Learning Outcomes

After completing this chapter, you will be able to

1. Describe intravenous medication administration.
2. Calculate the rate of flow of intravenous piggyback medications.
3. Calculate the flow rate of intravenous solutions based on the amount of drug per minute or per hour.
4. Determine the amount of drug a patient will receive IV per minute or per hour.
6. Calculate IVPB flow rates based on body surface area.
7. Calculate the infusion time of an IVPB solution.
8. Calculate the rate of flow for a medication requiring titration.

This chapter extends the discussion of intravenous infusions to include administration of intravenous medications. You will also learn how to calculate the flow rates for IVs based on body weight or BSA.
Intravenous Administration of Medications

Intravenous administration of medications provides rapid access to a patient’s circulatory system, thereby presenting potential hazards. Errors in medication, dose, or dosage strength can prove fatal. Therefore, caution must be taken in the calculation, preparation, and administration of IV medications.

Typically, a primary IV line provides continuous fluid to the patient. Secondary lines can be attached to the primary line at injection ports, and these lines are often used to deliver continuous or intermittent medication intravenously. A secondary line is referred to as a piggyback or intravenous piggyback (IVPB). With intermittent IVPB infusions, the bags hold generally 50–250 mL of fluid containing dissolved medication and usually require 20–60 minutes to infuse. Like a primary line, an IVPB infusion may use a manually controlled gravity system or an electronic pump.

A heplock, or saline lock, is an infusion port attached to an indwelling needle or cannula in a peripheral vein. Intermittent IV infusions can be administered through these ports via IV lines connected to these ports. An IV push, or bolus (IVP), is a direct injection of medication either into the heplock/saline lock or directly into the vein.

Syringe pumps can also be used for intermittent infusions. A syringe with the medication is inserted into the pump. The medication is delivered at a set rate over a short period of time.

A volume-control set is a small container, called a burette, that is connected to the IV line. Burettes are often used in pediatric or geriatric care, where accurate volume control is critical. The danger of overdose is limited because of the small volume of solution in the burette. Burettes will be discussed in Chapter 12.

Intravenous Piggyback Infusions

Patients can receive a medication through a port in an existing IV line. This is called intravenous piggyback (IVPB); Figure 11.1. The medication is in a secondary bag. Notice in Figure 11.1 that the secondary bag is higher than the primary bag so that the pressure in the secondary line will be greater than the pressure in the primary line. Therefore, the secondary medication infuses first. Once the secondary infusion is completed, the primary line begins to flow. Be sure to keep both lines open. If you close the primary line, when the secondary IVPB is completed the primary line will not flow into the vein.

A typical IVPB order might read: cimetidine 300 mg IVPB q6h in 50 mL NS infuse over 30 min. This is an order for an IV piggyback infusion in which 300 mg of the drug cimetidine diluted in 50 mL of a normal saline solution must infuse in 30 minutes. So, the patient receives 300 mg of cimetidine in 30 minutes via a secondary line, and this dose is repeated every 6 hours.
Chapter 11  Calculating Flow Rates for Intravenous Medications

Example 11.1

The prescriber ordered: Ancef 1 g IVPB q4h

The package insert information is as follows: Add 50 mL sterile water to the bag of Ancef 1 g and infuse in 30 min. The tubing is labeled 20 drops per milliliter. Calculate the flow rate in drops per minute for this antibiotic.

The patient receives 50 mL in 30 minutes. You want to change this flow rate from mL per minute to an equivalent flow rate in drops per minute.

\[
\frac{50 \text{ mL}}{30 \text{ min}} \rightarrow \frac{\text{gtt}}{\text{min}}
\]

Using the drop factor of 20 gtt/mL, you can do this on one line as follows:

\[
\frac{50 \text{ mL}}{30 \text{ min}} \times \frac{20 \text{ gtt}}{1 \text{ mL}} = \frac{100 \text{ gtt}}{3 \text{ min}} = 33.3 \text{ gtt/min}
\]

So, the flow rate is 33 drops per minute.
Example 11.2

The order is Mefoxin 1 g IVPB q6h in 50 mL over 30 minutes. Read the label for the premixed Mefoxin in Figure 11.3 and find the drip rate if the drop factor is 10 gtt/mL. The package insert indicates that the Mefoxin should be infused in 30 minutes.

The label states: 1 g in 50 mL. This entire solution must be infused in 30 minutes.

You want to change the flow rate from 50 mL per 30 minutes to an equivalent flow rate in drops per minute.

\[
\frac{50 \text{ mL}}{30 \text{ min}} \rightarrow \text{? gtt min}^{-1}
\]
Using the drop factor of 10 gtt/mL, you can do this on one line as follows:

\[
\frac{50 \text{ mL}}{30 \text{ min}} \times \frac{10 \text{ gtt}}{\text{mL}} = \frac{50 \text{ gtt}}{3 \text{ min}} = 16.67 \text{ gtt/min}
\]

So, the flow rate is 17 drops per minute.

**Example 11.3**

The medication order reads: 1,000 mL 5% D/W with 1,000 mg of a drug at 1 mg/min. Calculate the flow rate in drops per minute if the drop factor is 15 drops per milliliter.

In this example, the prescriber has specified the amount of solution and its strength (1,000 mL of 5% D/W containing 1,000 mg of the drug) and also the rate at which the patient receives the drug (1 mg/min). This “flow rate” is not the usual volume per time (mL/h or gtt/min), but it is in terms of weight of drug per time (mg/min).

Given flow rate: 1 mg/min (notice that a flow rate always has “time” in the denominator)

Known equivalences: 1,000 mg/1,000 mL (strength)
15 gtt/mL (drop factor)

Flow rate you want to find: ? gtt/min

You want to convert the flow rate from milligrams per minute to an equivalent flow rate in drops per minute.

\[
\frac{1 \text{ mg}}{\text{min}} \rightarrow \frac{? \text{ gtt}}{\text{min}}
\]

You want to cancel mg. To do this you must use a unit fraction containing mg in the denominator. Using the strength, this fraction will be

\[
\frac{1 \text{ mg}}{\text{min}} \times \frac{1,000 \text{ mL}}{1,000 \text{ mg}} = ? \text{ gtt/min}
\]

Now, on the left side mL is in the numerator, and it must be cancelled. This will require a unit fraction with mL in the denominator. Using the drop factor, this fraction will be

\[
\frac{15 \text{ gtt}}{\text{mL}}
\]

Now cancel and multiply the numbers

\[
\frac{1 \text{ mg}}{\text{min}} \times \frac{1,000 \text{ mL}}{1,000 \text{ mg}} \times \frac{15 \text{ gtt}}{1 \text{ mL}} = 15 \text{ gtt/min}
\]

So, you would administer 15 gtt/min.
**Example 11.4**

The prescriber writes an order for 1,000 mL of 5% D/W with 10 units of a drug. Your patient must receive 30 mU of this drug per minute. Calculate the flow rate in microdrops per minute.

Given flow rate: 30 mU/min (notice that a flow rate always has “time” in the denominator)

Known equivalences: 
- 10 units/1,000 mU (strength)
- 60 gtt/mL (standard microdrop drop factor)
- 1 unit = 1,000 mU

Flow rate you want to find: ? mcgtt/min

You want to change the flow rate from milliunits per minute to microdrops per minute.

\[
\frac{30 \text{ mU}}{\text{min}} = ? \frac{\text{mcgtt}}{\text{min}}
\]

You want to cancel mU. To do this you must use a unit fraction containing mU in the denominator. Using the equivalence 1 mU = 1,000 units, this fraction will be \(\frac{1 \text{ unit}}{1,000 \text{ mU}}\).

\[
\frac{30 \text{ mU}}{\text{min}} \times \frac{1 \text{ unit}}{1,000 \text{ mU}} = ? \frac{\text{mcgtt}}{\text{min}}
\]

Now, on the left side unit is in the numerator, and it must be cancelled. This will require a unit fraction with unit in the denominator. Using the strength, this fraction will be \(\frac{1,000 \text{ mL}}{10 \text{ units}}\).

\[
\frac{30 \text{ mU}}{\text{min}} \times \frac{1 \text{ unit}}{1,000 \text{ mU}} \times \frac{1,000 \text{ mL}}{10 \text{ units}} = ? \frac{\text{mcgtt}}{\text{min}}
\]

Now, on the left side mL is in the numerator, and it must be cancelled. This will require a unit fraction with mL in the denominator. Using the drop factor, this fraction will be \(\frac{60 \text{ mcgtt}}{\text{mL}}\).

Now, cancel and multiply the numbers

\[
\frac{30 \text{ mU}}{\text{min}} \times \frac{1 \text{ unit}}{1,000 \text{ mU}} \times \frac{1,000 \text{ mL}}{10 \text{ units}} \times \frac{60 \text{ mcgtt}}{\text{mL}} = 180 \frac{\text{mcgtt}}{\text{min}}
\]

So, you will administer 180 mcgtt/min.

**Example 11.5**

Calculate the flow rate in milliliters per hour if the medication order reads: Add 10,000 units of heparin to 1,000 mL 5% D/W IV. Your patient is to receive 1,250 units of this anticoagulant per hour via an infusion pump.

You want to change the flow rate from units per hour to milliliters per hour.

\[
\frac{1,250 \text{ units}}{1 \text{ h}} \rightarrow ? \frac{\text{mL}}{\text{h}}
\]
Using the strength of the solution (10,000 units/1,000 mL) you do this on one line as follows:

\[
\frac{1,250 \text{ units}}{1 \text{ h}} \times \frac{1,000 \text{ mL}}{10,000 \text{ units}} = \frac{1,250 \text{ mL}}{10 \text{ h}} = 125 \frac{\text{mL}}{\text{h}}
\]

So, your patient will receive 125 mL per hour.

In Examples 11.6, 11.7, and 11.8, you are given the flow rate in milliliters per hour, and you need to determine the amount of medication the patient will receive in a given amount of time.

**Example 11.6**

Calculate the number of units of Regular insulin a patient is receiving per hour if the order is 500 mL NS with 300 units of Regular insulin and it is infusing at the rate of 12.5 mL per hour via the pump.

You want to convert the flow rate from mL per hour to units per hour.

\[
\frac{12.5 \text{ mL}}{\text{h}} \rightarrow \frac{\text{units}}{\text{h}}
\]

Using the strength of the solution (300 units/500 mL) you do this in one line as follows:

\[
\frac{12.5 \text{ mL}}{\text{h}} \times \frac{300 \text{ units}}{500 \text{ mL}} = \frac{37.5 \text{ units}}{5 \text{ h}} = 7.5 \frac{\text{units}}{\text{h}}
\]

So, the patient is receiving 7.5 units per hour.

**Example 11.7**

Order: heparin 40,000 units continuous IV in 1,000 mL of D5W infuse at 30 mL/h. Find the flow rate in units/day and determine if it is in the safe dose range—the normal heparinizing range is between 20,000 to 40,000 units per day.

You want to convert the flow rate from milliliters per hour to units per day.

\[
\frac{30 \text{ mL}}{\text{h}} \rightarrow \frac{\text{units}}{\text{day}}
\]

Using the strength of the solution (40,000 units/1,000 mL) and that there are 24 hours in a day, you do this on one line as follows:

\[
\frac{30 \text{ mL}}{\text{h}} \times \frac{40,000 \text{ units}}{1,000 \text{ mL}} \times \frac{24 \text{ h}}{\text{day}} = \frac{28,800 \text{ units}}{\text{day}}
\]

So, your patient is receiving 28,800 units of heparin per day. This rate is within the safe dosage range of 20,000 to 40,000 units per day.

**Example 11.8**

Your patient is receiving an IV of 1,000 mL of NS with 1,000 mg of the bronchodilator aminophylline. The flow rate is 50 mL/h. How many milligrams per hour is your patient receiving?
You want to convert the flow rate from milliliters per hour to milligrams per hour.

\[
\frac{50 \text{ mL}}{1 \text{ h}} \rightarrow ? \frac{\text{mg}}{\text{h}}
\]

Using the strength of the solution (1,000 mg/1,000 mL) you do this on one line as follows:

\[
\frac{50 \text{ mL}}{1 \text{ h}} \times \frac{1,000 \text{ mg}}{1,000 \text{ mL}} = \frac{50 \text{ mg}}{\text{h}}
\]

So, your patient is receiving 50 mL of aminophylline per hour.

---

**Calculating Flow Rates Based on Body Weight**

In Chapter 6 you calculated dosages based on *body weight alone*. Suppose a patient weighing 100 kg is to receive a drug at the rate of **2 micrograms per kilogram** (2 mcg/kg). You could convert the single unit of measurement (kg) into the single unit of measurement (mcg), and the patient would receive 200 mcg of the drug as the following computation shows:

\[
100 \text{ kg} \times \frac{2 \text{ mcg}}{\text{kg}} = 200 \text{ mcg}
\]

In this chapter you will see that some IV medications are not only prescribed based on the patient's body weight, but the amount of drug the patient receives also depends on time. For example, an order might indicate that a drug is to be administered at the rate of **2 micrograms per kilogram per minute** (2 mcg/kg/min). This means that *each minute* the patient is to receive 2 mcg of the drug for every kilogram of body weight. Therefore, the amount of medication the patient receives is based on *both body weight and time*.

For computational purposes this new type of rate (compound rate) is written as

\[
\frac{2 \text{ mcg}}{\text{kg} \times \text{min}}
\]

Suppose that a patient weighing 100 kg is receiving a drug at the rate of 2 mcg/kg/min. If you multiply the weight of this patient (a single unit of measurement) by the compound rate, you obtain a rate which depends only on time as follows:

\[
100 \text{ kg} \times \frac{2 \text{ mcg}}{\text{kg} \times \text{min}} = \frac{200 \text{ mcg}}{\text{min}}
\]

So, the patient is receiving the drug at the rate of 200 mcg/min.

---

**Example 11.9**

The prescriber ordered: **250 mL 5% D/W with 60 mg Aredia 0.006 mg/kg/min IVPB**. The patient weighs 75 kg, and the drop factor is 20 gtt/mL. Calculate the flow rate for this antihypercalcemic drug in drops per minute.

**Given:**
- 75 kg (weight of the patient)

**Known equivalences:**
- 0.006 mg/kg/min (order)
- 60 mg/mL (strength)
- 20 gtt/mL (drop factor)

**Find:**
- ? gtt/min (flow rate)
Chapter 11  Calculating Flow Rates for Intravenous Medications

As shown, multiplying the weight of the patient by the order will yield a rate based on time. This rate can then be converted to the desired flow rate (drops per minute). So you want to start with the weight of the patient (kilograms) and convert to drops per minute.

\[ 75 \text{ kg} = \text{gtt/min} \]

You want to cancel kg. To do this you must use a fraction containing kg in the denominator. Using the order, this fraction will be \( \frac{0.006 \text{ mg}}{\text{kg} \times \text{min}} \).

\[ 75 \text{ kg} \times \frac{0.006 \text{ mg}}{\text{kg} \times \text{min}} = ? \text{ gtt/min} \]

Now, on the left side mg is in the numerator, but you don’t want mg. You need a fraction with mg in the denominator. Using the strength of the solution, the fraction is \( \frac{250 \text{ mL}}{60 \text{ mg}} \).

\[ 75 \text{ kg} \times \frac{0.006 \text{ mg}}{\text{kg} \times \text{min}} \times \frac{250 \text{ mL}}{60 \text{ mg}} = ? \text{ gtt/min} \]

Now, on the left side mL is in the numerator, but you don’t want mL. To cancel the mL you need a fraction with mL in the denominator. Using the drop factor, the fraction is \( \frac{20 \text{ gtt}}{\text{mL}} \).

Now cancel and multiply the numbers.

\[ 75 \text{ kg} \times \frac{0.006 \text{ mg}}{\text{kg} \times \text{min}} \times \frac{250 \text{ mL}}{60 \text{ mg}} \times \frac{20 \text{ gtt}}{\text{mL}} = 37.5 \text{ gtt/min} \]

So, the flow rate is 38 gtt/min.

**Titrating Medications**

Sometimes medications must be titrated. That is, the dose of the medication must be adjusted until the desired therapeutic effect (e.g., blood pressure maintenance) is achieved. The following example includes a drug that is titrated.

**Example 11.10**

Order: Intropin (dopamine) 2 mcg/kg/min IVPB, titrate to maintain SBP above 90, increase by 5 mcg/kg/min q 10–30 minutes. Maximum dose 20 mcg/kg/min. Monitor BP and HR q 2–5 minutes during titration. The label on the 500 mL medication bag states 800 mcg/mL, and the patient weighs 175 pounds.

(a) How many mcg/min of Intropin should the patient receive initially?

(b) Calculate the initial pump setting in mL/h.
Calculating Flow Rates Based on Body Surface Area

As you know, certain medications are ordered based on body surface area (BSA). Chapter 6 discussed how to determine BSA. The following examples show how to calculate flow rates for this type of medication order.

**Example 11.11**

The order is 100 mg/m² IVPB in 50 mL NS. The patient has BSA of 1.55 m². The package insert indicates that the infusion should be given in 30 minutes. The label on the vial indicates that the strength of the reconstituted drug is 38 mg/mL.

(a) How many mg of the drug would the patient receive?  
(b) How many mL of the drug would you need to take from the vial?  
(c) What is the total volume (in mL) to be infused?  
(d) What is the flow rate in mL/h?  
(e) If the drop factor is 10 gtt/mL, what is the rate of flow in gtt/min?

(a) You want to change the size of the patient (in m²) to the number of milligrams of the drug.

\[
1.55 \text{ m}^2 \longrightarrow \frac{? \text{ mg}}{} \\
1.55 \text{ m}^2 \times \frac{100 \text{ mg}}{\text{m}^2} = 155 \text{ mg}
\]

(b) You want to convert the weight of the patient (175 pounds) to micrograms of Intropin per minute.

\[
175 \text{ lb} \longrightarrow \frac{? \text{ mcg}}{\text{min}} \\
175 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} \times \frac{2 \text{ mcg}}{1 \text{ kg} \times \text{ min}} = 159 \text{ mcg/min}
\]

So, initially the patient will receive 159 mcg/min.

(b) Now, convert 159 mcg/min to mL/h.

Using the strength of the solution (800 mcg/mL) and 1 h = 60 min you can do this on one line as follows:

\[
\frac{159 \text{ mcg}}{\text{min}} \times \frac{1 \text{ mL}}{800 \text{ mcg}} \times \frac{60 \text{ min}}{1 \text{ h}} = 11.96 \text{ mL/h}
\]

So, the pump would initially be set at 12 mL/h.
So, the patient would receive 155 mg of the drug.

(b) You want to convert the amount of drug (in mg) to the volume of drug (in mL).

\[
155 \text{ mg} \rightarrow \text{ mL}
\]

The label indicates that the strength of the reconstituted drug is 38 mg/mL.

\[
155 \frac{\text{mg}}{\text{mg}} \times \frac{1 \text{ mL}}{38 \text{ mg}} = 4.1 \text{ mL}
\]

Since your patient should receive 4.1 mL of the drug, 4.1 mL should be withdrawn from the vial.

(c) Since the 4.1 mL of the drug must be added to the 50 mL bag, the total volume to be infused will be \((50 + 4.1) 54.1 \text{ mL}\).

(d) Since the entire volume must infuse in 30 minutes \((\frac{1}{2} \text{ hour})\), the flow rate, in milliliters per hour, is \(\frac{54.1 \text{ mL}}{\frac{1}{2} \text{ h}} = 108.2 \text{ mL/h}\).

(e) Since the drop factor is 10 gtt = 1 mL, the flow rate found in part (d) can be converted to gtt/min as follows:

\[
\frac{108.2 \text{ mL}}{\text{h}} \times \frac{10 \text{ gtt}}{1 \text{ mL}} \times \frac{1 \text{ h}}{60 \text{ min}} = 18.03 \text{ gtt/min}
\]

So, the flow rate, in drops per minute, is 18 gtt/min.

**Example 11.12**

Order: *Camptosar 125 mg/m² IVPB in 250 mL of NS over 90 minutes once weekly for 4 weeks*. The patient has a BSA of 1.67 m². Read the label for this antineoplastic drug in Figure 11.4 and determine the pump setting in milliliters per hour.

First change the size of the patient (BSA) to the number of milliliters needed to be taken from the Camptosar vial.

\[
1.67 \text{ m²} \rightarrow \text{ mL}
\]

From the order, you need to use 125 mg/m²; and from the label, the concentration of the Camptosar is 100 mg/5 mL.

\[
1.67 \text{ m²} \times \frac{125 \text{ mg}}{\text{m²}} \times \frac{5 \text{ mL}}{100 \text{ mg}} = 10.4 \text{ mL}
\]

So, 10.4 mL is taken from the Camptosar vial and is added to the 250 mL bag. This means that the total volume of the infusion is \((250 + 10.4) 260.4 \text{ mL}\), and the patient would receive 260.4 mL of Camptosar in 90 minutes.
Now, change the flow rate of \( \frac{260.4 \text{ mL}}{90 \text{ min}} \) to mL/h.

\[
\frac{260.4 \text{ mL}}{90 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ h}} = 173.6 \text{ mL/h}
\]

So, the pump is set at 174 mL/h.

**Example 11.13**

Order: Infuse 50 mL IVPB in \( \frac{1}{2} \) hour. After 20 minutes, it is discovered that 30 mL still remain to be infused. Recalculate the rate of flow in gtt/min if the drop factor of the administration set is 20 gtt/mL.

Since the remaining volume (30 mL) must infuse in the remaining time (10 minutes), the flow rate is 30 mL/10 minutes.

You want to change 30 mL/10 minutes to gtt/minute. Since the drop factor is 20 gtt/mL:

\[
\frac{30 \text{ mL}}{10 \text{ min}} \times \frac{20 \text{ gtt}}{1 \text{ mL}} = 60 \text{ gtt/min}
\]

So, the flow rate is 60 gtt/min.

**Example 11.14**

The prescriber ordered Vancomycin 1.5 g in 200 mL of D₅W. Infuse in 60 minutes, the label reads: 1.5 g of Vancomycin. The vial available is used with a reconstitution device similar to that shown in Figure 11.5. The tubing is labeled 15 drops per milliliter. Calculate the flow rate in drops per minute.

You want to change the flow rate from milliliters per minute to gtt/min.

\[
\frac{200 \text{ mL}}{60 \text{ min}} \rightarrow ? \text{ drops/min}
\]

Do this in one line as follows:

\[
\frac{200 \text{ mL}}{60 \text{ min}} \times \frac{15 \text{ gtt}}{1 \text{ mL}} = 50 \text{ gtt/min}
\]

So, the flow rate is 50 gtt/min.

There are reconstitution systems that enable the health care provider to reconstitute a powdered drug and place it into an IVPB bag without using a syringe. One such device is shown in Figure 11.5. With this device, when the IVPB bag is squeezed, fluid is forced into the vial, dissolving the powder. The system is then
placed in a vertical configuration with the vial on top and the IVPB bag on the bottom. The IVPB bag is then squeezed and released, thereby creating a negative pressure, which allows the newly reconstituted drug to flow into the IVPB bag.

Another reconstitution device is the ADD-Vantage system, which employs an IV bag containing intravenous fluid. The bag is designed with a special port, which will accept a vial of medication. When the vial is placed into the bag port, the contents of the vial and the fluid mix to form the desired solution.

Example 11.15

A patient who weighs 55 kg is receiving a medication at the rate of 30 mL/h. The concentration of the medication is 400 mg in 500 mL of D5W. The recommended dose range for the drug is 2–5 mcg/kg/min. Is the patient receiving a safe dose?

**Method 1** Convert the safe dose range of 2–5 mcg/kg/min to mL (of the drug)/hour.

First, use the minimum recommended dose (2 mcg/kg/h) and start with the weight of the patient to determine how many mL/h the patient should minimally receive as follows:

\[
55 \text{ kg} \times \frac{2 \text{ mcg}}{\text{kg} \times \text{min}} \times \frac{60 \text{ min}}{\text{h}} \times \frac{1 \text{ mg}}{1,000 \text{ mcg}} \times \frac{500 \text{ mL}}{400 \text{ mg}} = 8.3 \frac{\text{mL}}{\text{h}} \quad \text{Min}
\]

Now, use the maximum recommended dose (5 mcg/kg/h) and start with the weight of the patient to determine how many mL/h the patient should maximally receive as follows:

\[
55 \text{ kg} \times \frac{5 \text{ mcg}}{\text{kg} \times \text{min}} \times \frac{60 \text{ min}}{\text{h}} \times \frac{1 \text{ mg}}{1,000 \text{ mcg}} \times \frac{500 \text{ mL}}{400 \text{ mg}} = 20.6 \frac{\text{mL}}{\text{h}} \quad \text{Max}
\]

So, the safe dose range for this patient is 8.3–20.6 mL/h. Since the patient is receiving 30 mL/h, the patient is not receiving a safe dose, but is receiving an overdose.

**Method 2** Convert the 30 mL/h, which the patient is receiving, to mcg/kg/min and then compare this to the safe dose range of 2–5 mcg/kg/min.

This may be a mathematically more sophisticated approach, but it requires fewer calculations.

Realize that what you are looking for, mcg/kg/min, is in the form of amount of drug/weight of patient/time.

An amount of drug (30 mL) is being administered to a (55 kg) patient over a period of time (1 hour). So, the patient is receiving 30 mL/55 kg/1 h.

You want to change 30 mL/55 kg/1 h to mcg/kg/min, which can be done in one line as follows:

\[
\frac{30 \text{ mL}}{55 \text{ kg} \times 1 \text{ h}} \times \frac{1 \text{ h}}{60 \text{ min}} \times \frac{400 \text{ mg}}{500 \text{ mL}} \times \frac{1,000 \text{ mcg}}{1 \text{ mg}} = 7.3 \frac{\text{mcg}}{\text{kg} \times \text{min}}
\]

The safe dose range for this patient is 2–5 mcg/kg/min, and since the patient is receiving 7.3 mcg/kg/min, the patient is not receiving a safe dose, but an overdose.
Case Study 11.1

A woman is admitted to the labor room with a diagnosis of preterm labor. She states that she has not seen a physician because this is her third baby and she “knows what to do while she is pregnant.” Her initial workup indicates a gestational age of 32 weeks, and she tests positive for Chlamydia and Strep-B. Her vital signs are: T 100°F; P 98; R 18; B/P 140/88; and the fetal heart rate is 140–150. The orders include the following:

- **NPO**
- **IV fluids:** D5/RL 1,000 mL q8h
- **Electronic fetal monitoring**
- **Vital signs q4h**
- **Dexamethasone** 6 mg IM q12h for 2 doses
- **Brethine** (terbutaline sulfate) 0.25 mg subcutaneous q30 minutes for 2h
- **Rocephin** (ceftriaxone sodium) 250 mg IM stat
- **Penicillin G** 5 million units IVPB stat; then 2.5 million units q4h
- **Zithromax** (azithromycin) 500 mg IVPB stat and daily for 2 days

1. Calculate the rate of flow for the D5/RL in mL/h.
2. The label on the dexamethasone reads 8 mg/mL. How many milliliters will you administer?
3. The label on the terbutaline reads 1 mg/mL. How many milliliters will you administer?
4. The label on the ceftriaxone states to reconstitute the 1 g vial with 2.1 mL of sterile water for injection, which results in a strength of 350 mg/mL. How many milliliters will you administer?
5. The instructions state to reconstitute the penicillin G (use the minimum amount of diluent), add to 100 mL D5W, and infuse in one hour. The drop factor is 15. What is the rate of flow in gtts/min? See the label in Figure 11.6.
Practice Sets

The answers to Try These for Practice, Exercises, and Cumulative Review Exercises appear in Appendix A at the end of the book. Ask your instructor for answers to the Additional Exercises.

Try These for Practice

Test your comprehension after reading the chapter.

1. Order: Tagamet (cimetidine) 300 mg IVPB q6h in 50 mL NS infuse over 30 min. The drop factor is 15 gtt/mL. Find the flow rate in gtt/min.

2. The order is for a continuous infusion of theophylline at a rate of 25 mg/h. It is diluted in 5% dextrose to produce a concentration of 500 mg per 500 mL. Determine the rate of the infusion in mL/h.

3. A 500 mL D5W solution with 2 g of Pronestyl (procainamide HCl) is infusing at 15 mL/h via a volumetric pump. How many mg/h is the patient receiving?

4. Order: Dobutrex (dobutamine) 250 mg in 250 mL of D5W at 3.5 mcg/kg/min. Determine the flow rate in mcgtt/min for a patient who weighs 120 pounds.

5. A patient is receiving heparin 1,200 units/hour. The directions for the infusion are, add “25,000 units of heparin in 250 mL of solution.” Determine the flow rate in mL/h.

Exercises

Reinforce your understanding in class or at home.

1. The patient is to receive 20 mEq of KCl (potassium chloride) in 100 mL of IV fluid at the rate of 10 mEq/h. What is the flow rate in microdrops per minute?
2. A maintenance dose of Levophed (norepinephrine bitartrate) 2 mcg/min IVPB has been ordered to infuse using an 8 mg in 250 mL of D5W solution. What is the pump setting in mL/h?

3. The patient is receiving lidocaine at 40 mL/h. The concentration of the medication is 1 g per 500 mL of IV fluid. How many mg/min is the patient receiving?

4. Order: dopamine 400 mg in 250 mL D5W at 3 mcg/kg/min IVPB. Calculate the flow rate in mL/h for a patient who weighs 91 kg.

5. A drug is ordered 180 mg/m² in 500 mL NS to infuse over 90 minutes. The BSA is 1.38 m². What is the flow rate in mL/h?

6. How long will a 550 mL bag of intralipids take to infuse at the rate of 25 mL/h?

7. The patient is receiving heparin at 1,000 units/hour. The IV has been prepared with 24,000 units of heparin per liter. Find the flow rate in mL/h.

8. Order: Humulin R 50 units in 500 mL NS infuse at 1 mL/min IVPB. How many units per hour is the patient receiving?

9. An IVPB of 50 mL is to infuse in 30 minutes. After 15 minutes, the IV bag contains 40 mL. If the drop factor is 20 gtt/mL, recalculate the flow rate in gtt/min.

10. The patient is receiving Nipride (nitroprusside) 50 mg in 250 mL of D5W for hypertension. The rate of flow is 20 mL/h. If the patient weighs 75 kg, determine the dosage in micrograms/kilogram/minute the patient is receiving.

11. Order: Coumadin (warfarin sodium) 4 mg IVP stat administer over 1 minute. The available 5 mg of Coumadin is in a vial with directions that state to dilute with 2 mL of sterile water:
   (a) How many mg will the patient receive?
   (b) How many mL will you administer?
   (c) How many mL/min will be infused?

12. The patient is to receive Aldomet (methyldopa) 500 mg IVPB dissolved in 100 mL of IV fluid over 60 minutes. If the drop factor is 15 gtt/mL, determine the rate of flow in gtt/min.

13. The patient is to receive Isuprel (isoproterenol) at a rate of 4 mcg/min. The concentration of the Isuprel is 2 mg per 500 mL of IV fluid. Find the pump setting in mL/h.

14. The patient is receiving aminophylline at the rate of 20 mL/h. The concentration of the medication is 500 mg/1,000 mL of IV fluid. How many mg/h is the patient receiving?

15. Nipride 3 mcg/kg/min has been ordered for a patient who weighs 82 kg. The solution has a strength of 50 mg in 250 mL of D5W. Calculate the flow rate in mL/h.

16. A medication is ordered at 75 mg/m² IVP. The patient has BSA of 2.33 m². How many milliliters of the medication will be administered if the vial is labeled 50 mg/mL?

17. A liter of D5½ NS with 10 units of Regular insulin is started at 9:55 A.M. at a rate of 22 gtt/min. If the drop factor is 20 gtt/min, when will the infusion finish?

18. Mefoxin 2 g in 100 mL NS IVPB. Infuse in 1 hour. After 30 minutes, 70 mL remain in the bag. Reset the flow rate on the pump in mL/h.
19. Order: heparin sodium 40,000 units IV in 500 mL of ½ NS to infuse at 1,200 units/hour. What is the flow rate in mL/h?

20. The patient is receiving Dobutrex (dobutamine) at a rate of 18 mcgtt/min. The concentration is 250 mg/250 mL of IV fluid. Determine the dosage in microdrops/kilogram/minute that the 150-pound patient is receiving.

**Additional Exercises**

Now, test yourself!

1. Physician’s order:
   
   **Dobutamine (Dobutrex) 500 mg in 500 mL **
   
   D₃W, 6 mcg/kg/min IVPB.
   
   **Weight 145 lb.**
   
   (a) Set the flow rate on the infusion pump in milliliters per hour. _______________
   
   (b) If the above infusion begins at 6 A.M., when will it be completed? _______________

2. Order: **Amiodarone 160 mg in 20 mL D₃W IVPB; infuse over 10 minutes.**
   The label reads 50 mg/mL. The drop factor is 60 mcgtt/mL. Calculate the flow rate in mcgtt/min. __________________

3. The dose of amiodarone (Cordarone) in Question 2 is increased to 720 mg in 24 hours in 500 mL D₃W. Set the rate on the infusion pump in milliliters per hour. _______________

4. Pamidronate disodium (Aredia), an antihypercalcemic drug, 0.09 g IV has been prescribed. The label reads: Add 10 mL to a 90 mg vial.
   
   (a) How many milliliters contain the prescribed dose? _______________
   
   (b) Add the correct amount of Aredia to 1,000 mL of 0.45% NaCl and infuse in 24 hours. Set the flow rate on the infusion pump in milliliters per hour. _______________

5. Order: **Lidocaine HCl IV drip 0.75 mg/kg in 500 mL D₅W.** The patient weighs 150 pounds.
   
   (a) How many milliliters of lidocaine 2% will be needed to prepare the IV solution? _______________
   
   (b) Calculate the flow rate in mL/h in order for the patient to receive 5 mg/h. _______________

6. Order: **Diltiazem (Cardizem) push over 2 min.** The label on the vial reads 5 mg/mL. The patient weighs 210 pounds.
   
   (a) How many milligrams of Cardizem will the patient receive? _______________
   
   (b) How many milliliters contain the dose of medication? _______________

7. Physician’s order:
   
   **Phenytoin (Dilantin) 500 mg IV push over 10 min**
   
   The label on the vial reads 50 mg/mL.
   
   (a) How many milliliters will you prepare? _______________
   
   (b) Calculate the flow rate in microdrops per minute. _______________

8. The loading dose of digoxin is 0.25 mg IV push q6h for 4 doses. The label on the ampule reads 0.5 mg/mL. How many milliliters contain this dose? _______________
9. The prescriber ordered cefuroxime 18 mg/kg IVPB in 200 mL NS. Infuse in 1.5 hours. The patient weighs 80 kg. The label on the vial states that after reconstitution the strength is 3 g/32 mL.
   (a) How many milligrams of cefuroxime will the patient receive?___________
   (b) How many milliliters of cefuroxime will you add to the 200 mL of NS? ________________
   (c) Calculate the flow rate in milliliters per hour.______________

10. Adenocor, (adenosine) 6 mg IV push over 1-2 seconds has been prescribed for your patient. The label on the vial reads 3 mg/mL. How many milliliters will you prepare? __________________

11. The order for cefuroxime is 500 mg in 100 mL D5W IVPB q8h; infuse in 20 min. The vial states: “add 77 mL of sterile water, and the concentration is 750 mg/8 mL.”
   (a) How many milliliters of cefuroxime contain this dose? ________________
   (b) Calculate the flow rate in milliliters per minute. ________________

12. Your patient has developed bradycardia, and Atropine gr \( \frac{1}{60} \) IV push stat is ordered. The label reads 0.5 mg/mL. How many milliliters will you administer? ________________

13. Ritodrine HCL (Yutopar) 150 mg added to 500 mL D5W has been ordered for a patient who is having premature uterine contractions.
   (a) Calculate the flow rate in microdrops per minute over a 15-hour period. ________________
   (b) Change the flow rate to milliliters per hour. ________________

14. A patient has been admitted to the ER with a diagnosis of lead poisoning. The physician orders edetate calcium disodium (calcium EDTA) 1.5 g/m² IV. The BSA is 2.0 m². The label on the vial reads 200 mg/mL. Add the prescribed amount of drug to 250 mL D5W and infuse at a rate of 11 mL/h. At what time will the infusion finish if it begins at 10 A.M.?

15. The order is cefuroxime 1.5 g added to 100 mL NS infuse in 60 minutes IVPB. The strength of the cefuroxime is 750 mg per 8 mL.
   (a) How many milliliters of cefuroxime will you add to the normal saline solution?
   (b) Calculate the milligrams per minute the patient is receiving.

16. The order is Narcan maxolone (a narcotic antidote) 2 mg IV push. The vial reads 0.4 mg/mL. How many milliliters will you give the patient? ________________

17. Prescriber order:
    Sufentanil 6 mcg/kg IVPB in 100 mL D5W, infuse over 30 minutes. Weight 172 lb. The label states that the concentration is 50 mcg/mL. Each ampule contains 1 mL.
    (a) How many milliliters contain the prescribed dose? ________________
    (b) How many ampules of this drug will you need? ________________
    (c) How many microdrops are infused per minute? ________________
18. The prescriber ordered morphine sulfate 50 mg to be added to 250 mL of NS IVPB. Infuse in 5 hours. The strength of the morphine is 1 mg/mL.
   (a) How many milliliters contain the prescribed dose? _________________
   (b) Calculate the flow rate in milliliters per hour. _________________
   (c) After 90 minutes, the patient had breakthrough pain, and the physician increased the morphine to 15 mg/h. Recalculate the flow rate. _________________

19. The prescriber ordered a continuous IV insulin drip of 500 units of Regular insulin added to 250 mL 0.45% NaCl q12h. Read the information on the label in Figure 11.7.

   Calculate the flow rate in units per hour. _________________

20. You have an infusion of heparin 50,000 units in 500 mL D5W. The patient is receiving 1,500 units/h. What is the setting on the pump? _________________

Cumulative Review Exercises

Review your mastery of earlier chapters.

1. The patient weighs 130 pounds. The medication order for a drug is 150 mcg/kg of body weight. The label reads 2 mg/mL. How many milliliters of solution are equal to the medication order? _________________

2. The prescriber ordered 0.04 mg of Methergine (methylergonovine maleate) PO q6h. How many tablets will you prepare if the label reads 0.02 mg/tab? _________________

3. The patient must receive 1,500,000 units of penicillin IM, and the vial contains 20,000,000 units (in powdered form). The directions are as follows: Add 38.7 mL to vial; 1 mL = 500,000 units. How many milliliters will equal 1,500,000 units? _________________

4. A patient must receive 0.5 mg of scopolamine IM, a parasympathetic antagonist. The label on the ampule reads 0.3 mg/mL. How many milliliters will you administer to this patient? _________________

5. The prescriber ordered cefprozil 200 mg PO q12h for 10 days. The bottle is labeled 100 mg/5 mL. How many milliliters of this antibiotic will you give your patient? _________________
6. If you have a vial labeled 120 mg/mL, how many milliliters would equal 1.2 g? ______________

7. If tablets are 250 mg each, how many tablets equal 0.5 g? ______________

8. The prescriber has requested that you give 40 mEq of potassium chloride (K-Lor) PO to a patient from a bottle labeled 10 mEq/5 mL. How many milliliters are needed? ______________

9. 2,400 mL = ______________ L

10. 0.6 mg = gr ______________

11. 23 mL/h = ______________ mcgtt/min

12. 5 pt = ______________ qt

13. 500 mcg = ______________ mg

14. 1 T = ______________ t

15. 45 mL = ______________ oz

MediaLink  www.prenhall.com/olsen

Animated examples, interactive practice questions with animated solutions, and challenge tests for this chapter can be found on the Prentice Hall Dosage Calculation Tutor that accompanies this text. Additional, unique, interactive resources and activities can be found on the Companion Website.