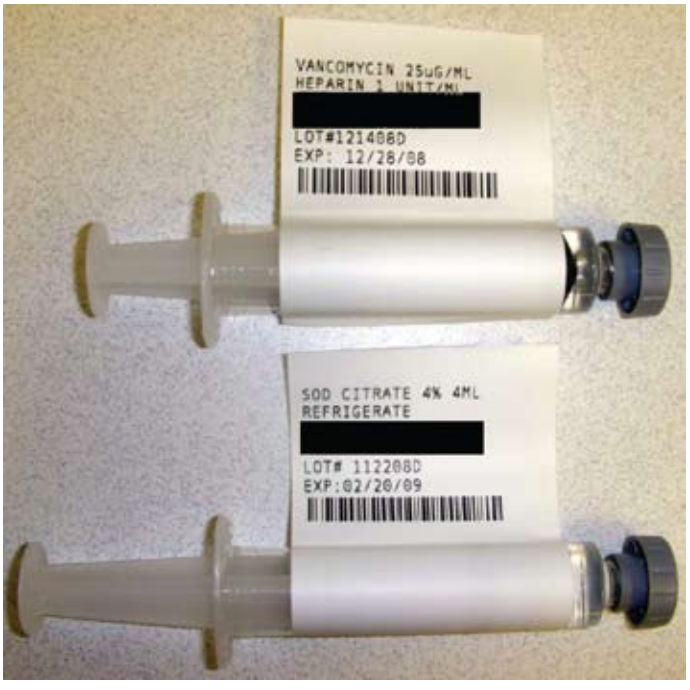
As a result of this dispensing error, the investigating pharmacists reviewed the central pharmacy's medication storage practices and noted how numerous commercially available parenteral medications indicated for neonates, in addition to phytonadione, were being stored on shelves in the central pharmacy adjacent to similar-sounding and similar-appearing medications for adults. For example, caffeine citrate was adjacent to caffeine benzoate, infant sodium bicarbonate 4.2% was adjacent to the adult 8.4% strength, gentamicin and tobramycin pediatric 20-mg/mL strengths in 2-mL vials were adjacent to the adult 40-mg/mL strengths in the same-size vials, and digoxin pediatric 100 µg/mL was adjacent to adult digoxin 250 µg/mL.

Members of the pharmacy purchasing services division were consulted by the pharmacists, and the parenteral medication storage area was reorganized. Neonatal medications were segregated into a "neonates only" portion of clearly marked shelving. Purchasing personnel created this new segregated shelving space and allocated purchased medications to this space when deliveries arrived from the distributor. An analogous "neonates only" domain of the storage shelves in the sterile parenteral products compounding room was also created with the help of a staff pharmacy technician. The shelving reorganization effort was initiated in December 2008 and was completed in January 2009. The medical director and the nursing manager of our NICU were informed of these changes at a multidisciplinary quarterly medication quality meeting. As of the first half of 2009, no further dispensing errors involving adult–neonatal medication mix-ups have been reported at our institution.

Case 2. A sodium citrate flush syringe was erroneously dispensed instead of a vancomycin–heparin flush syringe to a patient-specific medication cassette in the NICU. Both flush products are extemporaneously compounded by our institution's off-site sterile products pharmacy division and have a similar appearance (Figure 2). The sodium citrate syringe is intended for maintaining patency of dialysis catheters in adults. The vancomycin–heparin syringe is intended for preventing nosocomial central-venous-catheter-associated bloodstream infections in neonates.[8] Both syringes were stored in the same refrigerator in the central pharmacy. The error was made by a pharmacy technician and a pharmacist in the central pharmacy. The point-of-care BCMA system used by the nurse did not catch the error because the patient-specific bar-coded pharmacy label affixed to the *outside* of the plastic bag containing the medication was correct and was scanned by the nurse through the BCMA system to identify the medication. The nurse realized the error before the medication was administered. The patient was a two-week-old, 750-g neonate. This same error happened one additional time with a different patient within one month of the first incident. In the second incident, the error was also detected by a nurse and the incorrect medication was not administered.

When reviewing this error, we uncovered three separate system problems. First, the storage of these two similar-appearing products adjacent to one another in a parenteral products refrigerator was a human error that went unnoticed. The bulk batches of neonatal vancomycin–heparin flush syringes were intended to be stored in a separate refrigerator from the sodium citrate syringes. This was a key safety element reviewed with central pharmacy and technician staff when the product was first

Figure 2. Syringes for vancomycin–heparin (top) and sodium citrate.



introduced into our practice. One day, the vancomycin–heparin syringes were inadvertently moved and continued to be stored in the wrong location next to the sodium citrate syringes. Predictably, when the errors were discussed among central pharmacy staff, reminder memorandums were quickly created and posted on refrigerator doors, directing staff to the correct storage locations of neonatal vancomycin–heparin flush syringes.

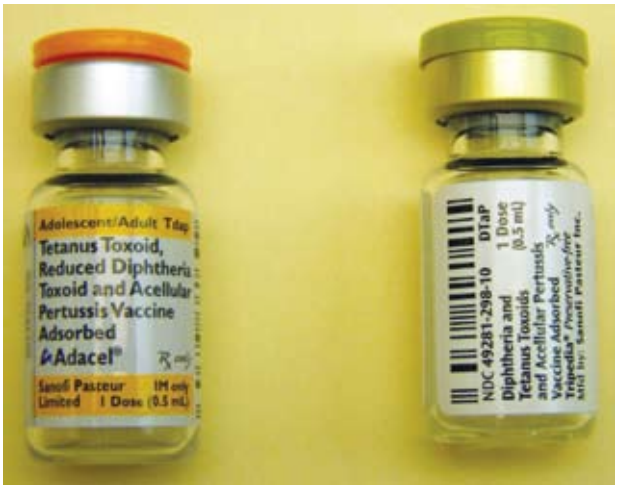
Second, the vancomycin–heparin and sodium citrate syringes were nearly identical in appearance. The leadership of the department's off-site sterile products pharmacy division was consulted and recommended a differently colored labeling scheme for the two different products. The new labels were implemented in February 2009. The medical director and members of the peripherally inserted central catheter (PICC) team of our NICU were informed of these changes at a regular PICC team meeting. As of the first half of 2009, no further dispensing errors due to syringe mix-ups have been reported at our institution.

The third system error identified in this case was the duplicate placement of bar codes by the central and off-site sterile compounding pharmacy. One bar code was being placed on the pharmacy-generated patient-specific label affixed to the dispensing container (a plastic zippered bag) and another on the product label affixed to the syringe. This led to the false-positive identification of the medication when the nurse used the point-of-care BCMA system to scan the patient-specific bar code on the outside of the bag instead of scanning the product inside the bag. Only the visual identification of the dispensing error by the neonate's nurse prevented the administration of an adult anticoagulant to a 750-g neonate. Resolving this system error has been challenging for us. Shortly after the error was identified, the pharmacy information services division was asked to investigate possibly removing the bar code from this product's patient-specific label. Unfortunately, the investigation revealed that such a change in the computer system was not technically possible. Use of the NICU ADC was not an option because of limited space. We have shared the nature of the problem with the NICU PICC team and nursing staff, asking that they scan the syringe bar code instead of the bar code on the dispensing container. We have also been experimenting with multiple methods of manually concealing the label's bar code upon dispensing. Of course, these solutions rely on individual diligence to prevent errors and are not true system corrections.

Case 3. Adult tetanus–diphtheria–acellular pertussis (TdaP) vaccine (Adacel, Sanofi Pasteur) was erroneously dispensed instead of the ordered infant diphtheria–tetanus–acellular pertussis (DTaP). vaccine (Tripedia, Sanofi Pasteur) (Figure 3). The intended patient was a two-month-old infant who was to receive age-appropriate vaccinations. The error was caught by the point-of-care BCMA system before medication administration. The initial error was made by a pharmacy technician and a pharmacist in the central pharmacy. Vaccines for adult and pediatric patients were not being stored separately, but rather alphabetically by generic name in the central pharmacy medication refrigerator. The generic description of both vaccines in the pharmacy patient care computer system was "diphtheria-tetanus-pertussis," which contributed to the sound-alike wrong-product selection by the technician and the pharmacist.

Case 4. Haemophilus B (Hib) and DTaP infant combination vaccine (TriHIBit, Sanofi Pasteur) was dispensed instead of the separately ordered DTaP and Hib (ActHIB, Sanofi Pasteur) infant vaccines. The intended patient was a 2-month-old infant due to receive age-appropriate vaccinations, including DTaP and Hib. Because the combination vaccine is indicated for children 12 months of age or older, it was not appropriate for the patient and not ordered by the provider and was thus a dispensing error. The Hib vaccine is available from the manufacturer with a separate diluent vial. Both the Hib vaccine and diluent vial are intended to be dispensed at the same time. In

Figure 3. Tetanus–diphtheria–acellular pertussis vaccine for adults (left) and diphtheria–tetanus–acellular pertussis vaccine for infants (right).



this case, the two vaccine vials in the combination were dispensed instead of DTaP and Hib plus diluent. The error was made by a pharmacist in the central pharmacy and caught by the patient's nurse, who contacted the pharmacy looking for the Hib diluent. TriHIBit and ActHIB are manufactured by the same company and have similar sounding names. Both vaccines were stored together in the central pharmacy refrigerator. The TriHIBit combination vaccine was available in the central pharmacy for dispensing to outpatient pediatric clinics and was not intended for inpatient use. A manufacturer's shortage of Hib vaccine at the time also contributed to this error, as central pharmacy staff unfamiliar with the esoterica of vaccine-naming conventions assumed the TriHIBit combination was the only commercially available form of Hib and thus the appropriate product to select when dispensing Hib to the NICU.

These cases 3 and 4 were documented in our health system's electronic quality variance database. In addition, the investigating pharmacists knew of several other anecdotal cases of infant vaccine mix-ups in the pharmacy. Most of these errors were caught before the vaccines left the pharmacy, but some errors did make it to the NICU and became near misses after being caught by a nurse. In all cases, the main problem was the organization of vaccine storage in the pharmacy. All vaccines for infants, children, and adults, including those for both outpatient and inpatient use, were organized alphabetically by generic name in one refrigerator. However, vaccines were often found above or below the shelf where their alphabetical designation would have logically placed them. For the inpatient central pharmacy technician, pulling the correct vaccines from this grand disorganized stockpile of arcanely named biologicals was an error-prone process. In addition, our pharmacy purchasing division installed new medication refrigerators in 2008, which were smaller than those being replaced. This made vaccine organization even more error-prone as some products were squeezed behind and on top of others in the new cramped space.

To correct this system flaw, we collaborated with our colleagues in pharmacy purchasing and segregated the infant vaccines for inpatient use from all the others, putting them in their own refrigerator in a different part of the central pharmacy in clearly labeled plastic bins. This was a reasonable first step given that the only pediatric vaccines dispensed to inpatients at our hospital are the recommended five vaccines for two- and four-month-old, preterm, growing infants in our NICU.[9] We do not have another pediatric inpatient service at our hospital, and all of the common adult vaccines are dispensed from ADC refrigerators on adult care nursing units. Thus, the only time an inpatient pharmacy technician filling non-ADC orders accesses the vaccine refrigerator is for NICU patients. Because vaccines for two- and four-month-old infants are always the same, having just those vaccines for the NICU in one separate place in the pharmacy reduced the possibility of mix-ups and dispensing errors. We then solicited information from our pharmacoeconomics and purchasing divisions regarding the possibility of adding the DTaP–hepatitis B–inactivated polio combination vaccine (Pediarix, GlaxoSmithKline) to our formulary. We believed this would decrease the number of choices central pharmacy staff had when pulling vaccines for dispensing to the NICU, further reducing the chance of vaccine mix-ups and dispensing errors. We were informed that switching to the combination vaccine would be cost neutral compared with the individual vaccines and that the combination vaccine could be purchased by contract from our distributor. We next consulted the neonatology service faculty and NICU nursing leadership at a monthly multidisciplinary NICU operations meeting regarding our interest in switching to use of the combination vaccine; they approved of the switch. One of the faculty members was a close collaborator with our health system's information services and a designer of the neonatal CPOE system. She offered to include the combination vaccine in place of the individual vaccines in the computerized vaccine ordering pathway. In the end, central pharmacy staff no longer had to search for five different infant vaccines among a large assortment of pediatric and adult vaccines and, instead, could go to one separate area in the pharmacy and find only three infant vaccines ever likely to be ordered.

The investigating pharmacists also discussed vaccine-dispensing errors with members of the NICU nursing staff who were designated superusers of the point-of-care BCMA system. They reported that NICU nurses were having their own vaccine sound-alike, look-alike documentation errors analogous to our dispensing errors. The system flaw contributing to these errors was the health system's form for documenting patient or parent receipt of Centers for Disease Control and Prevention vaccine information statements and for documenting vaccine administration. The form was universally disliked by NICU nursing staff for its variable and confusing vaccine-naming conventions and for its inclusion of adult vaccines whose names sounded similar to the vaccines they gave their NICU patients. Indeed, in the electronic quality variance report filed for one of the dispensing errors reported herein, the nurse involved documented that the form significantly compounded the confusion of the dispensing error and resulted in a documentation error, which was later corrected. In an effort to simplify the form, one of the investigating pharmacists collaborated with members

of the forms department and with faculty from the neonatology service. It was discovered that throughout the entire health system, only WISs were using the form. A new form was designed with a narrower focus that met the needs of WISs providers (appendix).

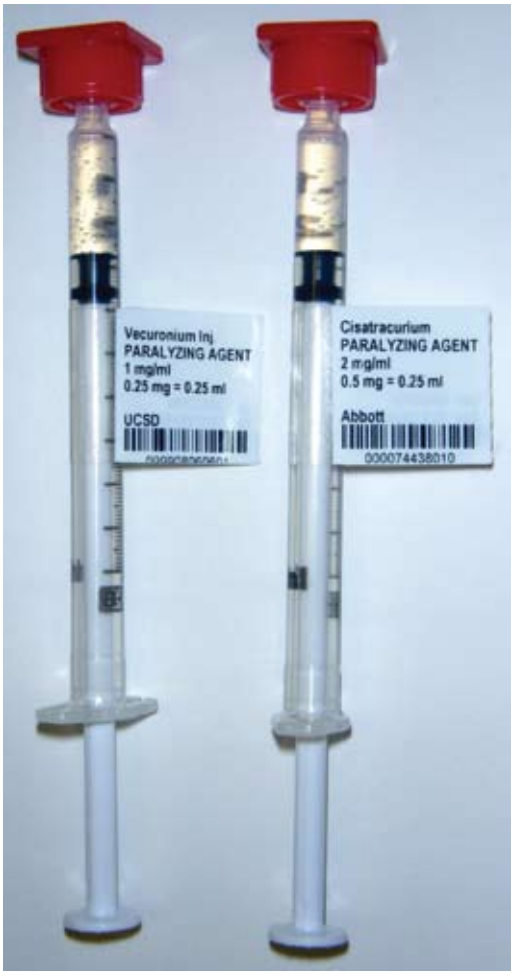
Changes to the ordering, storage, dispensing, and documentation systems for infant vaccines occurred from July through September 2008. Since that time, there have been no quality variance reports of dispensing or documentation errors involving vaccines administered to hospitalized infants at two or four months of age. We also have not heard of any anecdotal reports of such errors.

Case 5. Cisatracurium, instead of vecuronium, was administered in error to a four-day-old, 1035-g neonate born at 30+1 weeks of gestational age via cesarean section resulting from severe pregnancy-induced hypertension. Vecuronium 0.1 mg/kg had been ordered every four hours as needed to minimize movement. The baby was already receiving intermittent i.v. morphine 0.05 mg/kg every four–six hours for pain and irritability as evidenced by increased heart rate, decreased oxygen saturation, and increased fraction of inspired oxygen (FiO_2) with handling while intubated and ventilated with a high-frequency ventilator for severe respiratory distress syndrome. When vecuronium was initiated, morphine was changed to a continuous i.v. infusion of 5 µg/kg/hr.

Neonatal unit-of-use syringes containing dilutions of vecuronium and cisatracurium are prepared daily by central pharmacy services and filled in the ADC in the NICU. The vecuronium preparation is 0.25 mg/0.25 mL, and the cisatracurium preparation is 0.5 mg/0.25 mL. Both preparations have identical appearances (Figure 4). Cisatracurium is only used in our NICU for premedicating babies before nonemergent intubation, along with a dose of an opiate and atropine. On the evening of the error, the pharmacy technician had misfilled the cisatracurium ADC pocket with vecuronium and vice versa. Before that time, the baby had received two doses of vecuronium. When preparing to administer the third dose of vecuronium, the nurse removed what she thought was vecuronium from the ADC and did not notice the error. She then used the point-of-care BCMA system to check the medication before administration. The system told her that the medication was incorrect. A second nurse providing a system-required double check for neuromuscular blocker administration also noted the warning. However, both nurses believed the BCMA system was incorrect and gave the baby a volume of cisatracurium equal to 0.2 mg/kg.

The error was noticed by the nurses within a short time after administration when the syringe was more closely examined. The physician was notified immediately. The baby had no apparent adverse effects from the cisatracurium, and no alteration in her management was required. During the 2.5 hours between cisatracurium administration and the next vecuronium dose, there were no significant changes in her vital signs; her heart rate remained 150–160 beats/min, and mean arterial pressure remained 40–44 mm Hg. The FiO_2 remained 0.21–0.24, and the ventilator

Figure 4. Syringes for vecuronium (left) and cisatracurium.



amplitude was decreased from 22 to 18 cm H_2O. The frequency requirement of vecuronium was the same before and after the error. There was thus no apparent need for increased neuromuscular blockade due to the error. The morphine drip remained stable at 5 µg/kg/hr, and no bolus doses of morphine were required to control the neonate's agitation and respirations after the error. The baby was already receiving 1:1 nursing care, so no change in level of care or monitoring was needed. Vecuronium was discontinued the next morning on day of life (DOL) 5. By that time, the baby had received three vecuronium doses after the error. The ventilator settings were weaned further, and the baby was switched to conventional synchronized intermittent mandatory ventilation on DOL 6.

Although this error did not result in any harm or increased monitoring, the fact that it involved a neuromuscular blocker was concerning. We recognized two system problems that led to the error. The first was the similar appearance of not only the two neuromuscular blockers involved in the error but three other pharmacy-prepared unit-of-use neonatal parenteral syringes—morphine 0.5 mg/0.5 mL, fentanyl 10 µg/mL, and lorazepam 1 mg/mL. All five agents are refilled in the NICU ADC by central pharmacy technician staff at the same time each evening. Had the cisatracurium been mistakenly swapped with the morphine, the outcome might not have been so benign, particularly for a nonintubated patient due to receive morphine. To prevent such an error, the two ADC pockets for the neuromuscular blockers had been labeled "Paralyzing Agent," as were the individual syringes. However, these labeled warnings were not enough to prevent a mix-up between the neuromuscular blocker and similar-appearing nonneuromuscular blocker syringes at the ADC or in the central pharmacy during batch preparation. In collaboration with the central pharmacy staff, it was agreed that cisatracurium and vecuronium syringe labeling would be augmented to include bright-red "Paralyzing Agent" stickers on each syringe. This change was consistent with recommendations from the American Society of Anesthesiologists.[10]

The second system error was the lack of decentralized pharmacist ADC checking of technician refills ("fill checking"). At the time of the error, our department had recently changed practice from decentralized to central pharmacist ADC fill checking in order to integrate better with a new inventory management system being offered by our distributor. ADC-refilling errors such as the one in this case, and also in case 1, prompted the investigating pharmacists to recommend reinstating decentralized pharmacist ADC fill checking in the neonatal–perinatal care areas. Department leadership concurred with the recommendation and applied it to all patient care areas. Decentralized pharmacist ADC fill checking was reinstated throughout the hospital, in combination with central pharmacist checking of ADC fills. There are now two instances of pharmacist review of pharmacy technician ADC-filling activities at our institution: once before leaving the central pharmacy and once after ADC fills. These staffing changes were shared with the medical director and the nursing manager of our NICU at a multidisciplinary quarterly medication quality meeting

Discussion

A study conducted by Suresh et al.[11] found that a majority (56%) of NICU medication errors were due to incorrect dispensing and administration, while only 28% were due to incorrect ordering and transcription.[11] The provision of decentralized clinical pharmacy services to neonatal and pediatric intensive and acute care areas is an evidence-based method of medication-error prevention[12,13] endorsed by experts[14] and the American Academy of Pediatrics.[15] However, such error-prevention strategies have focused primarily on erroneous *ordering* and not necessarily on the more-common NICU problems of erroneous *dispensing* and administration. Providing leadership and guidance throughout all domains of the medication-use process where errors are likely to occur, including product inventory, storage, and delivery, is thus an important and unique challenge for the decentralized NICU pharmacist.

Before the occurrence of the errors reported herein, our inpatient pharmacy system had already adopted many recommended strategies for preventing medication errors in our neonatal patients, including limiting the number of medication concentrations and strengths available, using standard concentrations for continuous medication infusions, using commercially available pediatric-specific formulations whenever possible, dispensing all medications in patient-specific unit dose i.v. and oral syringes, and implementing 24-hour pharmacy oversight of medication ordering, verification, and dispensing.[5] Futhermore, common i.v. and intraarterial solutions containing heparin are premade by pharmacy services and available in the NICU at all times. Our NICU ADC contains only those adult medication concentrations commonly used for neonatal emergency resuscitation. Potent and high-risk medications stored in the ADC are repackaged from adult containers into neonatal unit-of-use syringes at appropriate doses and concentrations. These errors taught us that despite the numerous neonatal medication safety systems already in place, we still had room for improvement.

Although we are unaware of any previous reports identical to these specific errors, the problem of adult–neonatal medication mix-ups is not

new. Numerous cases have been reported describing the accidental administration to neonates of intramuscular ergotamine and oxytocin intended for their mothers.[16-18] The providers in these cases thought they were giving phytonadione. One case resulted in a neonate's death.[18] Sound-alike adult–pediatric and pediatric–pediatric vaccine mix-ups are also not uncommon in infants and young children.[19-24] Reported sound-alike errors resulting in harm frequently involve DTaP-containing vaccines.[20-22] Our two cases did not result in harm, but both involved DTaP. We have consistently observed confusion among pediatric nurses, pharmacists, and pediatricians associated with the naming conventions of the various commercially available pediatric and adult DTaP-containing vaccines. Interestingly, while many previously reported cases of DTaP and TdaP mix-ups have involved a trade-name sound-alike error (Daptacel and Adacel),[21,22] one of the mix-ups we reported involved a generic-name sound-alike error involving two very different-sounding trade-name products.

The system problems at our institution that contributed to the observed neonatal sound-alike, look-alike medication errors can be summarized as follows:

- There was a lack of separate storage sites for neonatal, pediatric, and adult medications.
- Pharmacists and pharmacy technicians without specialized training or knowledge of neonatal drug therapy were significantly involved in the care of neonates.
- Pharmacy-compounded products were a source of look-alike errors.
- Vaccines, despite being dispensed infrequently, were a significant source of dispensing errors.
- System-safety enhancements, such as unit dosing or bar coding, were effective only when the human–system interaction was harmonized.

The system improvements described here have far corrected these problems. To maintain these improvements, we plan on adding a standing agenda item at weekly staff meetings for discussion of neonatal-specific operations updates and of distribution–clinical pearls. We also plan on providing more decentralized NICU training to centralized pharmacists.

We believe the dispensing errors reported here are not uncommon in hospitals with a centralized pharmacy serving adult, pediatric, and neonatal patients. As a best practice to correct and prevent such errors, we recommend close, ongoing collaboration among centralized and decentralized pharmacists and quality-improvement specialists.

Conclusion

An institution providing services to both neonatal and adult patients experienced five cases of medication-dispensing errors with look-alike or sound-alike medications. Multidisciplinary collaboration within the system helped the pharmacy identify, resolve, and prevent errors related to medication storage, labeling, delivery, knowledge, and administration documentation.

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Appendix—New documentation form for infant vaccine administration

UNIVERSITY of CALIFORNIA, SAN DIEGO MEDICAL CENTER

IMMUNIZATION/VACCINE INFORMATION TRACKER

INFANT VACCINES

RASTREADOR DE INFORMACIÓN SOBRE VACUNACIÓN/PREVENCIÓN *VACUNAS INFANTILES*

Patient Identification

I have read or had explained to me the information contained in the vaccine information pamphlet(s) (VIS), or the *Important Information* statement(s) about the vaccine(s) checked below. I have reviewed this material and my doctor has answered my questions about the content of the VIS.

He leído o me fue explicada la información contenida en el/los panfleto(s) de información de vacunas o Declaración(es) de información de vacunas (VIS, por sus siglas en inglés) sobre la(s) vacuna(s) marcada(s) a continuación. He tenido la oportunidad de hacer preguntas que fueron contestadas a mi entera satisfacción.

INFANT VACCINES	MANUFACTURER	BRAND NAME	LOT #	DOSE	ROUTE	SITE	VIS DATE
Diphtheria, Tetanus and acellular Pertussis (DTaP)	❒ Sanofi Pasteur ❒ GlaxoSmithKline ❒ Sanofi Pasteur ❒	❒ Tripedia ❒ Infanrix ❒ Daptacel ❒		0.5 mL	IM		
Hepatitis B (HBV) pediatric	❒ GlaxoSmithKline ❒ Merck ❒	❒ Engerix-B ❒ Recombivax ❒		0.5 mL	IM		
Haemophilus influenzae type b (Hib)	❒ Sanofi Pasteur ❒ Wyeth Lederle ❒	❒ ActHib ❒ HibTITER ❒		0.5 mL	IM		
Pneumococcal conjugate (PCV)	❒ Wyeth Lederle ❒	❒ Prevnar ❒		0.5 mL	IM		
Inactivated polio (IPV)	❒ Connaught ❒	❒ IPOL ❒		0.5 mL	SQ/IM		
Combination HBV + Hib	❒ Merck ❒	❒ Comvax ❒		0.5 mL	IM		
Combination HBV + DTaP + IPV	❒ GlaxoSmithKline ❒	❒ Pediarix ❒		0.5 mL	IM		

Administered by (Signature) Date & Time

Patient/Parent or Guardian Signature / *Firma del paciente/padre o tutor* | Relationship to Patient / *Parentesco o relación con el paciente* | Date / *Fecha*

Witness Signature / *Firma del Testigo* | Date / *Fecha*