Dose Confusion with Phosphorus-Containing Products

by Matthew Grissinger, RPh

PROBLEM: Confusion regarding the administration of phosphorus supplements has led to numerous medication errors. Variations in the way prescribers express doses of potassium and sodium phosphate have led to errors in conversions between milligrams (mg), milliequivalents (mEq), and millimolar (mM) for the phosphorus component of products as well as inattention to the amount of potassium or sodium delivered with each dose. In addition, oral and parenteral product labels can be confusing. Some labels list up to five different measurement units, such as mg, mM, mEq, milliosmolar (mOsmol), and milliliters (mL), when expressing the container’s volume and strength of various salts and other ingredients.

In one case, label confusion and access to the pharmacy after hours led to an error in which an intravenous (IV) solution containing 132 mEq/L of potassium and 90 mM/L of phosphate was administered to a patient. During the night, an order was written for 30 mEq of potassium phosphate in 1,000 mL IV to run over six hours. A nursing supervisor entered the pharmacy after hours and attempted to determine the contents of 15-mL vials of potassium phosphate injection. In large bold print. The label information overwhelmed the supervisor, and she misread “15 mL” as 15 mEq.

Believing that 15 mM and 15 mEq were equivalent, she dispensed two vials. The patient’s nurse, equally confused, added both vials to the IV fluid and started the infusion. The pharmacy reopened about an hour later, and the error was detected immediately. The supervisor documented the removal of two vials of potassium phosphate 15 mM, but she left a sample of the 15-mL vial on the counter for inspection. The patient received 150 mL of the solution (about 20 mEq of potassium and 14 mM of phosphorus), and serious harm was averted.

SAFE PRACTICE RECOMMENDATION: Two forms of phosphate—monovalent ($H_2PO_4^{-}$) and divalent ($HPO_4^{2-}$)—are present in the normal physiological range of blood pH. Thus, phosphorus supplements are a combination of monobasic and dibasic salts, the ratio of which is dependent on the pH.

Because of the polyvalent nature of phosphate anions, mEq should not be used to order or express a given amount of phosphorus. Milliequivalents are calculated by dividing the atomic weight in milligrams by the valence. Because phosphate anions are polyvalent and the ratio of monovalent to divalent forms is dependent on pH, mEq cannot be derived reliably.

To avoid confusion, prescribers should order phosphorus supplements in mM of phosphorus (a measurement that is immune to pH changes) and mM of potassium or sodium in parentheses (to avoid overlooking the total amount of potassium or sodium). Phosphorus supplements should be entered into the computer as mM of phosphorus and mEq of potassium or sodium.

Alerts should be built into the system to warn of excessive doses, and computer-generated medication administration records (MARs) and labels should list both mM of phosphorus and mEq of potassium or sodium. To guide therapy, a written protocol and standard order form should be established.

Access to the pharmacy after hours should be prohibited. In organizations without a 24-hour pharmacy service, a “night formulary” should be created and stocked in a specific dispensing cabinet. If phosphate supplements must be stocked in the cabinet, auxiliary labels should be applied that clearly state the total contents of phosphorus (in mM) and potassium or sodium (in mEq).

On-call pharmacists should be contacted for questions, and an independent double-check system should be established to verify all calculations and any drugs that are removed from the night cabinet. Each morning, the pharmacy staff should immediately reconcile all drugs removed from the night cabinet by comparing what was removed from stock against the physicians’ orders.

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