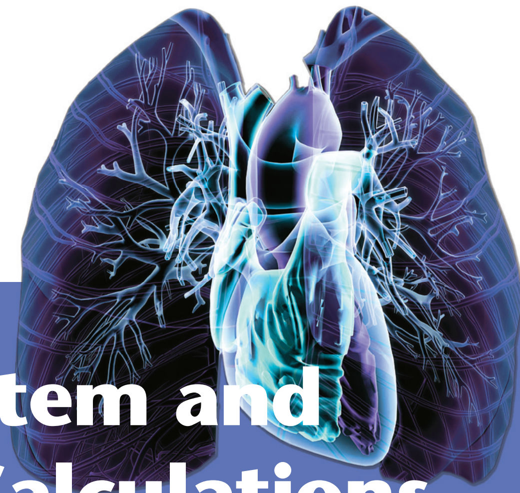
Chapter 2

The Metric System and Drug Dosage Calculations



OBJECTIVES

Upon completion of this chapter you will be able to

- Define key terms relevant to drug dosage calculations.
- Perform conversions of units of measurement within the metric system.
- Perform conversions between units of measurement in the metric and English systems.
- Calculate strength of solutions in percentage forms.
- Perform drug dosage calculations.

KEY TERMS

base
cancelling units
English system of measurement
exponent
factor-label method or fraction method
gram
liter
meter
metric system of measurement
percentage of solution
proportion
ratio solution
scientific notation
solute
solution
solvent
volume/volume solution
weight/volume solution

ABBREVIATIONS

BSA	body surface area	**m**	meter
c	centi-	**m**	milli-
cc	cubic centimeter	**mcg**	microgram
d	deci-	**mg**	milligram
g	gram	**ml**	milliliter
gtt	drops	**SI**	Système International
k	kilo-	**USCS**	United States Customary System
kg	kilogram	**v/v**	volume/volume
l	liter	**w/v**	weight/volume
mc	micro-		

Whereas Chapter 1 gave you the basics of the language of pharmacology, this chapter will give you the mathematical language of medicine. Many respiratory drugs form aerosols from various percentage strengths of solutions that are then administered via the inhalation route. In addition, many of the dosages are in milligrams or micrograms, and some conversions are necessary to other metric units. Therefore you need knowledge of strengths of solution and the metric system to perform drug dosage calculations.

Although most respiratory medications are packaged in *single-unit dosages* and are already premixed at a standard dose for you to aerosolize, occasions may arise when you will need to deviate from that standard premixed dose. You may have to adjust the dosage because of factors such as patient size or age, or the concentration of the medication on hand may be different than what is ordered. For example, a particular drug may be ordered to be given at 5 milligrams/kilogram (mg/kg) of body weight. To find the right amount to administer, you must be able to convert the patient's body weight in pounds to kilograms and then calculate how many milligrams need to be delivered from the strength of solution you have on hand. The process may seem complicated, but it really isn't if you have a basic understanding of the following concepts:

- Exponential powers of 10
- Systems of measurement
- The metric system
- Strengths of solution

This chapter will give you a solid understanding of each of these concepts so that you can perform drug dosage calculations. Make sure you understand each section and the example calculations completely before you move on, as each section builds on the ones before.

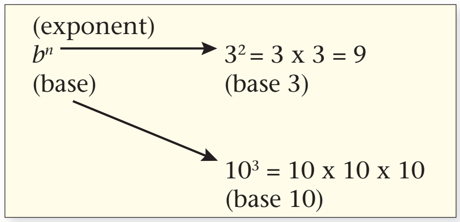
2.1 EXPONENTIAL POWERS OF 10

2.1a Exponents

The **metric system of measurement** is based on the powers of 10. Therefore understanding the powers of 10 will allow you to understand the basis of the metric system.

To understand the powers of 10, we need to review some terminology. Consider the expression b^n, where b is called the **base** and n is the **exponent.** The n represents the number of times that b is multiplied by itself. Please see Figure 2-1.

FIGURE 2-1 The Exponential Expression



If we use 10 as the base, we can develop an exponential representation of the powers of 10 as follows:

$$10^0 = 1 \quad \text{(mathematically, any number that has an exponent of 0 = 1)}$$

$$10^1 = 10$$

$$10^2 = 10 \times 10 = 100$$

$$10^3 = 10 \times 10 \times 10 = 1{,}000$$

$$10^4 = 10 \times 10 \times 10 \times 10 = 10{,}000$$

$$10^5 = 10 \times 10 \times 10 \times 10 \times 10 = 100{,}000$$

$$10^6 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 1{,}000{,}000$$

Thus far we have discussed positive exponents that result in numbers equal to or greater than 1. However, small numbers that are less than 1 can also be represented in exponential notation. In this case we use negative exponents. A negative exponent can be thought of as a fraction. For example:

$$10^{-1} = \frac{1}{10} = 0.1$$

$$10^{-2} = \frac{1}{10} \times \frac{1}{10} = 0.01$$

$$10^{-3} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = 0.001$$

$$10^{-4} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = 0.0001$$

$$10^{-5} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = 0.00001$$

$$10^{-6} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = 0.000001$$

Clinical pearl

In Chapter 1, we discussed JCAHO standards for medical abbreviations. This body also recommends that one never write a 0 by itself after a decimal point (write 1 mg, not 1.0 mg) and always use a 0 before a decimal point (0.1 mg). This helps prevent the decimal point from being missed.

Clinical pearl

In medicine we often use numbers that are extremely large (there are about 25,000,000,000 blood cells circulating in an adult's body) and extremely small (0.0000005 meter is the size of some microscopic organisms). It is often useful to write these numbers in a more convenient (or shorthand) form based on their powers of 10. This abbreviated form is known as **scientific notation**. *The rule is to move the decimal point to a place where you have one integer to the left of the decimal point and to note the appropriate power of 10 based on the number of spaces (powers of 10) moved. For example 25,000,000,000 becomes 2.5 x 10^{10} since you moved the decimal 10 spaces to the left. The number 0.0000005 becomes 5 x 10^{7}. Note that if the number is less than 1, the exponent is negative, and if greater than 1, the exponent is positive.*

2.2 SYSTEMS OF MEASUREMENT

2.2a United States Customary System

There are two major systems of measurement in use in the world today. The United States Customary System (USCS) is used in the United States and Myanmar (formerly Burma), and the Système International (SI) is used everywhere else—especially in health care (including in the United States). The SI system is also known as the International System of Units or metric system of measurement. The metric system is also the system used by drug manufacturers.

The USCS system is based on the British Imperial System and uses several different designations for the basic units of length, weight, and volume. We commonly call this the **English system of measurement**. For example in the English system, volumes can be expressed as ounces, pints, quarts, gallons, pecks, bushels, or cubic feet. Distance can be expressed in inches, feet, yards, and miles. Weights are measured in ounces, pounds, and tons. This may be the system you are most familiar with, but it is not the system of choice used throughout the world and in the medical profession. That is because the English system is very cumbersome to use because it has no common base. It is very difficult to know the relationships between these units because they are not based on powers of 10 in an orderly fashion, as in the metric system. For example how many gallons are in a peck? Just what the heck is a peck? How many inches are in a mile? These all require extensive calculations and the memorization of certain equivalent values, whereas with the metric system you simply move the decimal point by the appropriate power of 10.

Clinical pearl

The apothecary system, developed in the 1700s, included some measurements that are still used today. For example the pint, quart, and gallon are derived from this system. Apothecary measurements for calculating liquid doses of drugs include the minim and the fluid dram. Solids are measured in grams, scruples, drams, ounces, and pounds. Two unique features of the apothecary system are the use of Roman numerals and the placement of the unit of measure before the Roman numeral. However, the metric system is now used to calculate drug dosages because the apothecary system is less precise.

PATIENT & FAMILY EDUCATION

Health-care professionals need to be aware that families continue to use inaccurate devices, such as household spoons, for measuring liquid medications. They should encourage the use of more accurate devices such as the oral dosing syringe. Dosing errors should be considered when health-care professionals encounter patients who appear to be failing treatment or experiencing dose-related toxicity.

Learning Hint

Try to visualize the physical relationships between the metric and English systems. For example, a meter is a little more than a yard, a kilometer is about two-thirds of a mile, and a liter is a little more than a quart. This visual comparison becomes important if, for example, you are ordered to immediately withdraw an endotracheal tube 2 centimeters.

2.2b The Metric System

Most scientific and medical measurements use the metric system. The metric system employs three basic units of measure for length, volume, and mass; these are the **meter**, **liter**, and **gram**, respectively. In the sciences the term *mass* is commonly preferred (over *weight*), as mass refers to the actual amount of matter in an object, whereas weight is the force exerted on a body by gravity. In space or at zero gravity, objects have mass but are indeed weightless. However, because current health care is confined mostly to Earth, where there are gravitational forces, in this text we will use the term *weight*. Table 2-1 lists metric designations for the three basic units of measure, along with an approximate English system equivalent.

TABLE 2-1 Metric and English System Comparison

Type	Unit	English System Equivalent (approximate)
Length	meter	Slightly more than 1 yard
Volume	liter	Slightly more than 1 quart
Mass/weight	gram	About 1/30 of an ounce

Again notice that there are only three basic types of measure (meter, liter, and gram), and the metric system has only one base unit per measure. Because the metric system is a base-10 system, prefixes are used to indicate different powers of 10. Conversion within the metric system simply involves moving the decimal point the appropriate direction and power of 10 according to the prefix before the unit of measure. For example the prefix *kilo-* means 1,000 times, or 10^3. Therefore 1 kilogram is equal to 1,000 grams. See Table 2-2 for the common prefixes and their respective powers of 10.

TABLE 2-2 Common Prefixes of the Metric System

Thousands	Hundreds	Tens	Base Units			Tenths	Hundredths	Thousandths
kilo-	*hecto-*	*deca-*	*liter, meter, or gram*			*deci-*	*centi-*	*milli-*
(k)	(h)	(da)	(l)	(m)	(g)	(d)	(c)	(m)
10^3	10^2	10^1	10^0 or 1			10^{-1}	10^{-2}	10^{-3}

It can be seen from Table 2-2 that a kilometer is 1,000, or 10^3, meters. A centigram can be expressed as 0.01 gram, one-hundredth of a gram, or 10^{-2} gram. The ease of working with the metric system is that to change from one prefix to another, you simply move the decimal point to the correct place. In other words to convert within the system, simply move the decimal point for each power of 10 according to the desired prefix. For example to convert grams to kilograms, move the decimal point three places to the left. Therefore 1,000 grams equal 1 kilogram.

Learning Hint

The prefix deci- *can be associated with "decade," meaning 10 years;* centi- *can be associated with cents, there being 100 cents in a dollar; and* milli- *can be associated with a millipede, the bug with 1,000 legs. Biology note: Millipedes don't actually have 1,000 legs; it just seems like they do*

2.2c Example Calculation 1

In calculating drug dosages we often need to convert between grams and milligrams or between liters and milliliters. A common conversion might be something like "500 milliliters is equal to how many liters?" We know from Table 2-2 that 500 milliliters (ml) is equal to 0.5 liter (l) because we can simply move the decimal point three places (or powers of 10) to the left to find the equivalent value. Here we are starting with milliliters and going to the base unit of liters.

2.2d Example Calculation 2

How many grams are equal to 50 kilograms (kg)? Again, knowing the prefixes and powers of 10, we can move the decimal point three places (powers of 10) to the right to give the answer of 50,000 grams (g).

Refer to Table 2-3 for a more complete listing of prefixes that can be used in the metric system. This knowledge of the metric system will prove invaluable as you work in the medical profession—and even just if you travel outside of the United States. (That is, of course, unless you go to Myanmar.)

BVT Lab

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Learning Hint

You should know the common prefixes in Table 2-2 and the micro- prefix in Table 2-3 because they are used frequently in medicine. Always check your result to see if it makes sense. For example a common mistake is to move the decimal point in the wrong direction. If you did that in Example Calculation 1, you would have erroneously said that 500 milliliters is equal to 500,000 liters. If you think about this, you would know that 500 comparatively very small units (milliliters) cannot possibly equal 500,000 comparatively larger units (liters).

Table 2-3 **Metric System Prefixes and Abbreviation**

Prefix	Power of 10	Meaning	Abbreviation
giga-	10^9	one billion	G
mega-	10^6	one million	M
kilo-	10^3	one thousand	k
hecto-	10^2	one hundred	h
deca-	10^1	ten	da
deci-	10^{-1}	one-tenth	d
centi-	10^{-2}	one-hundreth	c
milli-	10^{-3}	one-thousandth	m
micro-	10^{-6}	one-millionth	mc
nano-	10^{-9}	one-billionth	n

Note: Remember that the base units of liters, meters, and grams are equal to 10^0 or 1. Because the handwritten symbol *μ* looks almost exactly like the letter *m* and is therefore a frequent cause of overdoses, the abbreviation *mc* is preferred in the medical field for micro.

Learning Hint

Yotta- *is the prefix that means 10^{24} power—that is, 1 with 24 zeros after it. That certainly is a "yotta" zeros. The mass of the earth is 5,983 yottagrams.*

time for review

An IV solution of 1,500 ml is equal to how many liters?

One final note before we go on: It has been determined that 1 cubic centimeter (cc) is approximately the same volume as 1 milliliter (ml). Therefore, 1 cc = 1 ml (see Figure 2-2). You may hear someone say there is a 500-cc IV solution on hand, while someone else may say there is a 500-ml solution; they are both saying the same thing. JCAHO standards recommend the use of ml or milliliters because cc can be mistaken for other abbreviations when it is written carelessly.

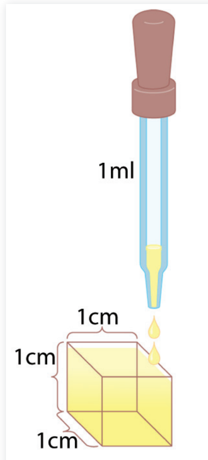
time for review

What are some of the advantages of the metric system?

2.2e Conversion of Units

You should now be able to work comfortably in the metric system; but what if you need to convert an English unit to a metric unit? For example in the introduction to this chapter we said that a certain drug's dosage schedule was 5 milligrams per kilogram of body weight. What is the relationship between pounds in the English system and kilograms in the metric system?

FIGURE 2-2 1 cc = 1 ml



The following is a method for changing units or converting between the English and metric systems. This method is sometimes referred to as the **factor-label method** or **fraction method.** This method allows your starting units to cancel or divide out until you reach your desired unit. There are two basic steps. First write down your starting value, with its unit, as a fraction with the number 1 as the denominator. Because the denominator is 1, the numerical value is the same as the starting value itself.

The second step involves placing the units you started with in the denominator of the next fraction to divide or cancel out, and placing the unit you want to convert to in the numerator, along with the corresponding equivalent values. The quantities in the numerator and denominator must be equivalent values in different units! Because the values are equivalent, this is the same as multiplying by 1, which does not change the value of the mathematical expression. This allows you to treat the units as in the multiplication of fractions and "cancel" them out. Notice that by carefully placing the units so that **cancelling units** is possible, the units can be converted.

2.2f Example Calculation 3

How many inches are there in 1 mile?

First put your starting value, with its unit, as a fraction with 1 in the denominator.

$$\frac{1 \text{ mile}}{1}$$

Next put miles in the denominator and the desired unit in the numerator with equivalent values. You know that 1 mile = 5,280 feet, so

$$\frac{1 \cancel{\text{mile}}}{1} = \frac{5{,}280 \text{ feet}}{1 \cancel{\text{mile}}}$$

You have cancelled out miles, but you need to get to inches. Just continue the process until you reach the desired unit.

BVT Lab

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$$\frac{1\ \cancel{\text{mile}}}{1} = \frac{5,280\ \cancel{\text{feet}}}{1\ \cancel{\text{mile}}} \times \frac{12\ \text{inches}}{1\ \cancel{\text{feet}}} = 63,360\ \text{inches}$$

2.2g Example Calculation 4

How many seconds are there in 8 hours?

$$\frac{8\ \cancel{\text{hours}}}{1} \times \frac{60\ \cancel{\text{minutes}}}{1\ \cancel{\text{hour}}} \times \frac{60\ \text{seconds}}{1\ \cancel{\text{minute}}} = 28{,}800\ \text{seconds}$$

2.2h Factor-Label Method to Convert Between Systems

You could try to memorize the hundreds of conversions between the English and metric systems, but that would be nearly impossible. All you really need to memorize is one conversion for each of the three units of measure. This will allow you to "bridge" between the systems. The conversions you need to know are:

1 in. = 2.54 cm	used for units of length
2.2 lb = 1 kg	used for units of mass or weight
1.06 qt = 1 liter	used for units of volume

2.2i Example Calculation 5

One foot is equal to how many centimeters? There is an equivalency somewhere for feet and centimeters, but you don't need to know it as long as you know the factor-label method and the conversion for distance.

To answer the question of how many centimeters are in 1 foot,

$$\frac{1\ \cancel{\text{foot}}}{1} \square \frac{12\ \cancel{\text{inches}}}{1\ \cancel{\text{foot}}} \square \frac{2.54\ \text{cm}}{1\ \cancel{\text{inch}}} = 30.48\ \text{cm}$$

2.2j Example Calculation 6

If an individual weighs 150 lb and the drug dosage order is 10 mg/kg, how much drug should he receive?

First, you must change pounds to kilograms; therefore write the given weight as a fraction with 1 in the denominator. Then place the unit you want to cancel (pounds) in the denominator and the unit you want to convert to (kilograms) in the numerator of the next fraction.

$$\frac{150\ \cancel{\text{pounds}}}{1} \times \frac{1\ \text{kilogram}}{2.2\ \cancel{\text{pounds}}} = 68.18\ \text{kilograms}$$

Because the dose reads 10 mg/kg, this patient should receive 10 × 68.18 mg or 681.8 mg of the drug. You then have to be practical, working with the dosage units available; so round the dose appropriately—that is, to 682 mg.

time for review

A quart of blood is equal to how many milliliters?

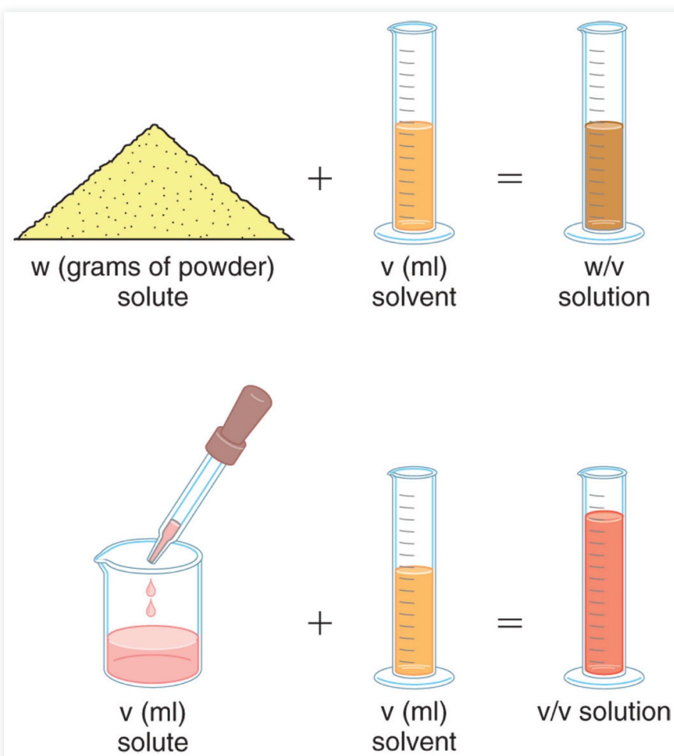
2.3 DRUG DOSAGE CALCULATIONS

2.3a Solutions

Many drugs are given in **solution** form. A solution is a chemical and physical homogeneous mixture of two or more substances. Solutions contain a **solute** and a **solvent.** A solute is either a liquid or a solid that is dissolved in a liquid to form a solution. The solvent is the liquid that dissolves the solute. For example you can make the solution hot coffee by dissolving granules of instant coffee (solute) in hot water (solvent).

Drug solutions can be made by dissolving either a liquid or a solid solute, which represents the active drug, in a solvent such as sterile water or saline solution to form a solution that is delivered to the patient through various routes of administration. If the solute being dissolved is a solid, such as a powder, the resulting solution is termed a **weight/volume** (w/v) **solution**, where the *w* represents weight or amount of solute and the *v* represents the total amount of solution. One can also have a **volume/volume** (v/v) **solution**, in which the first *v* represents the volume of the liquid solute and the second *v* represents the volume of the solution (see Figure 2-3). A delicious nondrug example of this is mixing liquid chocolate syrup (solute) in hot milk (solvent) to form the solution hot chocolate. (Don't ask about the marshmallows.)

FIGURE 2-3 w/v and v/v Solutions



Learning Hint

The SOLVEnt is the one that disSOLVEs the solute.

2.3b Percentage Solutions

One way the potency of a drug can be described is by stating its **percentage of solution**, which is the strength of the solution expressed as parts of the solute (drug) per 100 ml of solution. After all that is what a percent is—some number related to 100. Remember that the solute can be either a solid or a liquid. If the solute is dissolved in a solid form, it will be expressed in grams per 100 ml of solution (w/v solution). If the solute is liquid, it will be expressed in milliliters (v/v solution).

For example a 20% saltwater or saline solution contains 20 g of salt (solid solute) dissolved in enough water (solvent) to create 100 ml of solution. We can use this information, coupled with proportions, to begin to solve drug dosage problems. The majority of drug dosage calculations can be solved by setting up simple proportions. A **proportion** is a statement that compares two conditions.

In general, the proportion

$$\frac{a}{b} = \frac{c}{d}$$

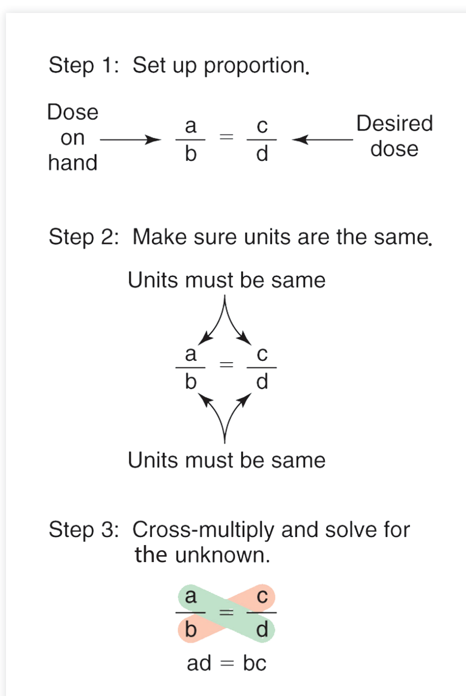
is equivalent to the equation $ad = bc$. Sometimes it is said that the product of the means (b and c) equals the product of the extremes (a and d). This is also known as *cross-multiplying,* so

$$\text{if } \frac{a}{b} = \frac{c}{d}, \text{ then } ad = bc$$

2.3c Setting Up Proportions

Armed with your previous knowledge from this chapter, you can solve drug dosage calculations with proportions in two basic steps. First set up a proportion of the *dose on hand* related to the *desired dose*. Second make sure all units are equal, then cross-multiply and solve the equation. See Figure 2-4, which illustrates these steps.

FIGURE 2-4 Steps to Solve Drug Dosage Calculations



Several calculation examples follow. Notice that, although they all contain different information, they can all be solved using the same three-step process.

2.3d Example Calculation 7

How much salt is needed to make 1,000 ml of a 20% solution?

First, put down what you know, or your dose on hand:

$$20\% \text{ solution} = \frac{20 \text{ g of salt}}{100 \text{ ml of solution}}$$

Now place this into a proportion and relate it to your desired dose.

$$\begin{array}{ccc} \text{Dose on hand} & : & \text{Desired dose} \\ \dfrac{20 \text{ g of salt}}{100 \text{ ml of solution}} & = & \dfrac{x \text{ g of salt}}{1{,}000 \text{ ml of solution}} \end{array}$$

The x g of salt represents how much salt is needed. The left side of the equation is what is known, or the dose on hand, and the right side is the unknown amount of the solute (in this case, salt) needed to make the final solution.

Solving by cross-multiplying,

$$\frac{20 \text{ g of salt}}{100 \text{ ml of solution}} = \frac{x \text{ g of salt}}{1{,}000 \text{ ml of solution}}$$

$$20 \times 1{,}000 = 100x$$

$$20{,}000 = 100x$$

Divide both sides of the equation by the amount in front of x to find out what x is by itself:

$$\frac{20{,}000}{100} = \frac{\cancel{100}x}{\cancel{100}}$$

$$200 = x$$

$$x = 200$$

So to make 1,000 ml of a 20% salt solution, you can take 200 g of salt and add enough water to fill a container to the 1,000-ml mark.

In this example 1,000 ml could have been given as the equivalent 1 liter. When that is the case, before cross-multiplying, you must make sure that all your units in the numerator and denominator are the same.

Learning Hint

After setting up the proportion, always ask yourself the catchy phrase, "Are my units congruent (equal or the same)?" This habit will help to ensure proper results.

2.3e Example Calculation 8

The bronchodilator drug albuterol is ordered to be given as 5 mg per aerosol dose. You have a 0.5% solution on hand. How many milliliters of drug solution should you deliver?

$$\text{What is known: } \frac{0.5 \text{ g of albuterol}}{100 \text{ ml of solution}}$$

$$\text{Proportion set up to what is needed: } \frac{0.5 \text{ g of albuterol}}{100 \text{ ml of solution}} = \frac{5 \text{ mg of albuterol}}{x \text{ ml of solution}}$$

Before solving, convert the 0.5 g to 500 mg so the units are the same as the units in the denominator.

Clinical pearl

Normally the drug albuterol is mixed with a diluent such as saline solution or sterile water to allow it to be nebulized over a longer period of time. This diluent does not decrease the amount of drug or weaken the amount of drug given to the patient. In this example, there are 5 mg of the active drug albuterol in the solution, regardless of whether 3 ml or 5 ml of diluent are added. Only the nebulization or delivery time is increased. We will have more to say about this in Chapter 4, where we will discuss aerosol delivery devices.

$$\frac{500 \text{ mg of albuterol}}{100 \text{ ml of solution}} = \frac{5 \text{ mg of albuterol}}{x \text{ ml of solution}}$$

$$500x = 500$$

$$x = 1$$

Therefore you need to draw up and deliver 1 ml of the drug solution to the patient.

2.3f Example Calculation 9

Clinical pearl

For some drugs, manufacturers have developed special systems for measuring doses. For example many types of insulin are available, but they are all measured in units.

Even if a drug such as heparin, insulin, or penicillin is given in units or international units, rather than grams or milligrams, you can solve the problem exactly the same way. If a solution of penicillin has 2,000 units/ml, how many milliliters would you give to deliver 250 units of the drug?

Dose on hand : Desired dose

$$\frac{2{,}000 \text{ U of penicillin}}{1 \text{ ml}} = \frac{250 \text{ U of penicillin}}{x \text{ ml}}$$

$$2{,}000x = 250$$

$$x = 0.125 \text{ ml}$$

Therefore 0.125 ml of the 2,000-unit solution can be given to deliver 250 units of penicillin to the patient.

time for review

You have a 10% drug solution on hand, and the order states to deliver 100 mg of drug. How many milliliters would you deliver?

CONTROVERSY

It has been shown that many medication errors occur each year. Controversy exists over how many mistakes go unreported or unnoticed and what factors lead to these errors. What if you make a medication delivery or calculation error? What steps should you take? Whom should you notify? How can medication errors be prevented?

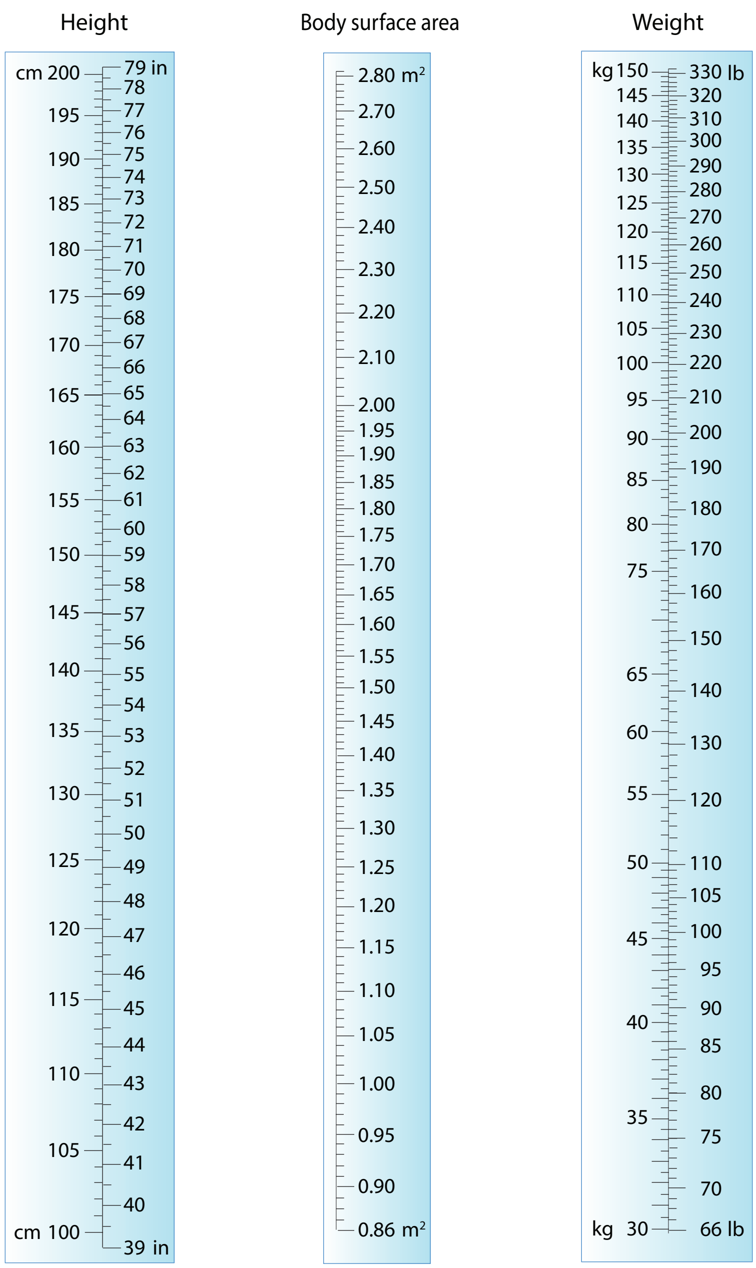
2.3g Ratio Solutions

Another possible means of expressing the strength of solution is by using a ratio instead of a percentage. A **ratio solution** represents the parts of the solute related to the parts of the solution. For example epinephrine is used in the treatment of anaphylactic shock and is usually administered IV in a 1:10,000 ratio. However, another route that can be used is the IM route; here a more concentrated 1:1,000 ratio solution is used since it is a lower volume to inject intramuscularly. A 1:1,000 solution of epinephrine contains 1 g of epinephrine in 1,000 ml (or, more practically, 1 mg of epinephrine in 1 ml) of solution. Confusing which ratio goes with which route can have serious consequences.

2.3h Drug Orders in Drops

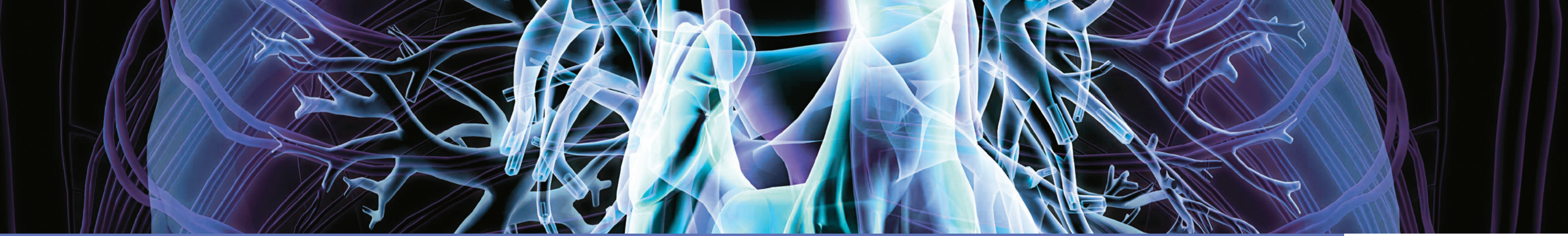
Some orders for respiratory solutions to be nebulized used to come in the form of number of drops to be mixed with normal saline or distilled water. Now drops are ordered primarily for eye or ear medications; therefore a brief discussion is still warranted. The Latin word for drops is *guttae,* which is abbreviated gtt. It is helpful to know the following: gtt = drops, and it was previously accepted that 16 gtt = 1 ml = 1 cc. However, it should be noted that not all droppers are standardized, and this equivalency may change according to the properties of the liquid and the orifice size of the dropper.

FIGURE 2-5 Nomogram for Determining Body Surface Area



Clinical pearl

A 6-foot-tall man who weighs 240 lbs may require a different dosage than a 6-foot-tall man who weighs 150 lb. This is especially true with highly toxic agents such as those used in cancer chemotherapy. A method to determine the total body surface area (BSA) combines both height and weight in a single measurement to determine the true overall body size. Comparisons like this are called nomograms. *See Figure 2-5 for a nomogram used in determining BSA. Simply mark the patient's height and weight on the respective scales, then either draw a straight line or use a ruler to find the intersection point, which gives the BSA.*



Summary

This chapter includes vital information that is necessary to understand the metric system and to calculate drug dosages accurately. You should feel comfortable making conversions between different systems of measurement and working within the metric system. Dosage measurements and calculations are a major responsibility because giving the wrong dose can be very dangerous to the patient.

REVIEW QUESTIONS

1. The metric system is based on exponential powers of
   (a) 100
   (b) 10
   (c) 2
   (d) 15
2. Which of the following is not a basic unit of measure in the metric system?
   (a) liter
   (b) gram
   (c) pound
   (d) meter
3. A cubic centimeter (cc) is equal to
   (a) 1 ml
   (b) 1 l
   (c) 1 mg
   (d) 10 kg
4. The body surface nomogram compares what two units of measure?
   (a) weight and sex
   (b) height and sex
   (c) surface area and length
   (d) height and weight
5. Which type of drug solution represents a powdered drug mixed in solution?
   (a) v/v
   (b) w/v
   (c) w/w
   (d) v/w
6. If a patient voids 3.2 l of urine in a day, what is the amount in milliliters?

7. Convert 175 lb to kilograms.
8. How many kilograms would a 3-lb baby weigh?
9. An order reads to deliver 200 mg/kg of poractant alfa, a natural surfactant, to a premature infant in the intensive care nursery. The infant weighs 500 g. You have a solution containing 80 mg of phospholipids per milliliter. How many milliliters will you administer to your patient?
10. If you give 6 ml of a 0.1% strength solution, how many milligrams are in the dose?
11. 500 cc of a solution is equal to how many liters?
12. Four milligrams of methylprednisolone is equivalent to 20 mg of hydrocortisone. Your patient is on 40 mg of hydrocortisone daily and the doctor wants to switch to methylprednisolone. What is the equipotent methylprednisolone dose?
13. If beclomethasone, an inhaled corticosteroid, is available in a device that delivers 42 mcg/puff, how many puffs per day will the patient need to get a dose of 336 mcg?
14. A patient is not controlled on 300 mg twice daily of theophylline sustained release. The doctor wants him to take 1,200 mg daily. How many 300-mg tablets should the patient take per day?