

Section 2

Solving dosage problems

Whether your organization uses a bulk medication administration system or a unit-dose administration system to prepare to administer pediatric medications, you may find that the dose the physician orders is different from that which is available. You will need to determine how much of the medication on hand should be given to the infant or child. In addition, you are ultimately responsible for verifying the dosage of any medication that you administer *before you administer it*.

Pediatric patients vary widely in weight—from small infants to large adolescents. Dosages vary widely, as well. You will not find a standard dose of a drug that is safe for all ages and sizes. Because of this, the doses of medication given to children also vary tremendously. Determining the correct dose for a child usually involves calculating the dose based on either the child's weight or the child's body surface area (BSA).

The most common way to calculate the dose of medicine is based on the child's weight. For example, a drug manufacturer may state its dosage recommendation as: 75 mg/kg/day divided every eight hours. When you know the weight of the child, it is easy to determine the correct dose of the medication for the child. If the child weighs 10 kg, then the child will get 750 mg/day divided every eight hours (that is, $750/3$ or 250 mg/dose).

Another way to calculate the dose of medication appropriate for a child is using the body surface area (BSA). This method isn't used quite as often as the weight-based calculation. It is frequently used with chemotherapeutic drugs. The BSA accounts for the fact that not all children who weigh the same look the same. For example, a child who weighs 25 pounds may be very tall (45 inches) and slender, while another child weighing 25 pounds may be very short (30 inches) and compact. Although each child has the same weight, each has a different amount of body surface area and a different body composition.

The BSA is estimated using a special formula or the West Nomogram, which is a special graph. To calculate the BSA, you must know both the height and weight of the child. Using the formula, the taller child would have a BSA of 0.62 m^2 and the shorter child's would have a BSA of 0.48 m^2 . If a drug were prescribed to be given $150 \text{ mg/m}^2/\text{day}$, then the 1st child (45 inches tall) would receive 90 mg/day, while the 2nd child (30 inches tall) would receive 72 mg/day. If you determined doses on weight alone, they would both receive the same dose.

Ratio method

Basic conversions

It is often necessary to be able to convert measurements into metric equivalents as well as to convert dose volumes. This self-study presents one commonly used method—the ratio method—for solving dosage problems. The ratio method requires that you learn two ratios.

The following ratio—the simple ratio—helps you convert simple measurements:

Given proportion:	$\frac{\text{Desired amount}}{\text{Unknown amount (U)}}$
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Let's look at some examples of conversions.

Example 1—How many micrograms are there in 0.5 mg?

1. Set up the equation using the equivalent table (Appendix A). You know that 1 mg is the same as 1000 mcg. This given proportion becomes the left side of the equation. Since 0.5 mg is the desired amount, you will place this known quantity over the unknown (U) quantity on the right side of the equation.

$$\frac{1 \text{ mg}}{1000 \text{ mcg}} = \frac{0.5 \text{ mg}}{U \text{ mcg}}$$

2. Cross multiply as follows:

$$\frac{1 \text{ mg}}{1000 \text{ mcg}} \quad \begin{array}{c} \text{↔} \\ \text{↔} \end{array} \quad \frac{0.5 \text{ mg}}{U \text{ mcg}}$$

$$1 \times U = 1000 \times 0.5$$

$$U = 500 \text{ mcg}$$

Result: There are 500 mcg in 0.5 mg.

Important!

When you set up an equation, it is critical that you include the units of measurement with the numbers (for example, mg, ml, kg, minutes). After you set up the equation—but before you do the math—make sure that the *units* of measurement on the *top* left side are the same as the units of measurement on the *top* right side of the equation. The *bottom* left and the *bottom* right also need to be in the same units.

If you find that you are working with three or more different units of measurement, you need to break the problem down into two or more steps. You can only deal with two different units of measurement at a time.

Example 2: How many kilograms are equal to 44 pounds?

1. Set up the equation using the equivalency table (see Appendix A). You see that 2.2 pounds is the same as 1 kg.

This given proportion becomes the left side of the equation. Since 44 pounds is the desired equivalent, you will place this known quantity over the unknown (U) quantity on the right side of the equation.

$$\frac{2.2 \text{ lb}}{1 \text{ kg}} = \frac{44 \text{ lb}}{U \text{ kg}}$$

2. Cross multiply as follows:

$$\begin{array}{ccc} 2.2 \text{ lb} & & 44 \text{ lb} \\ \hline & \begin{array}{c} \swarrow \quad \searrow \\ \nwarrow \quad \swarrow \end{array} & \hline 1 \text{ kg} & & U \text{ kg} \end{array}$$

$$2.2 \times U = 44 \times 1$$

$$2.2 \times U \div 2.2 = 44 \div 2.2$$

$$U = 20 \text{ kg}$$

Result: 20 kg = 44 pounds.

Important!

Suppose you said that 1 kg is the same as 2.2 pounds (lb) and set the given proportion as:

$$\frac{1 \text{ kg}}{2.2 \text{ lb}}$$

This would be acceptable because the mathematical statement is still correct. The right side of the equation would need to have the unknown (U) quantity on the *top*, because you don't know how many kg ("U kg") equals 44 pounds. Remember that you have to keep your units the same on both the *top* left side and the *top* right side of the equation. The same thing goes for the *bottom* left and *bottom* right, both sides need to be in the same units.

$$\frac{1 \text{ kg}}{2.2 \text{ lb}} = \frac{U \text{ kg}}{44 \text{ lb}}$$

Note that when you cross multiply, you get the same equation as before.

$$1 \times 44 = 2.2 \times U$$

Divide both sides by 2.2 so that you get 1 U on one side.

$$44 \div 2.2 = 2.2 \times U \div 2.2$$

$$20 \text{ kg} = U$$

Result: 20 kg = 44 pounds

Example 3: How many milliliters (ml) are in 9 ounces (oz)?

1. Set up the equation.

$$\frac{1 \text{ oz}}{30 \text{ ml}} = \frac{9 \text{ oz}}{U \text{ ml}}$$

2. Cross multiply as follows:

$$\frac{1 \text{ oz}}{30 \text{ ml}} \quad \begin{array}{c} \text{X} \\ \text{X} \end{array} \quad \frac{9 \text{ oz}}{U \text{ ml}}$$

$$1 \times U = 9 \times 30$$

$$U = 270$$

Result: 270 ml = 9 ounces.

Complex conversions

The ratio method of calculating conversions helps you solve more complex problems, as well. The following ratio—the complex ratio—helps you solve more complex dosage problems:

Dose on hand	=	Desired amount
<hr style="width: 100%;"/>		<hr style="width: 100%;"/>
Quantity on hand		Unknown amount (U)


Tip: The word “per” usually means division or ratio. 10 mg per 1 ml is written 10 mg/1 ml.

Example 1: The physician has ordered 2 mg of morphine. The vial you have on hand is labeled, “Morphine, 10 mg per 1 ml.” How many ml of morphine will you draw up to administer to your patient?

- Write your ratio as follows:

$$\frac{10 \text{ mg}}{1 \text{ ml}} = \frac{2 \text{ mg}}{U \text{ ml}}$$

- Cross multiply as follows:

10 mg		2 mg
1 ml		U ml

$$10 U = 2 \times 1$$

$$10 U = 2$$

$$U = 2 \div 10 \text{ or } 0.2 \text{ ml}$$

Result: You would draw up 0.2 ml of morphine from the vial to obtain a dose of 2 mg for your patient.

Example 2: The physician has ordered 0.5 gram of cefazolin to be given IV. Cefazolin is packaged in a dry form of 1 gram, and the package directions state to add 2.5 ml sterile water to reconstitute the dry volume to a liquid volume of 3 ml. How many ml will you give to obtain a dose of 0.5 gram?

- Write your ratio as follows:

$$\frac{1 \text{ gram}}{3 \text{ ml}} = \frac{0.5 \text{ gram}}{U \text{ ml}}$$

- Cross multiply as follows:

$$\frac{1 \text{ gram}}{3 \text{ ml}} \quad \begin{array}{c} \text{X} \\ \text{X} \end{array} \quad \frac{0.5 \text{ gram}}{U \text{ ml}}$$

$$1 \times U = 0.5 \times 3$$

$$U = 1.5 \text{ ml}$$

Result: You will give 1.5 ml of the reconstituted cefazolin to obtain a dose of 0.5 gram.

Example 3: The physician has ordered 2 micrograms of a drug per kilogram patient body weight per minute, to be given intravenously. The pharmacy has sent a mixture of 20 mg of the drug in 50 ml IV solution in a syringe. Your patient weighs 44 pounds. How many ml will you give per hour?

- Begin with basic conversions. Because the drug was ordered on a per kilogram basis, you first need to change the patient's body weight in pounds to kilograms.

$$\frac{2.2 \text{ lb}}{1 \text{ kg}} = \frac{44 \text{ lb}}{U \text{ kg}}$$

$$2.2 U = 44$$

$$U = 20 \text{ kg}$$

Your 44-pound patient weighs 20 kg.

2. The second basic conversion you need is to determine the number of micrograms (mcg) that you will administer per kilogram (kg) of your patient's body weight. You now know that your patient weighs 20 kg, so simple multiplication will give you the total dose in micrograms per minute: the order dose was 2 mcg per kg per minute, which is:

$$\frac{1 \text{ kg}}{2 \text{ mcg}} = \frac{20 \text{ kg}}{U \text{ mcg}}$$

$$U = 40$$

3. The third basic conversion you need is to change micrograms per minute to micrograms per hour. Remember that the question was how many ml to administer per hour, because many IV monitoring systems are only set up to count volume per hour.

$$\frac{1 \text{ minute}}{40 \text{ mcg}} = \frac{60 \text{ minutes}}{U \text{ mcg}}$$

$$1 \times U = 40 \times 60$$

$$U = 2400 \text{ mcg/hr}$$

Your patient requires 2400 mcg of the drug per hour.

4. The final basic conversion you need is to change the dose in mcg to the dose in mg. The pharmacy sent a mixture of 20 mg drug in 50 ml IV solution in a syringe. From your conversion table, you know that 1 mg = 1000 mcg, so you can set up your ratio as follows:

$$\frac{1000 \text{ mcg}}{1 \text{ mg}} = \frac{2400 \text{ mcg}}{U \text{ mg}}$$

$$1000 \times U = 2400 \times 1$$

$$1000 U = 2400$$

$$U = 2400 \div 1000$$

$$U = 2.4 \text{ mg}$$

You need to administer 2.4 mg of the drug per hour. You also have all the necessary conversions to determine the number of ml per hour to administer of this IV solution.

5. Complete your ratio. Remember, you know that you have 20 mg of the drug in 50 ml IV solution in a syringe. You need to calculate how many ml is equivalent to 2.4 mg of the drug.

$$\frac{20 \text{ mg}}{50 \text{ ml}} = \frac{2.4 \text{ mg}}{U \text{ ml}}$$

Cross multiply:

$$\frac{20 \text{ mg}}{50 \text{ ml}} \quad \longleftrightarrow \quad \frac{2.4 \text{ mg}}{U \text{ ml}}$$

$$20 \times U = 2.4 \times 50$$

$$20 U = 120$$

$$U = 120 \div 20$$

$$U = 6 \text{ ml}$$

6. Finally, you need to determine the IV rate you would set the pump for, in ml/hour.

Result: You will need to set the pump to administer 6 ml of the IV solution per hour to obtain the ordered dose of 2 mcg of drug per kg per minute for your 44 pound patient.

Tip: For multi-step problems, start by converting pounds to kilograms, micrograms to grams, and minutes to hours. The order is not important.

Take care with decimal places, and don't do too much calculating in your head. A misplaced decimal point could result in giving a dose that is 10 times too small or too large.

Check your answers
on page 22.

Section 2—Competency test

Calculate your answers for the following math conversions and medication calculations carefully. Show your work to review how you arrived at the solution.

- Complete the equivalents:
 - $0.6 \text{ gm} = \underline{\hspace{1cm}} \text{ mg}$
 - $1 \text{ mg} = \underline{\hspace{1cm}} \text{ mcg}$
 - $25 \text{ kg} = \underline{\hspace{1cm}} \text{ lb}$
 - $1 \text{ tsp} = \underline{\hspace{1cm}} \text{ ml}$
 - $1 \text{ cc} = \underline{\hspace{1cm}} \text{ ml}$
 - $1 \text{ Tbsp.} = \underline{\hspace{1cm}} \text{ ml}$
- A typical acetaminophen dose for children is 10 mg/kg of body weight. Acetaminophen chewable tablets come as 80 mg per tablet. How many tablets will you give to a child weighing 36 pounds? (Remember to show your work.)
- The physician's order reads: "Amoxicillin 225 mg p.o., q12 hrs." The bottle from pharmacy is labeled: "250 mg = 5 ml." Calculate how many ml to give.
- Scott is receiving 200 mg of cefdinir p.o., once daily. The concentration of cefdinir is 125 mg/5 ml. This means Scott will receive how many ml of cefdinir per dose?
- Your patient weighs 44 pounds. You need to give 5 mcg per kg per minute of dopamine to the patient. The medication is mixed as 15 mg dopamine in 60 ml D5W. How many ml per hour must you give to administer this dose?
- Joey is to receive 125 mg Amoxil every 12 hours. The bottle from pharmacy is labeled, "250 mg/5 ml". What volume of this medicine will you give per dose?
- Tina's physician has ordered 1200 ml of a D5 0.45 NS with 20 mEq KCl/liter IV solution over the next 24 hours. An IV pump is being used that allows you to set a rate in ml per hour. At what rate in ml would you set the IV pump?

8. Your patient is to receive 6 mg diazepam IV. Diazepam is packaged for injection as 10 mg/2 ml. How many ml would you administer?
9. Your patient is to receive a pre-op dose of midazolam 7 mg. The midazolam injection is labeled “5 mg/ml.” How many ml would you administer?
10. Your patient is to receive digoxin 125 mcg. The digoxin elixir in the medication room reads, “50 mcg/ml.” How many ml would you give?
11. Dopamine is ordered at a rate of 10 mcg/kg/min. The IV syringe contains 40 mg in 50 ml D5W. Jon weighs 99 lb. How many ml fluids with medication will Jon receive in one hour?
12. During a resuscitation effort, the physician orders epinephrine to be run at 20 mcg/minute. You mix 4 mg of the drug in 50 ml D5W for administration via an IV syringe pump. At how many ml per hour should the pump be set?
13. Betsy is a 14-month-old child who weighs 9.5 kg. She has come into the Emergency Room with a severe ear infection. The physician’s order reads, “225 mg Ceftriaxone IM.” The bottle states to add 0.9 ml diluent for each ml to contain 250 mg of the medication. How many ml will you give?

Check your answers

1. a. $0.6 \text{ gm} = 600 \text{ mg}$

$$\frac{1 \text{ gm}}{1000 \text{ mg}} = \frac{0.6 \text{ gm}}{U \text{ mg}}$$

Cross multiply:

$$1 \times U = 1000 \times 0.6$$

$$U = 600 \text{ mg}$$

$$0.6 \text{ gm} = 600 \text{ mg}$$

b. $1 \text{ mg} = 1000 \text{ mcg}$ (by definition)

c. $25 \text{ kg} = 55 \text{ lb}$

$$\frac{1 \text{ kg}}{2.2 \text{ lb}} = \frac{25 \text{ kg}}{U \text{ lb}}$$

Cross multiply:

$$1 \times U = 25 \times 2.2$$

$$U = 55$$

d. $1 \text{ tsp} = 5 \text{ ml}$ (by definition)

e. $1 \text{ cc} = 1 \text{ ml}$ (by definition)

f. $1 \text{ Tbsp} = 15 \text{ ml}$ (by definition)

2. 2 tablets

First change lb to kg:

$$\frac{2.2 \text{ lb}}{1 \text{ kg}} = \frac{36 \text{ lb}}{U \text{ kg}}$$

Then cross multiply:

$$2.2 \times U = 36 \times 1$$

$$36/2.2 = 16.36$$

$$U = 16.36 \text{ kg}$$

Next calculate dose:

$$\frac{1 \text{ kg}}{10 \text{ mg}} = \frac{16.36 \text{ kg}}{U \text{ mg}}$$

Cross multiply:

$$1 \times U = 10 \times 16.36$$

$$U = 163.6$$

Finally, calculate number of tablets per dose:

$$\frac{80 \text{ mg}}{1 \text{ tab}} = \frac{163 \text{ mg}}{U \text{ tab}}$$

Cross multiply:

$$80 \times U = 163$$

$$U = 163/80$$

$$U = 2 \text{ tablets}$$

3. Give 4.5 ml per dose

$$\frac{250 \text{ mg}}{5 \text{ ml}} = \frac{225 \text{ mg}}{U \text{ ml}}$$

Cross multiply:

$$250 \times U = 5 \times 225$$

$$250 U = 1,125$$

$$U = 4.5$$

4. 8 ml per dose

$$\frac{125 \text{ mg}}{5 \text{ ml}} = \frac{200 \text{ mg}}{U \text{ ml}}$$

Cross multiply:

$$125 U = 5 \times 200$$

$$125 U = 1,000$$

$$U = 1000/125$$

$$U = 8$$

5. 24 ml per hour

First change lb to kg:

$$\frac{2.2 \text{ lb}}{1 \text{ kg}} = \frac{44 \text{ lb}}{U \text{ kg}}$$

Cross multiply:

$$2.2 \times U = 44 \times 1, \text{ so } U = 44/2.2$$

$$U = 20 \text{ kg}$$

Dose = 5 mcg per kg per minute and patient weighs 20 kg

$$20 \text{ kg} \times 5 \text{ mcg} = 100 \text{ mcg/min}$$

$$\text{Dosage} \quad \frac{100 \text{ mcg}}{1 \text{ min}} = \frac{U \text{ mcg}}{60 \text{ min}}$$

Cross multiply:

$$1 U = 100 \times 60, \text{ so } U = 6000 \text{ mcg}$$

Next convert mcg to mg:

$$\frac{1000 \text{ mcg}}{1 \text{ mg}} = \frac{6000 \text{ mcg}}{U \text{ mg}}$$

Cross multiply:

$$1000 U = 6000$$

$$U = 6 \text{ mg}$$

Lastly, convert dose in mg to volume in ml

$$\frac{15 \text{ mg}}{60 \text{ ml}} = \frac{6 \text{ mg}}{U \text{ ml}}$$

Cross multiply:

$$15 U = 6 \times 60, \text{ so } 15 U = 360$$

$$U = 24 \text{ ml}$$

6. 2.5 ml
7. 50 ml per hour
8. 1.2 ml
9. 1.4 ml
10. 2.5 ml
11. 33.75 ml
12. 15 ml per hour
13. 0.9 ml