It Doesn’t Pay to Play the Percentages with Drug Dosages

Matthew Grissinger, RPh, FASCP

PROBLEM: The Institute for Safe Medication Practices (ISMP) has received several reports in which patients were given undiluted intravenous (IV) epinephrine 1:1,000 (1 mg/ml) instead of the 1:10,000 (0.1 mg/ml) concentration. In each case, the more diluted epinephrine (1:10,000) was available for use, but the staff inadvertently prescribed or selected the 1:1,000 concentration.

One error occurred in an outpatient radiology unit, where the nurse on duty rarely administered medications. The patient reacted to the contrast medium with visible hives and respiratory distress. The physician prescribed 3 ml of the 1:10,000 concentration IV, but 3 ml of the 1:1,000 concentration was administered in error. This mistake resulted from a lack of understanding about the difference between the two concentrations. In this case, however, there was an additional problem: the dilutions were difficult to differentiate, because “1,000” looks like “10,000.”

In another case, a physician’s assistant ordered the incorrect concentration for a patient in an urgent-care clinic. The nurse administered the agent without recognizing the problem. In fact, there was no warning anywhere on the ampules of these products about the need to dilute the 1:1,000 concentration before IV administration. Both patients experienced rapid heart rates and an elevated blood pressure, necessitating an overnight hospital stay.

These errors highlight an ongoing problem with drug concentrations. Typically, the contents of most injectable medications are given as their mass concentration—in milligrams (mg) or micrograms (mcg) per milliliter (ml). For a few drugs, however, their concentrations are expressed as a dilution ratio or percentage (e.g., epinephrine 1:1,000, lidocaine 1%). These expressions tend to result in errors, as evidenced by studies showing that knowledge about concentrations expressed as a ratio or percentage—even among physicians and emergency medicine residents—is inadequate.1–3

More alarming is the fact that these poorly understood expressions are particularly prevalent with drugs used for resuscitation (e.g., calcium, epinephrine, lidocaine, magnesium sulfate, neostigmine, and sodium bicarbonate). Thus, the occurrence of an inappropriate dose or a life-threatening delay in treatment is quite possible, especially if these drugs are prescribed in milligrams (for which prior knowledge of ratio or percent concentrations and calculations is required) or milliliters (which is a problem if multiple concentrations exist).

To cite one example, a newborn stopped breathing, and a Code Blue alert went into effect. An epinephrine dose was ordered in milliliters. Despite much initial confusion, a pharmacist who attended the patient was able to guide the staff in giving the proper dose, because both 1:1,000 and 1:10,000 dilutions were available on the “code cart.” The neonatal nurses and physicians had assumed that only the 1:10,000 dilution was available on the cart.

SAFE PRACTICE RECOMMENDATION: On the basis of research findings and everyday practice experiences, the following steps can be taken to ensure accurate dosing:

1. Not all health care practitioners can be expected to be familiar with percentage or ratio expressions of concentrations, and not all are adept at calculating drug doses with concentrations expressed in this manner. Therefore, it would be helpful to create a “dose-conversion chart” to reflect concentrations that are available in the facility and to post them on code carts and in areas where emergency medications are prepared.

2. Because an independent double-check by another clinician might not be feasible in emergency situations, staff members should be encouraged to refer to the dose chart before they administer these products.

3. During annual cardiopulmonary resuscitation (CPR) certifications for the clinical staff, the dose chart should be reviewed; any potential confusion with emergency drugs that are given in ratios or percent concentrations should be discussed.

4. All personnel should be alerted to the hazards of ordering injectable medications by volume alone.

5. When possible, a single concentration of the drug should be stored.

6. Warning labels should be affixed to the ampules, as appropriate, to minimize confusion between the two concentrations of epinephrine.

7. In some locations, such as on code carts, it might be feasible to store epinephrine in 1:10,000 prefilled syringes as the only option.

8. In areas where multiple concentrations might be needed, such as in the emergency department, an auxiliary warning can be applied to the labels of the 1:1,000 ampules to alert the staff to the concentration in milligrams and to dilute it before IV use.

Because many of the emergency medications with concentrations that are expressed in ratios or percentages predate the 1938 Food, Drug, and Cosmetic Act, they do not fall under the current Food and Drug Administration (FDA) labeling standards. However, because the issue is so serious, the ISMP has asked the FDA to address the problem. Although ratio or percentage expressions pose less danger when topical continued on page 318
products or local anesthetics are used, they do not serve us well when dosing is systemic.

REFERENCES

The reports described in this column were received through the USP–ISMP Medication Errors Reporting Program (MERP). Errors, close calls, or hazardous conditions may be reported on the ISMP (www.ismp.org) or the USP (www.usp.org) Web site or communicated directly to ISMP by calling 1-800-FAIL SAFE or via e-mail at ismpinfo@ismp.org.