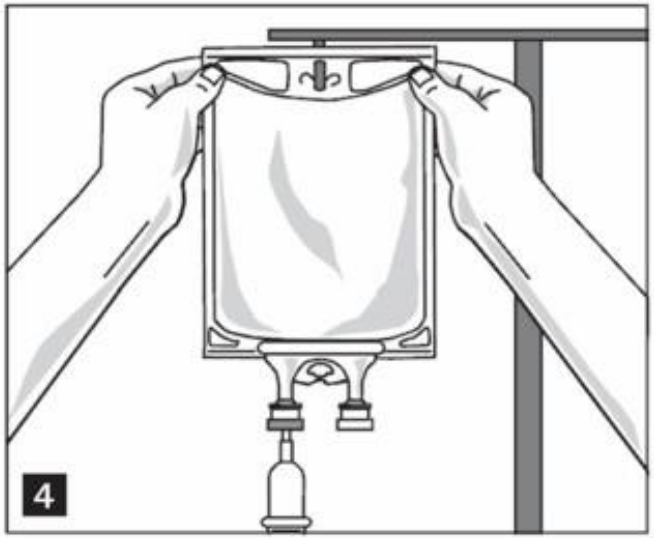
CHAPTER 13 : IV INFUSIONS, PARENTERAL ADMIXTURES, AND RATE FLOW CALCULATIONS



Objectives

Upon successful completion of this chapter, the student will be able to:

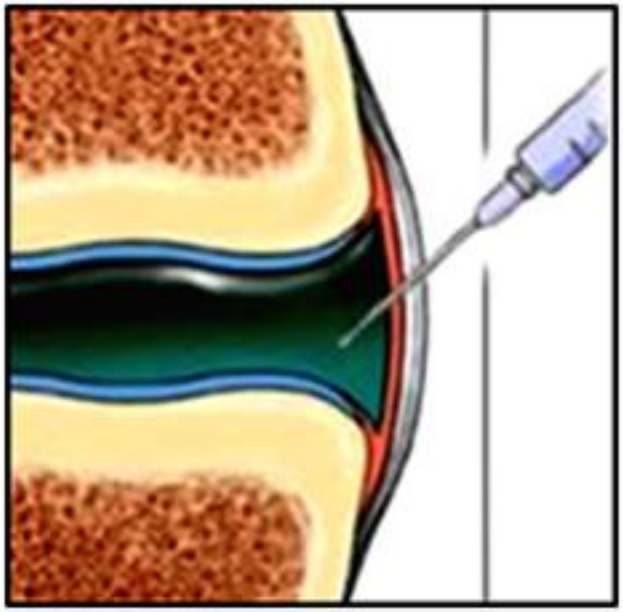
- Perform calculations for adult and pediatric intravenous infusions.
- Perform calculations for intravenous additives.
- Perform rate-of-flow calculations for intravenous fluids.
- Utilize correctly rate-of-flow tables and nomograms

Introduction

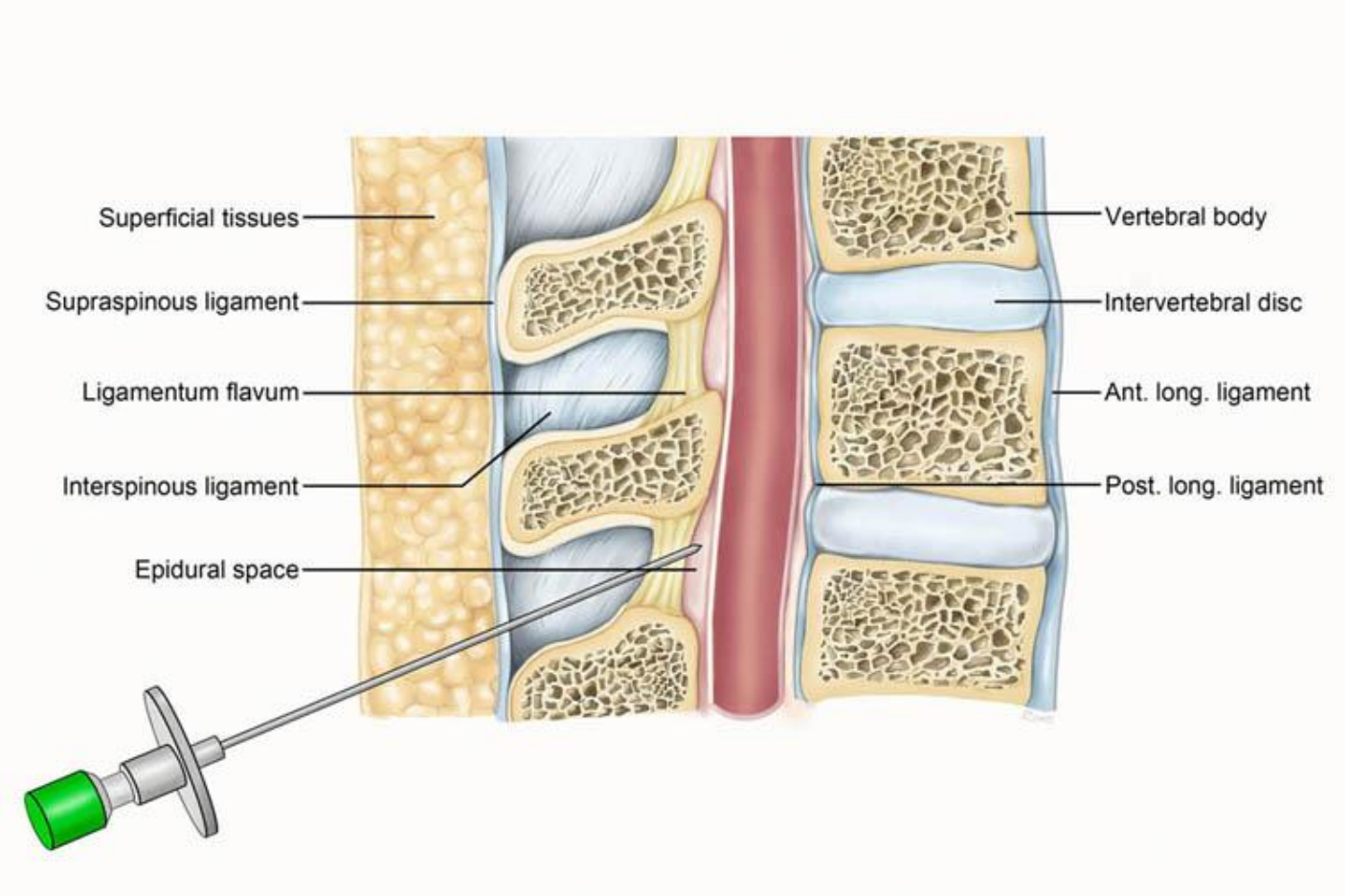
- ***Injections*** are sterile pharmaceutical solutions or suspensions of a drug substance in an aqueous or nonaqueous vehicle.

They are administered by needle into almost any part of the body, including:

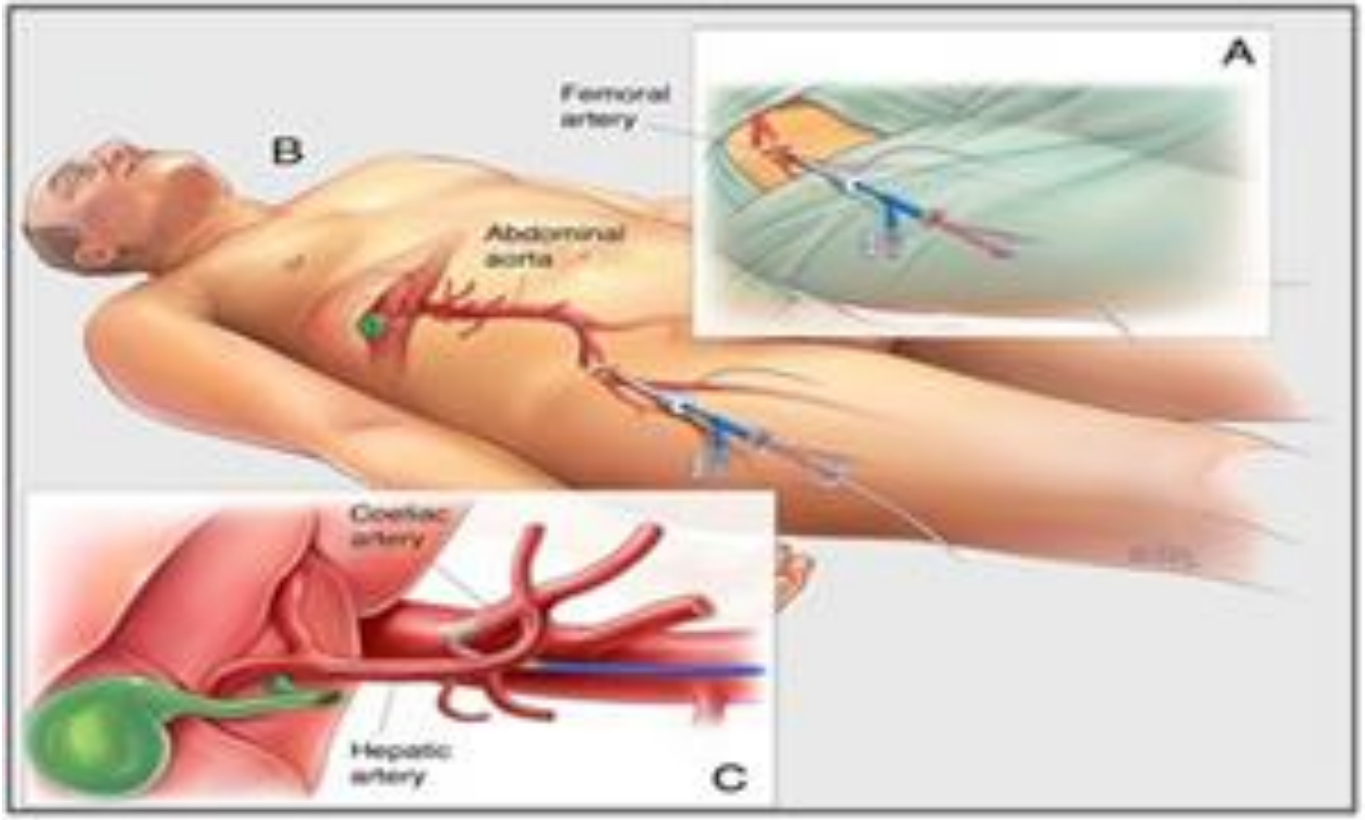
The joints (*intra-articular*)



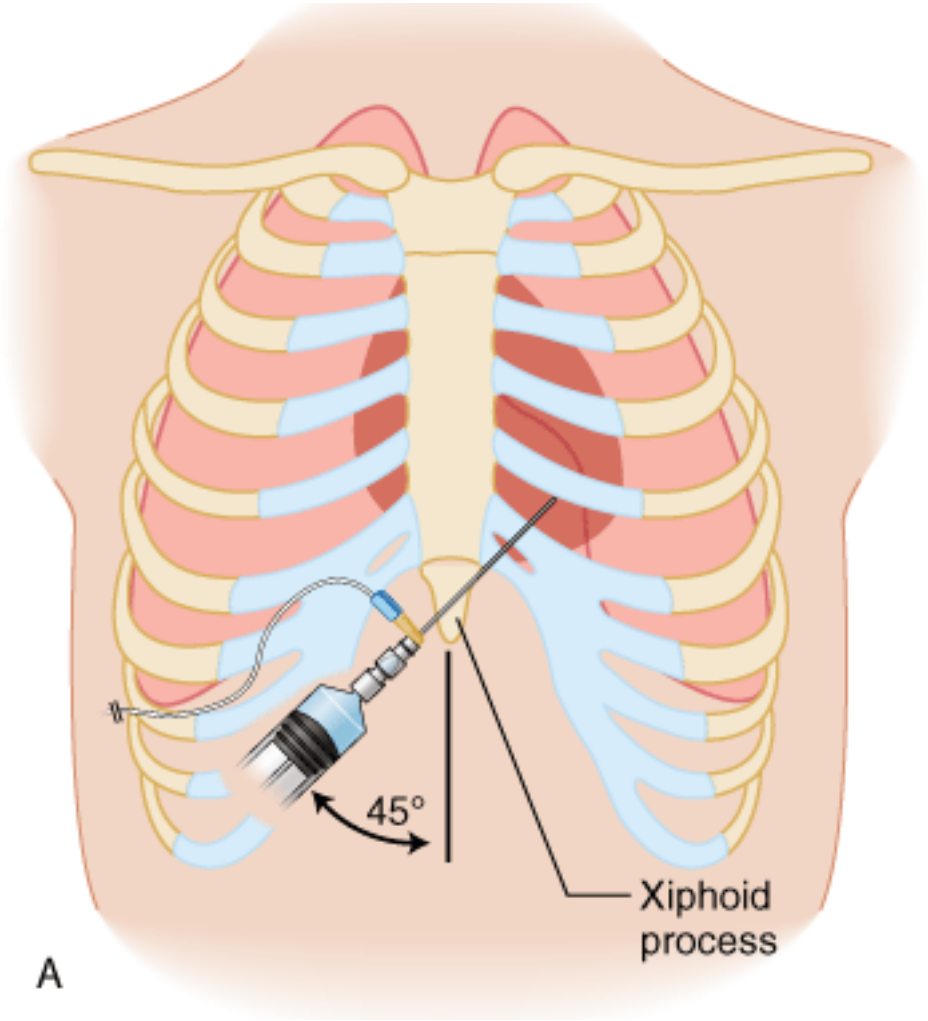
Spinal column (*intraspinal*)



Arteries (*intra-arterial*)



The heart (*intracardiac*)



However, most injections are administered into:

1. a vein (*intravenous, I.V., IV*)

1. muscle (*intramuscular, I.M., IM*)

2. skin (*intradermal, I.D., ID, intracutaneous*)

3. under the skin (*subcutaneous, sub- Q, SQ, hypodermic*).


5%
Dextrose
Injection USP
100mL
Baxter


REGULAR


REGULAR


Apidra SoloStar
Lantus SoloStar

Intravenous (IV) infusions

- ***Intravenous (IV) infusions*** are sterile, aqueous preparations administered intravenously in relatively **large volumes.**

- They are used to: (1) extend blood volume (2) provide electrolytes, nutrients, or medications.

- Most intravenous infusions are administered to critical care, infirm, dehydrated, or malnourished patients, or to patients prior to, during, and/or following surgery.

Commercially prepared infusions are available in **glass** or **plastic** bottles or **collapsible plastic** “bags” in volumes of:

- ✓ 50 mL (a *minibag*)
- ✓100 mL
- ✓250 mL
- ✓500 mL
- ✓1000 mL

- When a smaller IV bag is attached to the tubing of a larger IV being administered, it is referred to as an IV piggyback (IVPB).

- LVP: *large-volume parenteral*
- SVP:*small-volume parenteral*

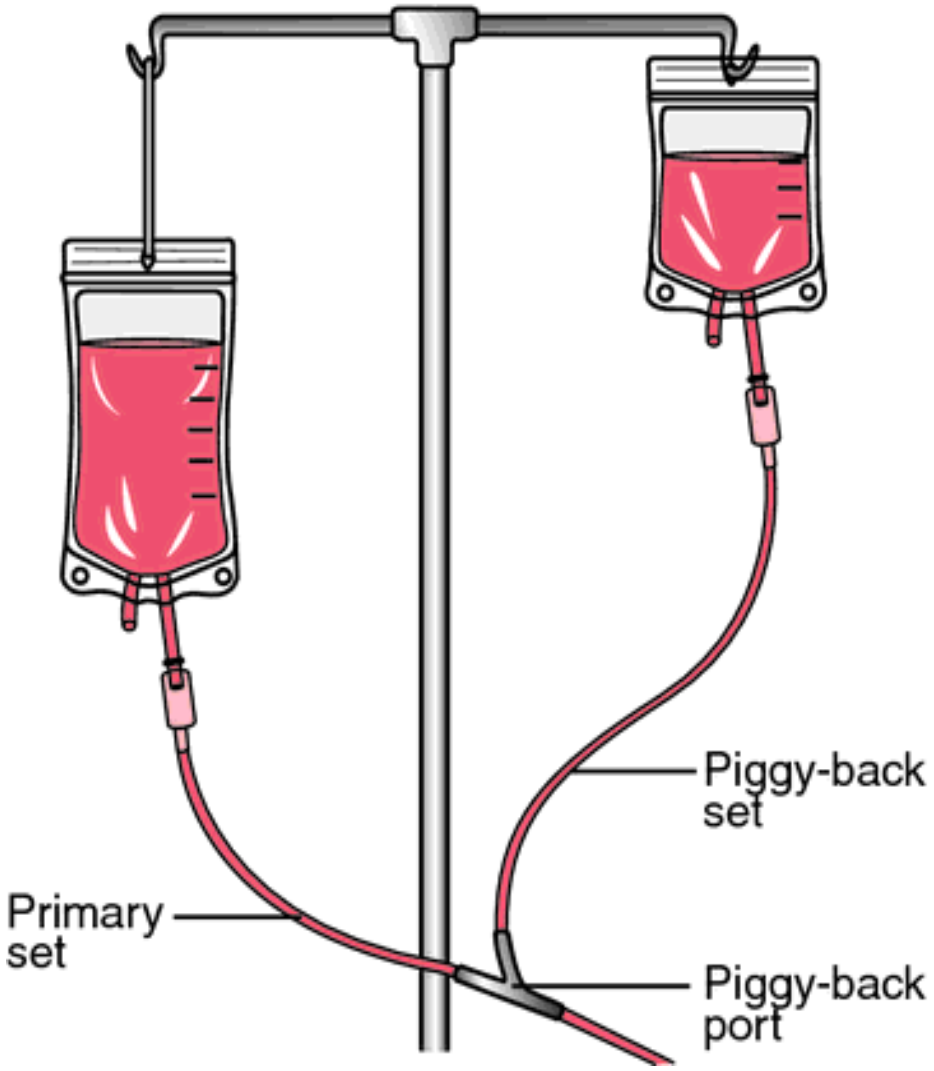


TABLE 13.1 SOME COMMON INTRAVENOUS INFUSION SOLUTIONS

SOLUTION[a]	ABBREVIATION
0.9% Sodium Chloride	NS (Normal Saline)
0.45% Sodium Chloride	½NS
5% Dextrose in Water	D5W or D_5W
10% Dextrose in Water	D10W or $D_{10}W$
5% Dextrose in 0.9% Sodium Chloride	D5NS or D_5NS
5% Dextrose in 0.45% Sodium Chloride	D5½NS or $D_5$1/2NS
Lactated Ringer's (0.86% Sodium Chloride, 0.03% Potassium Chloride, 0.033% Calcium Chloride)	LR
5% Dextrose in Lactated Ringer's	D5LR or D_5LR

[a] All solutions are prepared in Water for Injection, USP. In addition to the solutions listed, other concentrations of dextrose and sodium chloride are commercially available. These solutions may be administered as such or used as vehicles for therapeutic agents, nutrients, or other additives.

- An ***administration set*** is attached to an intravenous bottle or bag to deliver the fluid into a patient's vein.
- The sets may be standard (macrodrip) or pediatric (microdrip).
- Depending on the particular set used, the drip rate can vary from 10 to 15 drops/mL for standard sets to 60 drops/mL for microdrip sets.
- The drip rate for blood transfusion sets is usually 10 to 15 drops/ mL with infusions of 250 to 500 mL administered over a 2- to 4-hour period.

- The passage of an infusion solution into a patient's vein of entry may be assisted:

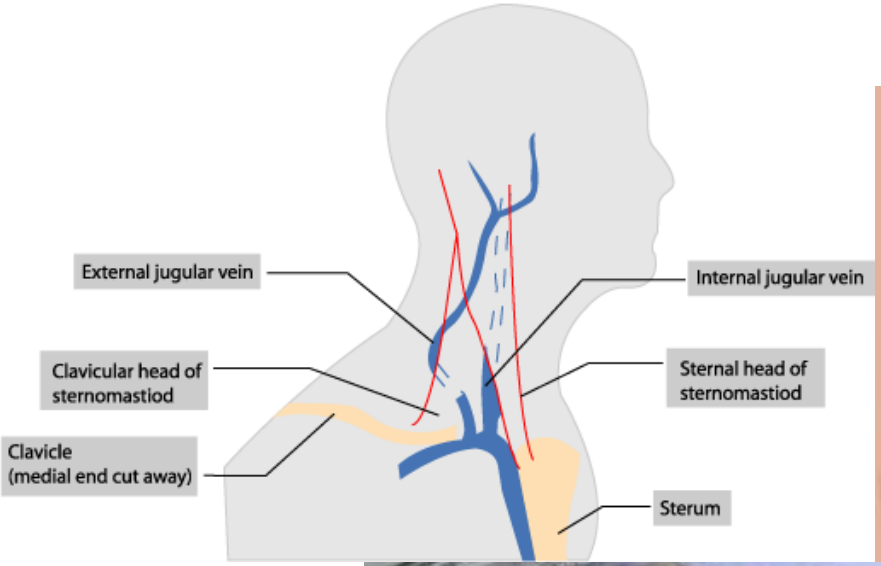
✓by gravity

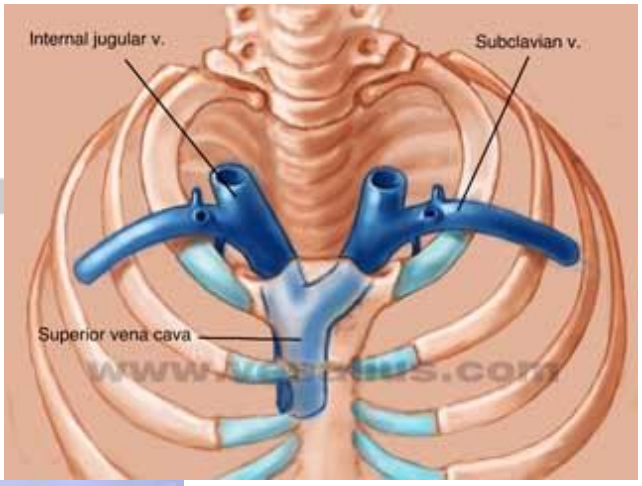
✓by electronic volumetric infusion pumps

- Some infusion pumps can be calibrated to deliver microinfusion volumes, such as 0.1 mL per hour, to as much as 2000 mL per hour

- In the administration of infusions, special needles or catheters provide intravenous entry for the intravenous fluid.

- Veins of the back of the hand, forearm, subclavian, jugular, and scalp (e.g., in premature neonates) may be used.



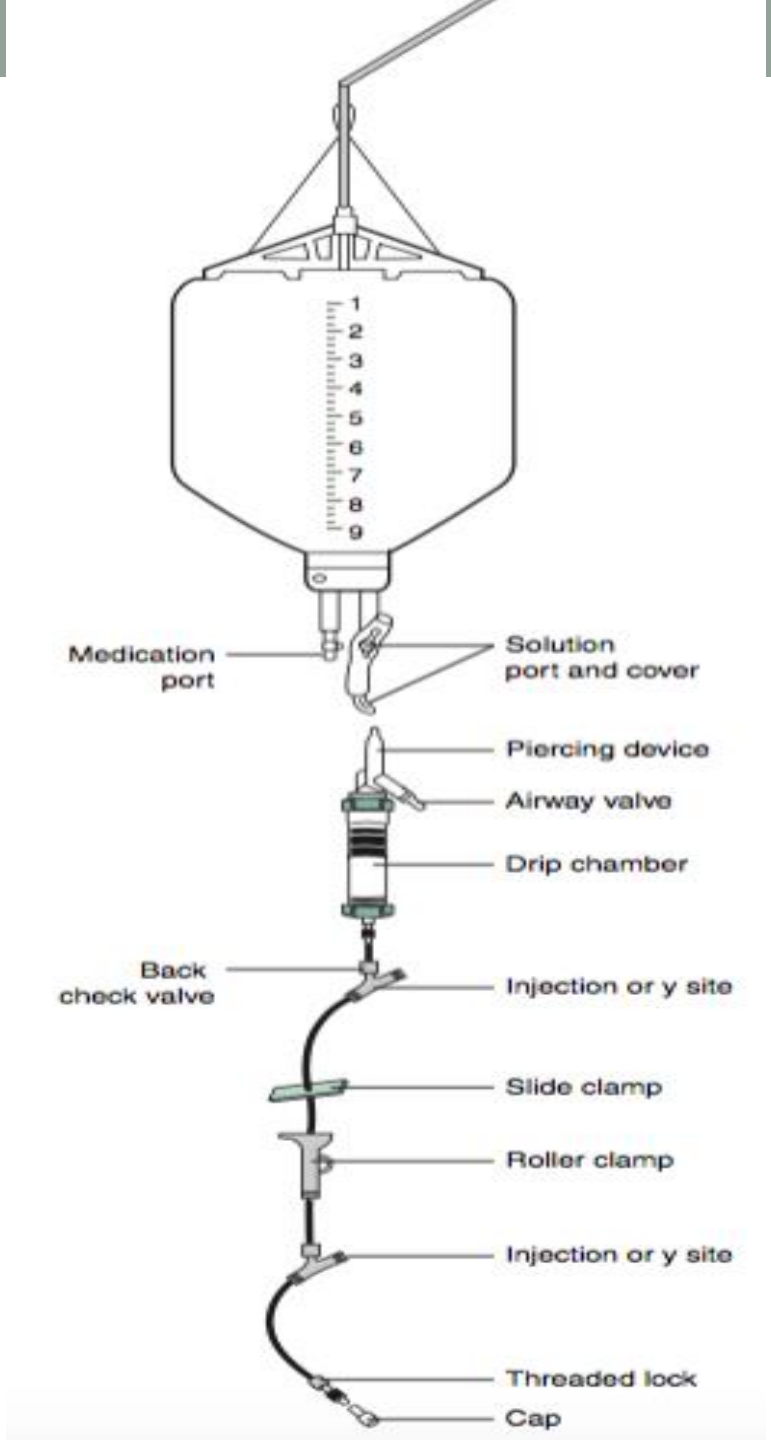


Intravenous infusions may be continuous or intermittent.

- In ***continuous infusions***, large volumes of fluid (i.e., 250 to 1000 mL), with or without added drug, are run into a vein uninterrupted

- ***Intermittent infusions*** are administered during scheduled periods.

- The rapid infusion of a medication into a vein is termed ***IV push*** and is usually conducted in less than a minute.


1
2
3
4
5
6
7
8
9
Medication port
Solution port and cover
Piercing device
Airway valve
Drip chamber
Back check valve
Injection or y site
Slide clamp
Roller clamp
Injection or y site
Threaded lock
Cap

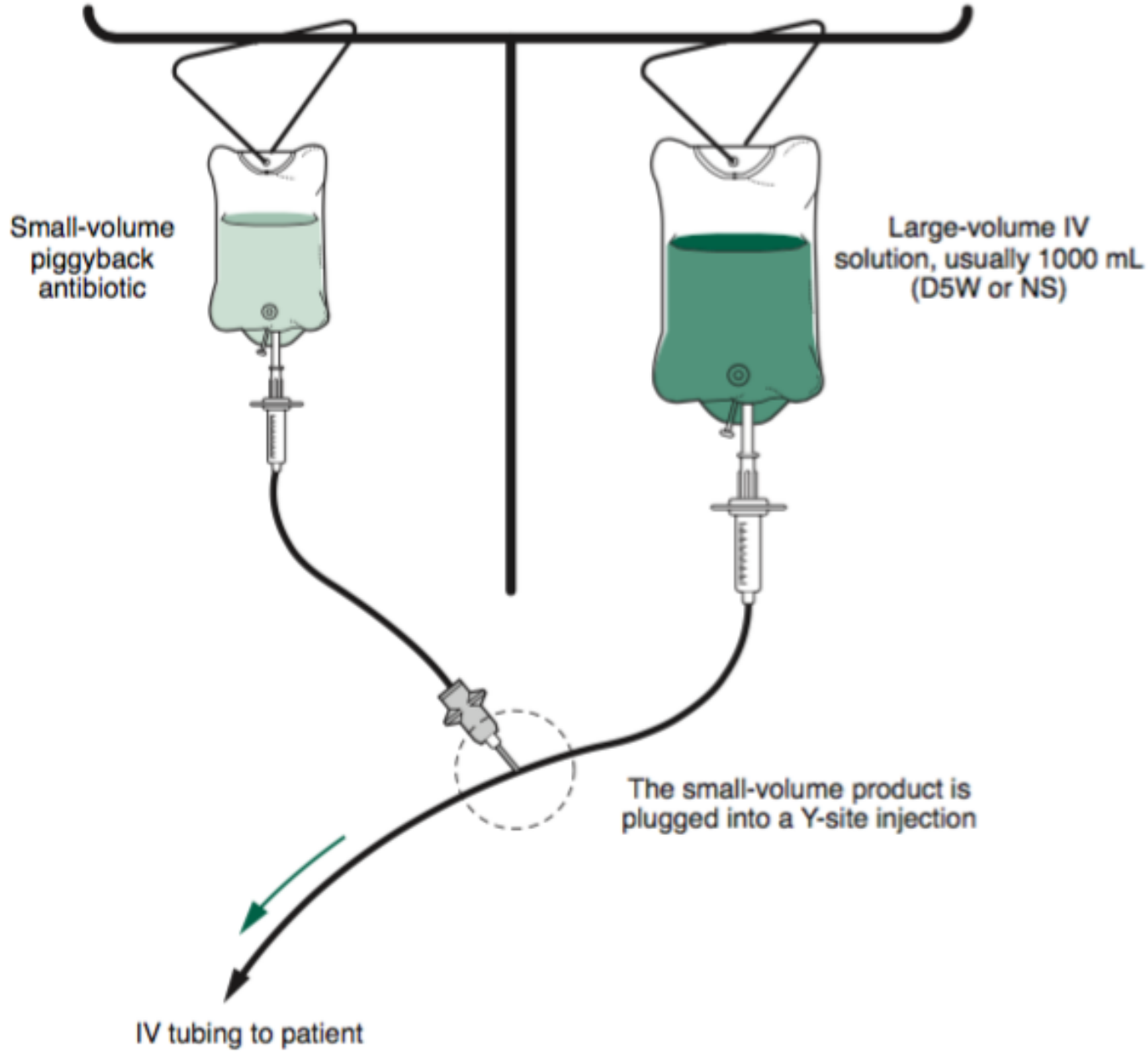


FIGURE 13.2 A typical intravenous infusion set-up with a piggybacked antibiotic. *(Courtesy of Lacher B.* Pharmaceutical Calculations for the Pharmacy Technician. *Baltimore: Lippincott Williams & Wilkins, 2008.)*

Common Intravenous infusion solutions

Aqueous solutions of dextrose, sodium chloride, and lactated Ringer's solution are the most commonly used intravenous fluids.

Example Calculations of Basic Intravenous Infusions

- How many grams each of dextrose and sodium chloride are used to prepare a 250-mL bag of $D5_{1/2}NS$ for intravenous infusion?

Compare

(a) the number of drops

(b) the length of time, in minutes, required to deliver 50-mL of intravenous solutions when using a microdrip set, at 60 drops/mL, and a standard administration set, at 15 drops/mL, if in each case one drop is to be administered per second.

Intravenous Push (IVP) Drug Administration

- The rapid injection of intravenous medications, as in emergency or critical care situations, is termed ***IV push***, ***IVP***, ***IV Stat***, or sometimes a ***bolus*** dose.

For the most part, drugs administered by IV push are intended to quickly control:

- ✓heart rate
- ✓blood pressure
- ✓cardiac output
- ✓respiration
- ✓other life-threatening conditions

Example Calculations of IV Push Drug Administration

1. A physician orders enalaprilat (VASOTEC IV) 2 mg IVP for a hypertensive patient. A pharmacist delivers several 1-mL injections, each containing 1.25 mg of enalaprilat. How many milliliters of the injection should be administered?

2. A physician orders midazolam hydrochloride (VERSED) 2 mg IV Stat. A pharmacist delivers a vial containing midazolam hydrochloride 5 mg/mL. How many milliliters should be administered?

3. General guidelines in the treatment of severe diabetic ketoacidosis include an initial bolus dose of 0.1 to 0.4 unit of insulin/kg IVP, followed by an insulin drip. Calculate the bolus dosage range for a 200-lb patient.

Special Considerations in Pediatric IV Infusion Delivery

- Depending on the institutional protocol, a medication order for an intravenous infusion for a 10-kg child may be stated as:

→ for example, "dopamine 60 mg/100 mL, IV to run at 5 mL/hr to give 5 mcg/kg/min."

- At some institutions in which *standardized drug products and established protocols* have been developed, the same medication order may be written simply as "dopamine 5 mcg/kg/min IV" to provide equivalently accurate drug dosing of the patient.

- This is because the standard solution of dopamine used in the institution (as described in the previous example), containing 60 mg of dopamine in each 100 mL and run at 5 mL/hr, *would deliver the same dose of 5 mcg/kg/min* to the 10-kg patient.

Examples

1. Calculate the daily infusion volume of D10W to be administered to a neonate weighing 3 lb. 8 oz. on the basis of 60 mL/kg/day.

2. Using an administration set that delivers 60 drops/mL at 20 drops per minute, calculate the total time for the above infusion.

3. Gentamicin sulfate, 2.5 mg/kg, is prescribed for a 1.5-kg neonate. Calculate (a) the dose of the drug, and (b) when the drug is placed in a 50-mL IV bag, the flow rate, in mL/minute, if the infusion is to run for 30 minutes.

Intravenous admixture

The preparation of intravenous admixtures involves the addition of one or more drugs to large- volume sterile fluids such as:

- ✓sodium chloride injection
- ✓dextrose injection
- ✓lactated Ringer's injection
- ✓Others.

The additives are generally in the form of small-volume sterile solutions packaged in ampuls, vials, small-volume minibags for use as piggybacks, or sterile solids, some requiring constitution with a sterile solvent before transfer.

Aseptic addition of an additive to a large-volume parenteral solution

- Patient care facilities often adopt *standard concentrations* of intravenous solutions of commonly used drugs to provide uniformity within the institution.

Common examples are:

1. dopamine 400 mg in 250 mL of D5W
2. insulin 25 units in 250 mL of NS
3. nitroglycerin 50 mg in 250 mL D5W.

TABLE 13.2 OPTIONS TO PREPARE INFUSIONS OF DIFFERENT CONCENTRATIONS

VOLUME USED			CONCENTRATION OF DOPAMINE HCl[a]	
IV FLUID	INJECTION	INJECTION:	40 mg/mL	80 mg/mL
250 mL	5 mL		800 mcg/mL	1.6 mg/mL
	10 mL		1.6 mg/mL	3.2 mg/mL
500 mL	5 mL		400 mcg/mL	800 mcg/mL
	10 mL		800 mcg/mL	1.6 mg/mL
1000 mL	5 mL		200 mcg/mL	400 mcg/mL
	10 mL		400 mcg/mL	800 mcg/mL

[a] Note: In practice, the volume of the added injection is generally disregarded in expressing the drug concentration of the resultant infusion solution.

Note ….

It is important to recognize that drug dosing by infusion is varied by:

1. The drug concentration in the infusion
2. The volume of infusion administered
3. The infusion set used
4. The rate of flow of the infusion (e.g., mL/min, mg/min)

Examples:

- A medication order for a patient weighing 154 lb. calls for 0.25mg of amphotericin B per kilogram of body weight to be added to 500 mL of 5% dextrose injection. If the amphotericin B is to be obtained from a constituted injection that contains 50 mg/10 mL, how many milliliters should be added to the dextrose injection?

- A medication order for a child weighing 44 lb. calls for polymyxin B sulfate to be administered by the intravenous drip method in a dosage of 7500 units/kg of body weight in 500 mL of 5% dextrose injection. Using a vial containing 500,000 units of polymyxin B sulfate and sodium chloride injection as the solvent, explain how you would obtain the polymyxin B sulfate needed in preparing the infusion.

Rate of Flow of Intravenous Fluids

On medication orders, the physician specifies the rate of flow of intravenous fluids in:

- ✓ milliliters per minute
- ✓ drops per minute
- ✓ amount of drug (as milligrams per hour)
- ✓ approximate duration of time of administration of the total volume of the infusion.

$$\text{Rate of flow (drops/minute)} = \frac{\text{Volume infusion (mL)} \times \text{Drip set (drops/mL)}}{\text{Time (minutes)}}$$

In common usage are:

- ***macro sets*** that deliver 10, 15, or 20 drops per milliliter
- **m*icrodrip* or *minidrip*** *sets* that deliver 60 drops per milliliter.

Examples

- A medication order calls for 1000 mL of D5W to be administered over an 8-hour period. Using an IV administration set that delivers 10 drops/mL, how many drops per minute should be delivered to the patient?

- Ten (10) milliliters of 10% calcium gluconate injection and 10 mL of multivitamin infusion are mixed with 500 mL of a 5% dextrose injection. The infusion is to be administered over 5 hours. If the dropper in the venoclysis set calibrates 15 drops/mL, at what rate, in drops per minute, should the flow be adjusted to administer the infusion over the desired time interval?

- An intravenous infusion contains 10 mL of a 1 5000 solution of isoproterenol hydrochloride and 500 mL of a 5% dextrose injection. At what flow rate should the infusion be administered to provide 5 g of isoproterenol hydrochloride per minute, and what time interval will be necessary for the administration of the entire infusion?

- ***If 10 mg of a drug are added to a 500-mL large-volume parenteral fluid:***

a. *what should be the rate of flow, in milliliters per hour, to deliver 1 mg of drug per hour?*
b. If the infusion set delivers 15 drops/mL, what should be the rate of flow in drops per minute?
c. How many hours should the total infusion last?

IV Infusion Rate Calculations for the Critical Care Patient

Example

- An order for a patient, with a 3-liter daily IV fluid limit, calls for 3 L of D5W with a 100-mL IVPB antibiotic to be run-in alone over a 1-hour period and administered every 6 hours. The administration set is calibrated to deliver 10 drops per milliliter. Calculate:

(a) The flow rate of the IVPB antibiotic
(b) The total flow time for the IV antibiotic
(c) The total volume for the IV antibiotic
(d) The total flow time for the D5W
(e) The total volume for the D5W
(f) The flow rate for the D5W.

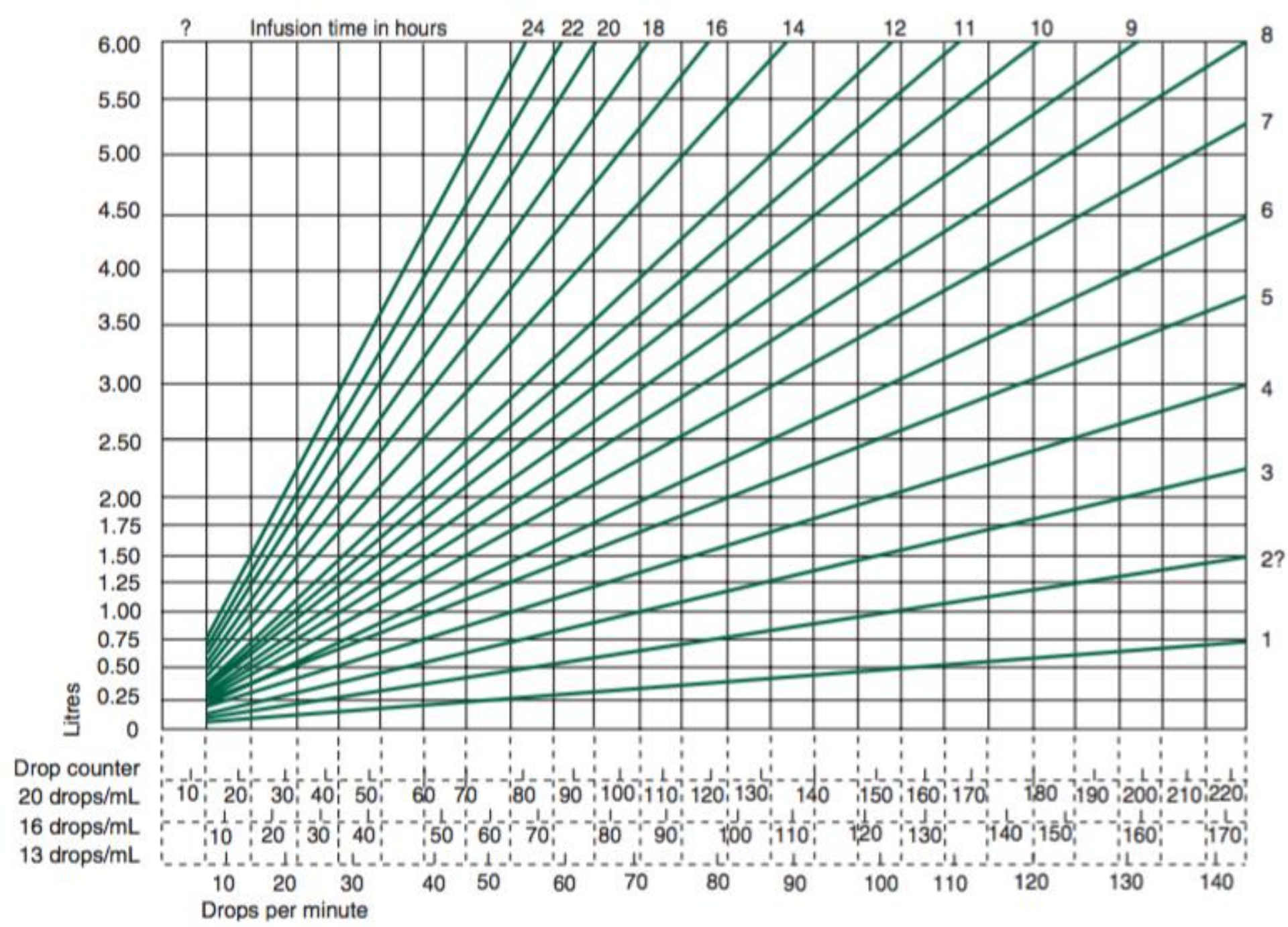
Using a Nomogram

Given the:

1. volume to be administered
2. the infusion time (duration)
3. the drops per milliliter delivered by the infusion set

→ the rate of flow, in drops per minute, may be determined directly.

- If 1 liter of a parenteral fluid is to be infused over a 12-hour period using an infusion set that delivers 20 drops/mL, what should be the rate of flow in drops per minute?


? Infusion time in hours 24 22 20 18 16 14 12 11 10 9
6.00 5.50 5.00 4.50 4.00 3.50 3.00 2.50 2.00 1.75 1.50 1.25 1.00 0.75 0.50 0.25 0
Litres
8 7 6 5 4 3 2? 1
Drop counter
20 drops/mL 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
16 drops/mL 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
13 drops/mL
10 20 30 40 50 60 70 80 90 100 110 120 130 140
Drops per minute

Using an infusion rate table

TABLE 13.3 INFUSION RATE OF A HYPOTHETICAL DRUG FOR A CONCENTRATION OF 0.2 mg/mL

PATIENT WEIGHT (kg)	DRUG DELIVERY RATE (mcg/kg per minute)								
	5	6	7	8	9	10	11	12	13
	INFUSION DELIVERY RATE (mL/hr)								
30	45	54	63	72	81	90	99	108	117
35	53	63	74	84	95	105	116	126	137
40	60	72	84	96	108	120	132	144	156
45	68	81	95	108	122	135	149	162	176
50	75	90	105	120	135	150	165	180	195
55	83	99	116	132	149	165	182	198	215
60	90	108	126	144	162	180	198	216	234
65	98	117	137	156	176	195	215	234	254
70	105	126	147	168	189	210	231	252	273
75	113	135	158	180	203	225	248	270	293
80	120	144	168	192	216	240	264	288	312
90	135	162	189	216	243	270	297	324	351
100	150	180	210	240	270	300	330	360	390

Examples ..

1. Determine the delivery rate, in mL/hr, for a drug to be administered at 10 mcg/ kg/minute to a patient weighing 65 kg.

2. If the infusion pump used in the previous example delivers 60 microdrops per milliliter, how many microdrops would be administered to the patient per minute?

3. Calculate the entry shown in Table 13.3 for the infusion delivery rate as determined in the first example problem (i.e., 195 mL/hr).

Intravenous Infusions

In certain calculations, the following equations find application.

To calculate infusion time:

$$\textit{Infusion time} = \frac{\textit{Volume of infusion in mL}}{\textit{Flow rate in mL/hr or mL/min}}$$

To calculate flow rate in drops/minute:

$$\textit{Rate of flow (drops/minute)} = \frac{\textit{Volume infused (mL)} \times \textit{Drip set (drops/mL)}}{\textit{Time (minutes)}}$$

To calculate flow rate in mL/hour when based on dose[4]*:*

$$\textit{Infusion rate (mL/hr)} = \frac{\textit{Patient's weight (kg)} \times \textit{Dose (mcg, mg, or units/kg/min)} \times 60}{\textit{Drug concentration, infusion (mcg, mg, or units/mL)}}$$

CASE IN POINT 13.1: **A physician prescribes amiodarone HCl IV (CORDARONE) for a patient with ventricular fibrillation. The prescribing information is:**

Loading infusions:

Rapid infusion over first 10 minutes:	15 mg/min
Slow infusion over the next 6 hours:	1 mg/min

Maintenance infusion:

Slow infusion over the remaining 18 hours:	0.5 mg/min

Amiodarone HCl IV is available in 3-mL ampuls containing 50 mg/mL. The pharmacist uses a 100-mL bag of D5W for the rapid infusion and 250-mL bottles of D5W for the slow infusions.

(a) How many milliliters from an amiodarone HCl IV ampul should be placed in the 100-mL bag for the rapid infusion?
(b) What is the drug concentration in the rapid infusion, in mg/mL?
(c) If the pharmacist added the contents of 3 ampuls to each 250-mL bottle of D5W needed for the slow infusions, calculate the drug concentration in mg/mL.
(d) What rate of administration, in mL/hr, should the pharmacist have recommend during the 6-hour infusion segment?
(e) Calculate the rate of administration in (d) in drops/minute with an administration set that delivers 15 drops/mL.
(f) Calculate the milligrams of drug administered by slow infusion over the 6-hour segment.
(g) Make the same calculation as that in (f) but over the 18-hour segment.

Practice questions

- A pharmacist prepared a “standard concentration” of a dopamine HCl solution to contain 400 mg/250 mL D5W. Calculate:

(a) the concentration of dopamine HCl in the infusion, in mg/mL

(b) the infusion flow rate, in mL/hr, for a 150- lb. patient, based on a dose of 5 mcg/kg/ minute.

- A certain fluid measures 1 liter. If the solution is to be administered over a period of 6 hours and if the administration set is calibrated at 25 drops/mL, at what rate, in drops per minute, should the set be adjusted to administer the solution during the designated interval?

- TORISEL (temsirolimus), for use in advanced renal cell carcinoma, is prepared for infusion by adding 1.8 mL of special diluent to the drug vial resulting in 3 mL of injection containing 10 mg/mL of temsirolimus.

- The required quantity is then added to a 250-mL container of sodium chloride injection for infusion. The recommended dose of temsirolimus is 25 mg infused over 30 to 60 minutes.

- The quantity of drug delivered, in mg/mL, and the rate of infusion, in mL/min, for a 30-minute infusion are:

(a) 0.099 mg/mL and 8.42 mL/min
(b) 0.099 mg/mL and 8.33 mL/min
(c) 1 mg/mL and 8.42 mL/min
(d) 1 mg/mL and 8.33 mL/min

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