Mismatches between prescribing and pharmacy templates can lead to errors in parenteral nutrition dosing. This is a significant issue, as errors can result in patient harm. The pharmacy pediatric PN template is widely used to support the nutritional needs of patients of all ages, from low-birth-weight infants to elderly patients who are temporarily unable to meet nutritional goals due to an acute illness or following surgery. The benefits of PN are significant, but the potential for harm is great with this high-alert medication if it is used in error. Inappropriate dosing of nutrients, order-entry errors, and compounding errors have all been associated with adverse outcomes and deaths. For example, in my December 2014 P&T column, I discussed an error that resulted in the death of a 6-week-old infant who received 60 times more sodium than prescribed after a technician entered the prescribed dose of calcium (982 mg) into the milliequivalent (mEq) field for sodium.

Recently we received another report of an order-entry error. In this case, a physician prescribed PN for a 16-year-old boy who weighed 72 kg using a standard pediatric PN template in an electronic health record. This template prompted prescribers to order most of the ingredients in measurement units of grams per kilogram (g/kg), milliequivalents per kilogram (mEq/kg), or millimoles per kilogram (mmol/kg), using the patient’s weight to calculate the daily amount of nutrients. Accordingly, the prescriber ordered the PN nutrients as g/kg or mEq/kg in a total volume of 2,640 mL to infuse over 24 hours.

The pharmacy pediatric PN template was arranged similarly (dose of ingredients per kilogram) for patients weighing 40 kg or less; however, once the patient weighed more than 40 kg, the PN template required entry of all nutrients in measurement units of grams per day (g/day), milliequivalents per day (mEq/day), or millimoles per day (mmol/day). The pharmacist who entered the PN order was still undergoing training in this area of the pharmacy. The pharmacist entered the order into the template for pediatric patients weighing more than 40 kg but failed to manually change the prescribed per-kilogram doses to the corresponding total daily amounts. As a result, errors were made while entering the PN order into the pharmacy PN template. The multivitamins and trace elements were prescribed and entered correctly as daily totals, as were the lipids.

After the PN order was entered, a trained technician prepared the solution using an automated compounding device. But he failed to notice that an unusually large amount of sterile water—more than 2,800 mL—was required to prepare the solution, even though a new bag of sterile water had to be hung during the compounding process. After the PN was mixed, another pharmacist checked the final preparation. All the numerical values matched the order, but the pharmacist failed to notice the incorrect units of measure and the very low total amounts of nutrients listed on the label. The patient’s nurse also verified the PN label with the prescriber’s order but failed to notice the errors. The patient received almost the entire bag of PN before the error was discovered the following day while preparing the next bag of solution.

After the correct PN solution was started, the erroneous solution was sent to the pharmacy for analysis. The osmolality of the incorrectly compounded solution was found to be exceedingly hypotonic at 138 mOsm/L. Thankfully, the patient did not experience any adverse effects from the error. He continued receiving correctly compounded PN for several days and was later discharged from the hospital.

SAFE PRACTICE RECOMMENDATIONS: If your organization prepares PN using an automated compounding device and associated order-entry software, consider the following recommendations to avoid potential harm to your patients due to data-entry errors. Most recommendations are also applicable in organizations that use automated compounder-associated software for PN computations alone (not actual compounding) and/or prepare PN solutions manually.

**Match the prescribing and pharmacy templates.** A mismatch between the PN template for prescribers and the PN template for pharmacists entering the order into the automated compounding-device software played a prominent role in this error. To avoid errors, the method of ordering PN solutions (and other routinely compounded solutions) for neonates, pediatric patients, and adults must be standardized in a way that matches the templates used when entering the orders into the pharmacy computer and/or automated compounding device. Standardization is required for the units of measure for each nutrient and the order in which each ingredient is prescribed and entered. The American Society of Parenteral and Enteral Nutrition (ASPEN) encourages use of a total daily dose when prescribing nutrients for adult PN, and daily weight-based doses (mg/kg/day) when prescribing nutrients for pediatric PN. This supports the use of the 24-hour nutrient infusion system. Standard PN formulations should also be used whenever appropriate.

**Build, test, and heed automated warnings.** Install, test, and maximize automated warnings in the pharmacy computer system and/or automated compounding-device software to alert pharmacy staff to low and high osmolality and subtherapeutic doses and overdoses of individual key ingredients. If possible, use a warning with a hard stop for low osmolality below a certain value (e.g., 154 mOsm/L), which requires an...
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independent verification of the PN order and order entry. Consider printing all alerts encountered during the pharmacy order-entry process so the person verifying the order entry can also view and respond to the alerts. Reinforce the importance of reading and reacting to low-osmolality or low-dose alerts with all staff.

**Heighten the suspicion of an error.** Continually emphasize to those preparing PN (or admixtures with other high-alert medications) that they should stop the process if they encounter situations in which they need to add any ingredient—be it an electrolyte, mineral, other nutrient, or diluent (sterile water, in this case)—in large doses or volumes in order to complete a single preparation. The need to use more than one container, whether it is a vial or a bag of diluent, should trigger a cognitive review of the order and work label to ensure an error has not occurred. Create a culture that encourages all staff members, regardless of their level of experience or education, to speak up about unusual preparations.

**Carry out effective redundancies.** Develop a standardized PN review process that begins with a clinical review of the appropriateness of PN and its prescribed ingredients and ends with a final independent double-check before administering the solution. At least four processes should occur in the pharmacy:

1. Appropriateness screening before the order is entered and the labels are printed, which includes an independent double-check of any dose calculations
2. Verification of order entry before product preparation
3. Verification of all manual additives before injection into the PN bag, if applicable
4. Verification of the final product after it has been compounded

If PN preparation is outsourced, appropriateness screening and verification of the final product must still occur before dispensing the PN. Each verification step should require a pharmacist to compare the actual prescriber’s order to the product and work labels, and to compare the labels to the vials, additives, and final product as appropriate. Verification of manual additives should include inspection of the actual vials and syringes that contain the additives. The final verification of the compounded PN should include a comprehensive review of the PN order, the label on the product, and the work label. When possible, automated quality-control checks such as osmolarity reading, specific gravity, or weight should be obtained and reviewed during the final product verification. Before administering PN, the patient’s nurse should also independently compare the label on the solution with the physician’s order.

**Provide clear labeling.** Because PN is a complex solution with multiple ingredients, pharmacy-generated labels for these products should be standardized to provide a clear and effective source of information to facilitate the verification processes mentioned above. Thus, the label should match the way the prescriber orders the PN (which should also match the way the pharmacist enters the order) and reflect all active ingredients so pharmacists and nurses can verify the PN. To support the use of a 24-hour nutrient infusion system, ASPEN notes that the amount per day is the only column required on the label for the base formula, electrolyte additives, micronutrients, and medications. Including the quantity per liter option in parentheses supports those programs that continue to prepare PN in 1-L volumes rather than daily volumes.

**Educate and validate competency.** Establish a formal training process for pharmacy staff members who enter PN orders into the pharmacy computer and automated compounding-device software, compound the solutions, or check the products after preparation. Designate and train specific staff members to function as preceptors, and require one-on-one supervision until trainees are comfortable providing the service and have demonstrated the skills and knowledge necessary to function independently. During training, the preceptor should conduct various supplemental independent double-checks in addition to the established verification processes. Training should focus on the total daily dose of PN ingredients and clues that might heighten the suspicion of an error, including the need for multiple dosage containers to prepare a single preparation or unexpected differences in the appearance of solutions. Plan adequate staffing with trained practitioners to cover vacations, illnesses, and other causes of planned and unplanned absences. Establish guidelines for closer supervision of work if coverage with an inexperienced staff member is necessary.

**Eliminate transcription of PN orders.** When possible, establish a computerized prescriber order-entry system for PN that:

1. Directly communicates with the pharmacy automated compounding-device software.
2. Is user friendly.
3. Includes decision support to warn about possible prescribing and order-entry errors.
4. Populates the required fields, which can then be evaluated by pharmacists before the PN preparation.

For additional recommendations regarding safe prescribing, dispensing, and administration of PN, please read the proceedings from the 2011 ASPEN Parenteral Nutrition Safety Summit.2

**REFERENCES**