

Chapter 5

Parenteral Drug Administration



LEARNING OUTCOMES

Photo Credit::

After completing this chapter, the pharmacy technician should be able to:

- L01** Differentiate among the intravenous (IV), intramuscular (IM), intradermal (ID), and subcutaneous (SC) methods of parenteral drug administration into skin tissue and the blood circulation. (NAPRA 3.3.2, 6)
- L02** Explain the advantages, disadvantages, limitations, and the potential patient safety issues and risk factors of the IV, IM, ID, and SC methods of drug administration. (NAPRA 3.2.5, 3.3.2, 6, 9.1.1)
- L03** Differentiate between piggyback/intermittent infusion systems, IV push/IV bolus, and continuous IV infusions used in IV delivery systems and the advantages and disadvantages of such delivery systems. (NAPRA 3.2.5, 3.3.2, 6, 9.1.1)
- L04** Differentiate between electronic and non-electronic IV administration devices such as primary and secondary type administration sets, flow regulators volume control sets, and positive pressure pumps, including parts and functions as IV delivery systems. (NAPRA 3.2.5, 3.3.2, 6)
- L05** Describe the vascular devices used for peripheral and central IV administration of drug solutions. (NAPRA 3.3.2, 6)
- L06** Recall the physical and clinical adverse effects of IV therapy. (NAPRA 6)
- L07** Discuss IV drug infusion by gravity flow and the factors that can affect the accuracy of this method of drug infusion. (NAPRA 3.1.5, 6)
- L08** Calculate flow rate in millilitres per hour or drops per minute, as well as in milligrams per kilogram per minute, when using gravity IV drug infusion. (NAPRA 3.1.4, 3.1.5)

L01 Differentiate among the intravenous (IV), intramuscular (IM), intradermal (ID), and subcutaneous (SC) methods of parenteral drug administration into skin tissue and the blood circulation.

alimentary tract:
gastrointestinal tract.

INTRODUCTION

Parenteral administration of sterile medications refers to the administration of medications by a route other than through the **alimentary tract**. Although this method of drug administration encompasses a number of routes, in medical practice it refers to medications being injected or infused into tissues, organs, and body cavities, through a hollow device, such as a needle and/or a catheter (Turco & King, 1979; Celeste et al, 1993; Perry & Potter, 2006).

The choice of device used for a specific type of parenteral drug administration will depend on a number of physicochemical factors—drug preparation, clinical factors, treatment choice, and desired outcome—as follows:

- Desired therapeutic effect
- Patient's condition
- Physicochemical characteristics of the drug preparation
- Drug dosage form
- Volume fluid restrictions
- Vascular access
- Urgency of administration and pharmacological effect
- Rate of administration

Parenteral drugs can be injected into almost any body tissue, organ, and body cavity. Parenteral routes of drug administration are as follows:

- Intravenous (drug injected into a vein)
- Intramuscular (drug injected into a muscle)
- Intradermal (drug injected into the dermis of the skin)
- Subcutaneous (drug injected into the fatty subcutaneous part of the skin)
- Intrathecal (drug injected into the subdural space of the spine)
- Intra-arterial (drug injected into an artery)
- Intrasynovial (drug injected into the synovial fluid of a joint)
- Intra-articular (drug injected into a joint)
- Intraperitoneal (drug injected into the peritoneal cavity)
- Intracardiac (drug injected into the heart)
- Intravitreal (drug injected into the eye)
- Intraventricular (drug injected into the ventricles of the brain)
- Epidural (drug injected into the space surrounding the dura matter of the spinal cord/brain; Celeste et al, 1993)

L02 Explain the advantages, disadvantages, limitations, and the potential patient safety issues and risk factors of the IV, IM, ID, and SC methods of drug administration.

Four primary routes are used more frequently than other routes that may be used for specific clinical conditions. The four primary routes of parenteral drug administration, intravenous (IV), intramuscular (IM), intradermal (ID), and subcutaneous (SC), involve the penetration of the skin at different levels with varying sizes of sterile hollow needles or cannulas to administer the medication. It is important to visualize the basic anatomy of the skin and the respective layers entered by the above methods. Figure 5.1 shows the skin layers used for the common routes of parenteral drug administration (Celeste et al, 1993; Perry & Potter, 2006; Lynn 2008).

Table 5.1 compares the four most commonly used parenteral routes of drug administration.

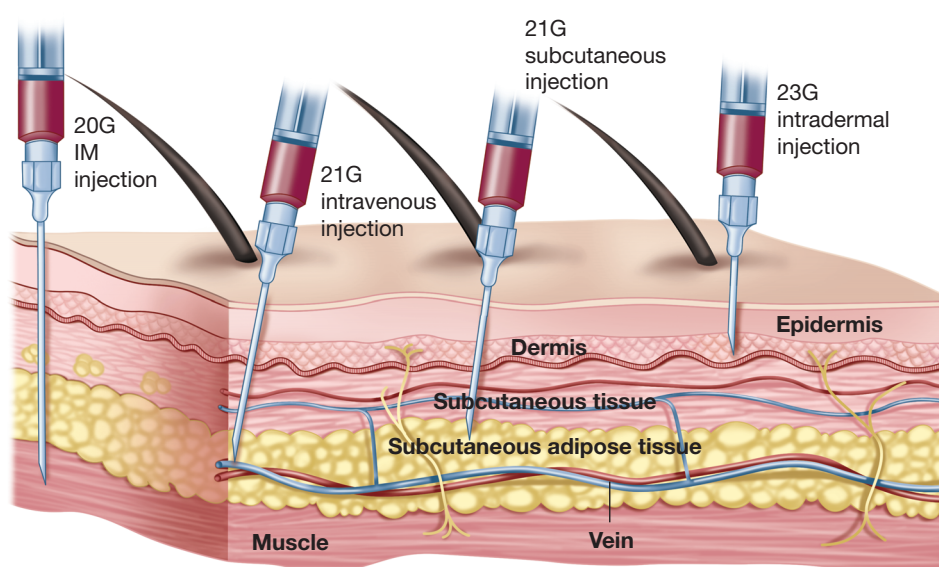


Figure 5.1 Four Common Routes of Parenteral Drug Administration of Medications.

Source: Author created.

Table 5.1 Most Common Parenteral Routes of Drug Administration

Route	Injection Site	Benefits	Complications	Needle Size	Injection Volume	Product Type
Intramuscular (IM) (Figure 5.2)	Skeletal muscle (i.e., gluteus medius, ventrogluteus, vastus lateralis, and mid-deltoid muscles)	- Offers greater number of blood vessels, allowing fast drug onset of drug action - For oil-based products (oleaginous) creates a depot effect at injection site, thus increasing duration of drug action	- Pain and discomfort at site of injection - Also, paralysis, abscess, cysts, embolism, hematomas, sloughing of skin, scarring, and tissue necrosis	20–25 gauge for water-based (aqueous) drugs and 18–25 gauge for oil-based drugs - Needle length varies, depending on whether the drug is administered to adults or children	0.5 mL–3 mL - Max. 5 mL when using the gluteal muscles or 2 mL when using the deltoid muscles - Volume reduced for children and elderly to 1–2 mL	Most common are the oil-based and suspension-type drugs
Subcutaneous (SC) and/or hypodermic injection (Figure 5.3)	- Into loose and fatty layer of the skin of the forearm, upper arm, thighs, and/or buttocks - Can be administered as continuous SC injection using electronic infusion systems	- Easy injection for aqueous, isotonic, nonirritating medications - Drug absorption faster than intradermal injection but slower than IM or IV administration	- Significant skin irritation if hypertonic or hypotonic drug solutions or acidic or basic or vesicant type medications - Continuous SC injection should be limited to acute cases and short-term therapies to minimize adverse effects - Continuous SC injection requires frequent site rotation	Fine-gauge short needle ~25 to 30+ gauge	0.5 mL–1 mL	- Isotonic, nonvesicant, nonacidic, and/or basic drug solutions - Narcotic analgesics, nonvesicant cancer chemotherapy drugs, insulin, and deferoxamine

(Continued)

Table 5.1 Most Common Parenteral Routes of Drug Administration (continued)

Route	Injection Site	Benefits	Complications	Needle Size	Injection Volume	Product Type
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depot: reservoir.

paralysis: loss or impairment of motor function.

abscesses: localized collection of pus formed in a cavity due to breakdown of tissue.

cyst: a sac containing liquid and/or semisolid material.

embolism: blocking of a blood vessel by blood clot or other type of obstruction.

hematoma: collection of blood under the skin caused by bleeding under that tissue.

necrosis: death of cell/tissue/organ.

hypodermic: beneath the skin.

vesicant: an agent that would cause blisters.

nonvesicant: an agent that would not cause blisters.

scapula: flat triangular bone in the back of the shoulder.

local anesthetics: medications or agents that cause partial or complete loss of sensation in a specific body part/area.

colloidal dispersion: liquid preparations that contain very fine dispersed particles of a medication or other agent.

emulsion: a fluid containing water-soluble and fat-soluble components homogenized into a smooth milky mixture.

phlebitis: inflammation of the inner wall of a blood vessel.

thrombosis: formation of a blood plug in a blood vessel.

local infection: pathogenic microorganisms on the skin.

systemic infection: pathogenic organisms in the blood.

circulatory overload: increased fluid in blood circulation.

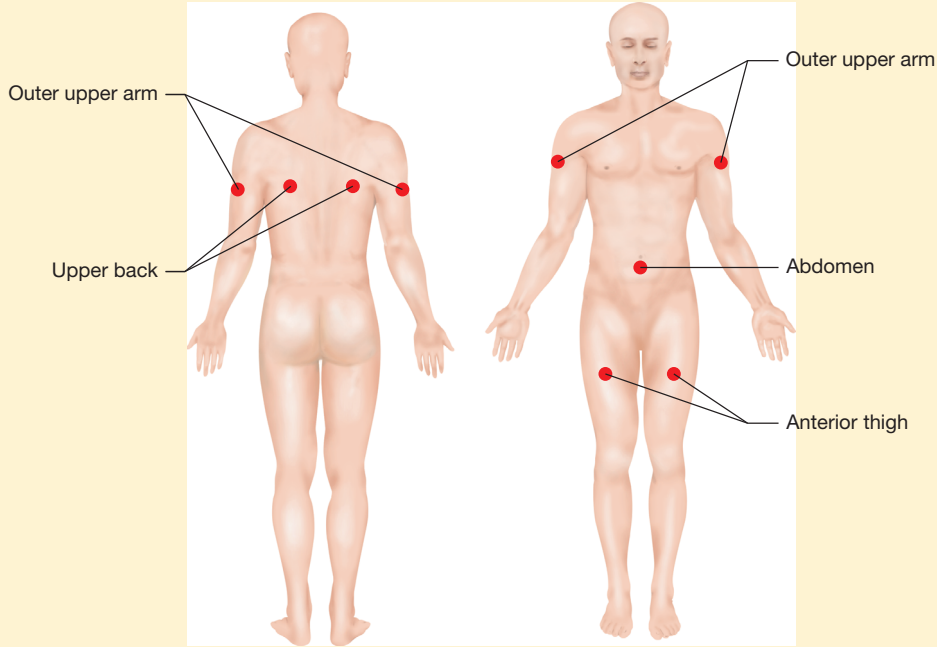


Figure 5.2 Subcutaneous Sites of Intramuscular Drug Administration.

Source: medical-dictionary.thefreedictionary.com/injection.

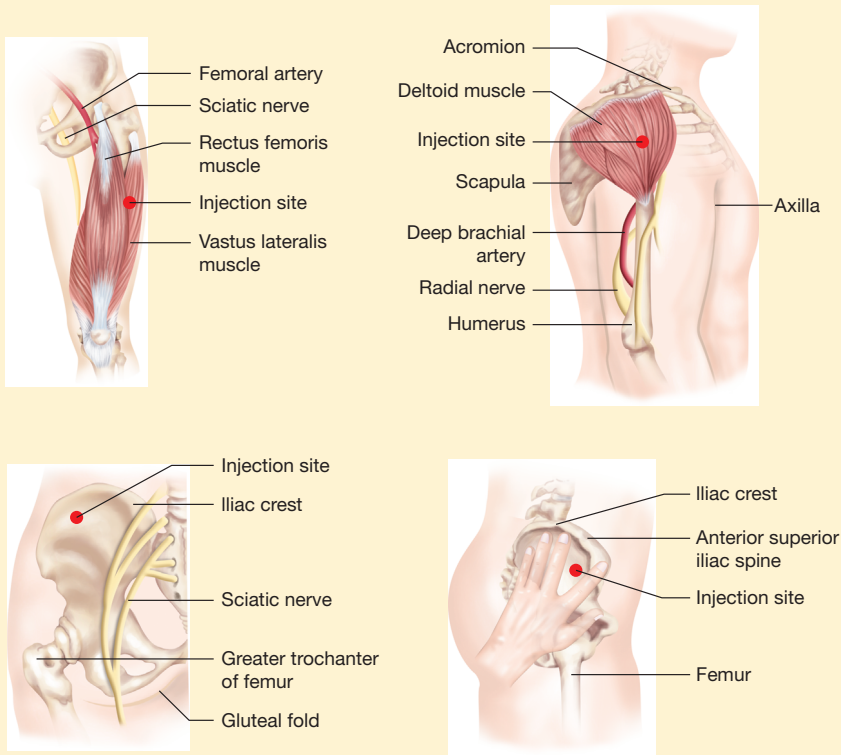


Figure 5.3 Intramuscular Drug Administration.

Source: medical-dictionary.thefreedictionary.com/injection.

Table 5.1 Most Common Parenteral Routes of Drug Administration (continued)						
Route	Injection Site	Benefits	Complications	Needle Size	Injection Volume	Product Type
Intradermal (ID)	• Into the dermis layer of the skin just below the epidermis • Inner aspect of forearm, upper chest area just below the scapula and back of the arm	• Longest absorption of all parenteral route sites, making it the preferred route for sensitivity and diagnostic tests		26- to 27-gauge needle	• 1.01–0.1 mL	• Method for tuberculin testing and allergy testing • Local anesthetics and certain vaccines
Intravenous (IV)	• Most common method used in hospitals • Includes IV bolus, IV push, IV infusion, and IV intermittent infusion • IV push and/or IV bolus involves direct injection into vein or IV line over 2–3 minutes • continues or intermittent IV infusion through a catheter into a blood vessel over 15 minutes to 24 hours	• Ability to administer large volume of fluids and/or medications • Ability to tolerate variations of solution tonicity due to rapid product dilution • Immediate delivery into the bloodstream and attainment of optimal blood concentration • Rapid onset of action • Provision of long-term therapy over repeated IM and SC injections • Drugs that cannot be administered by other parenteral routes	• Phlebitis • Thrombosis • Tissue injury • air or particle emboli • Local infection or systemic infection • Dosage errors or circulatory overload	• Use of special catheters, depending on the IV method of administration	• Volumes vary, depending on IV method used • Can administer as small as 0.1 mL to 3000 mL	• Often used to administer fluids and electrolytes • Sterile aqueous solutions, colloidal dispersions, or emulsions • Suspensions and oil-based preparations; must never be given by the IV route

Source: Lynn, P. (2008). *Photo Atlas of Medication Administration* (3rd ed.). Philadelphia, PA: Lippincott Williams & Wilkins; Perry, A. G., and Potter, P. A. (2006). *Clinical Nursing Skills & Techniques* (6th ed.). St. Louis, MO: Mosby; Turco, S. J., and King, R. E. (1979). *Sterile Dosage Forms* (2nd ed.). Philadelphia, PA: Lea & Febiger; Buchanan, E. C., and Schneider, P. J. (2009). *Compounding Sterile Products* (3rd ed.). Bethesda, MD: American Society of Health-System Pharmacists.

L03 Differentiate between piggyback/intermittent infusion systems, IV push/IV bolus, and continuous IV infusions used in IV delivery systems and the advantages and disadvantages of such delivery systems.

INTRAVENOUS DRUG DELIVERY SYSTEMS

The pharmacy technician prepares admixtures that are going to be administered to patients as either continuous infusions or intermittent infusions. These methods of IV drug administration utilize automated and nonautomated devices, including packaging systems to carry the medication, and assist the nurse to administer the medication to the patient efficiently. Table 5.2 compares the IV drug delivery systems commonly used in hospital settings and home care settings to administer sterile solutions of medications.

Table 5.2 Commonly Used Systems of Intravenous (IV) Drug Delivery

Drug Delivery System	Description	Advantages	Disadvantages
Primary line/primary solution drug delivery system (Figures 5.4 and 5.5)	Use of a large volume of IV fluid (e.g., 5% dextrose injection or 0.9% sodium chloride) with or without medication, infused either by gravity or by an electronic device over a period of time to replace fluid and electrolytes or to administer a medication	Enables parenteral administration for continuous infusion, is a vehicle for a medication, and is a means of keeping the blood vessel open and available for drug administration	- Not suitable for short time IV drug infusion - Potential drug stability/compatibility issues due to fluid volume, infusion time, and drug contact time with container

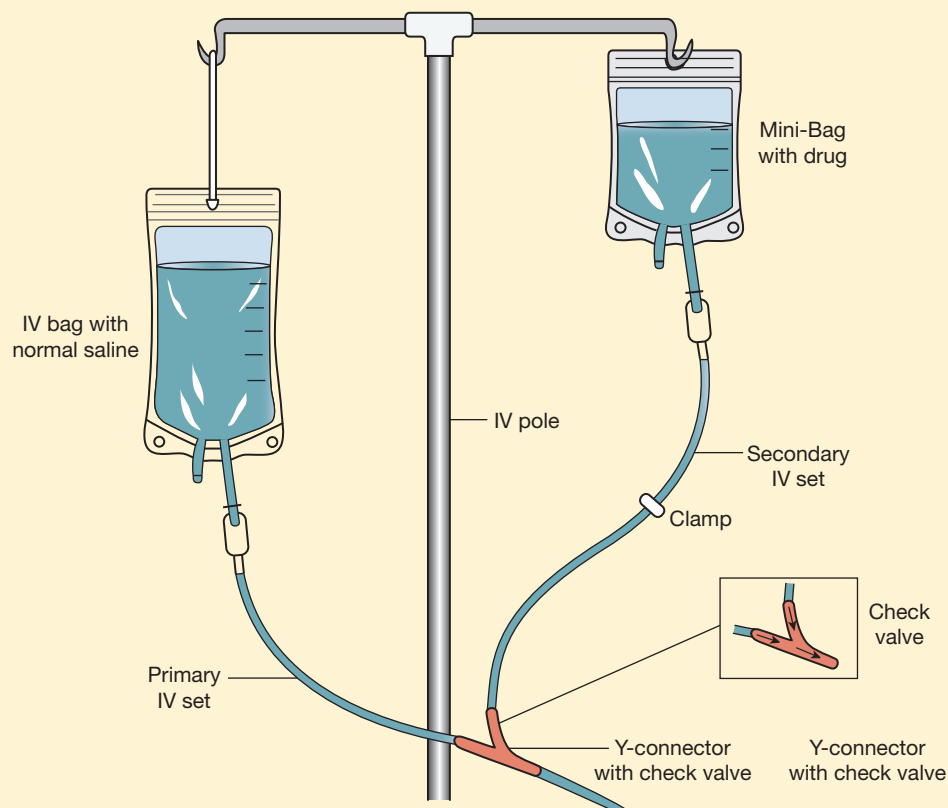


Figure 5.4 Primary Line/Primary and Piggyback and Intermittent Solution Intravenous Drug Delivery System.

Source: Author created.

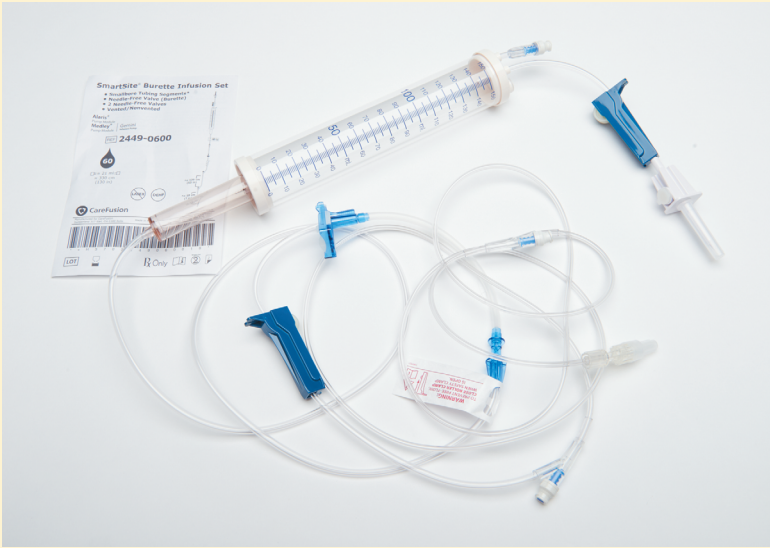
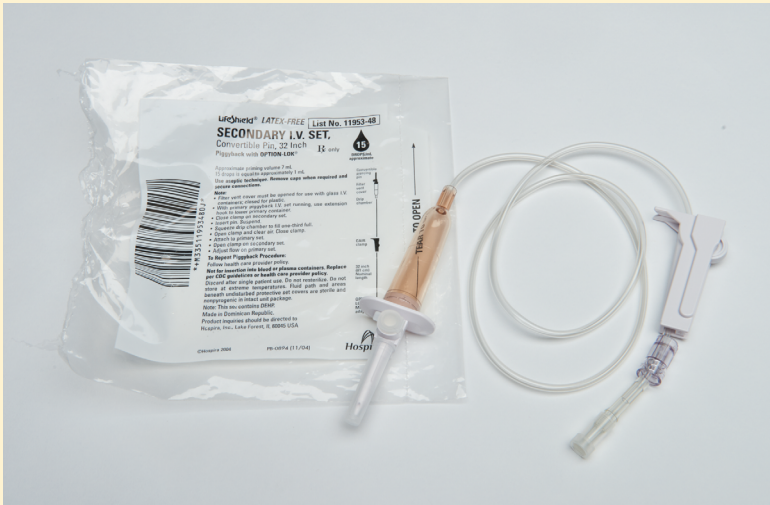
Table 5.2 Commonly Used Systems of Intravenous (IV) Drug Delivery (continued)			
Drug Delivery System	Description	Advantages	Disadvantages
		Figure 5.5 Primary Intravenous Administration Set. Source: Ian Crysler.	
Secondary (piggy back/intermittent) drug delivery system (Figure 5.6)		• Simple to prepare • Relatively inexpensive • Bags easy to store • Bags not breakable • Allows (to an extent) dosage individualization	• Susceptible to microbial contamination • Susceptible to particulate matter contamination • Fixed delivery volumes • Limited solution type availability • Bottles take up space and are breakable
		Figure 5.6 Secondary Intravenous Administration Set. Source: Ian Crysler.	
		(Continued)	

Table 5.2 Commonly Used Systems of Intravenous (IV) Drug Delivery (continued)

Drug Delivery System	Description	Advantages	Disadvantages
The Add-Vantage drug delivery system (Figure 5.7)	• Similar delivery system to the Mini-Bag, containing similar sterile fluids for drug admixing • Bag has special adaptor to attach the specially configured drug vial • Drug vial attached to the Add-Vantage bag under living-away-from-home (LAFH) conditions are labelled and sent to the nursing unit • Nurse activates system by outside manipulation of the Add-Vantage bag, removing an internal seal on the drug vial, and allowing solution from the bag to mix and dissolve drug Removed drug vial seal remains in the drug admixture solution in the Add-Vantage bag • Add-Vantage bag with drug admixture is piggybacked to the primary line and administered over a short time (i.e., 15–30 minutes)	• Simple admixing, reducing preparation time • Drug remains intact until inner seal broken • Reduced microbial contamination risk • Minimum waste • Easy and fast reconstitution and admixing, requiring no needles/syringes • Individualization of dose	• Limited availability of drugs in such form • Expensive • Potential for nondelivery of drug and/or infusion of nondiluted drug • Fixed drug and diluent quantity • Activation of drug vial critical to ensure drug has been administered • Pharmacy validation of drug vial activation essential to confirm drug has been administered when attached drug vials returned to pharmacy for recycling or disposal

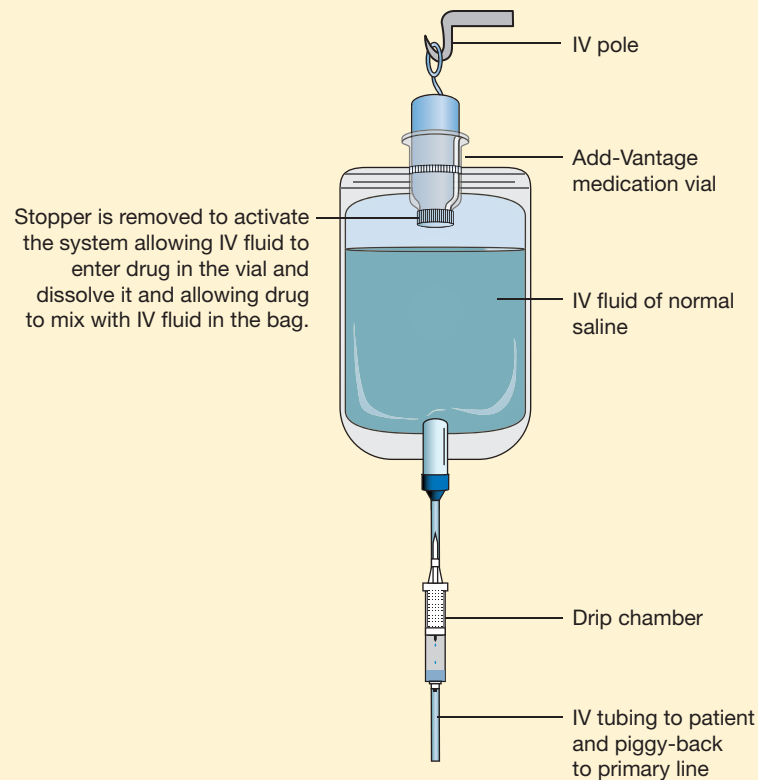


Figure 5.7 Add-Vantage Drug Delivery System.

Source: Author created.

Table 5.2 Commonly Used Systems of Intravenous (IV) Drug Delivery (continued)			
Drug Delivery System	Description	Advantages	Disadvantages
Mini-Bag Plus drug delivery system (Figure 5.8)	• Similar system to Add-Vantage system • No special vial adaptor and vial configuration • Accommodates attachment of standard 20-mm vial • Pharmacy aseptically attaches drug vial under LAFH conditions • Nurse activates drug vial by breaking adaptor seal inside the Mini-Bag Plus, allowing solution from the Mini-Bag Plus to enter drug vial mix and dissolve drug • Nurse inverts Mini-Bag Plus with attached drug vial and squeezes Mini-Bag Plus to push air into the vial and force dissolved drug to enter and mix with the rest of the Mini-Bag-Plus solution • Empty drug vial remains attached to the Mini-Bag-Plus during administration	• Reduced preparation time • Reduced drug wastage • Reduced microbial contamination risk • No additional diluent for drug reconstitution • Activation and drug reconstitution at time of administration	• Fixed drug and diluent quantity • Potential for nondelivery of drug and infusion of undissolved drug particles • Expensive system • Pharmacy validation of drug vial activation essential to confirm drug administered when attached drug vials returned to pharmacy for recycling or disposal

Figure 5.8 Mini-Bag-Plus Drug Delivery System: Aseptic Attachment of Drug Vial to the Adaptor, Breaking of Seal, Reconstituting Drug, and Admixing With Mini-Bag Fluid.

Source: Author created.

(Continued)

Table 5.2 (continued)			
Drug Delivery System	Description	Advantages	Disadvantages
Premixed Mini-Bag drug delivery system (Figure 5.9)	• Premixed stable drugs in Mini-Bag delivery systems of varied volumes (i.e., 50–250 mL) • Available both as drug solution form and frozen for certain drugs, requiring thawing prior to administration	• Avoidance of incompatibility • Avoidance of contamination that could potentially occur during compounding • Savings in preparation time • Reduction of wastage	• Expensive • Fixed drug/diluent quantities • Limited product availability



Figure 5.9 Premixed Intravenous Drug Delivery System.
Source: Ian Crysler.

Source: Celeste, M. L., et al. (1993). *Infusion Technology Manual: A Self-Instructional Approach*. Bethesda, MD: American Society of Hospital Pharmacists; Turco, S., and King, R. E. (1979). *Sterile Dosage Forms* (2nd ed.). Philadelphia, PA: Lea & Febiger.

L04 Differentiate between electronic and non-electronic IV administration devices, such as primary and secondary type administration sets, flow regulators volume control sets and positive pressure pumps including parts and functions as IV delivery systems.

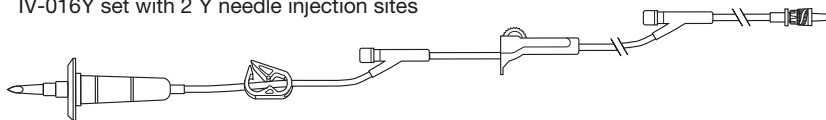
NONAUTOMATED AND SEMIAUTOMATED INTRAVENOUS INFUSION ADMINISTRATION DEVICES

Devices with varied configurations and sizes are commercially available to meet specific clinical needs. The devices are disposable and constructed of sterile and pyrogen-free polyvinyl chloride (PVC). The simplest and most frequently used IV administration devices are referred to as “primary or secondary IV administration sets (i.e., non-automated/semiautomated).”

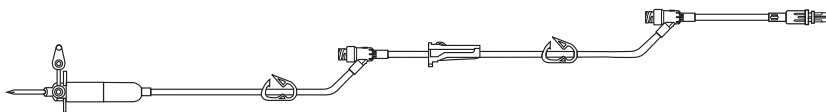
Primary Intravenous Administration Sets

Primary intravenous administration sets comprise long, sterile PVC tubing and are used to deliver a primary IV infusion fluid on a continuous basis (see Figure 5.5).

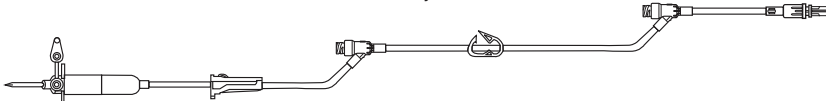
IV-016Y set with 2 Y needle injection sites



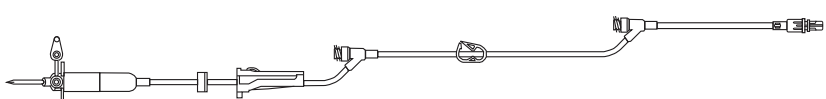
IV-016N vented set with two needle-free injection sites



IV-017N vented set with two needle-free injection sites



IV-018N vented primary set with backcheck valve and two needle-free injection sites



IV-027N vented primary set with backcheck valve and two needle-free injection sites

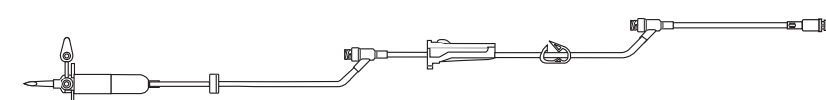


Figure 5.10 Common Parts of a Primary Intravenous Administration Set.

Source: www.kawasumiamerican.com/gravity-iv-administration-sets.

Structure of Primary Intravenous Administration Sets The primary IV administration set has a number of parts to facilitate the infusion and control of administration of drugs and fluids (see Figure 5.10). Table 5.3 describes the essential parts of a primary administration set (Figures 5.11 to 5.15).

Secondary Intravenous Administration Set

Secondary intravenous administration sets consist of shorter sterile PVC tubing and are used to piggyback and intermittently administer an IV medication in a separate container through attachment to the primary IV administration set (see Figure 5.6).

Structure of Secondary Intravenous Administration Set A secondary intravenous administration set is made up of straight tubing that is shorter than that of the primary IV administration set, with a spike at one end and a Luer-lock connection or needle on the other end for attachment to an injection port of a primary IV administration set. It is used to piggyback a drug admixture either in a Mini-Bag or a Mini-Bottle. It may also have a one-way back-check valve to prevent retrograde flow (backflow) of solution from the primary IV administration set during drug infusion.

Table 5.3 Parts of a Commonly Used Primary Intravenous Administration Set

Part	Description
Spike	• Facilitates insertion of the administration set into the injection site of the intravenous (IV) solution container • May be vented to allow easy solution flow

Drop orifice (Figure 5.11)	• Opens into the drip chamber • Determines size and shape of drop • Available sizes as macrodrip delivering 10–20 drops/mL and microdrip delivering 60 drops/mL • Provides on label of administration set the drop factor value of the set as drops per millilitre that can be used to calculate flow rate by gravity
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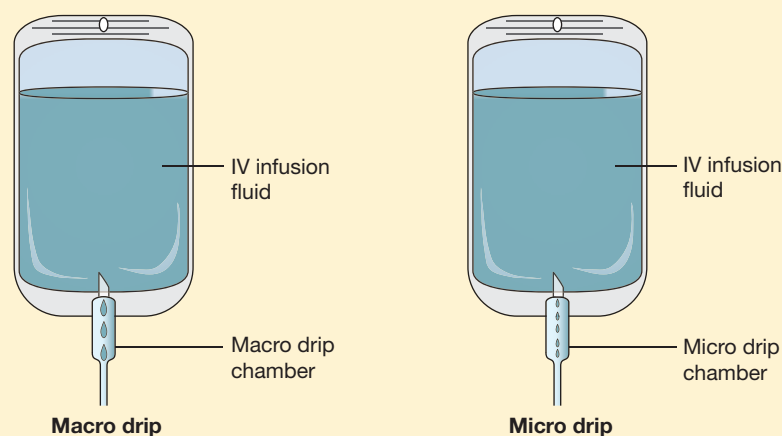


Figure 5.11 Macro drip and Microdrip Orifices and Drip Chambers.

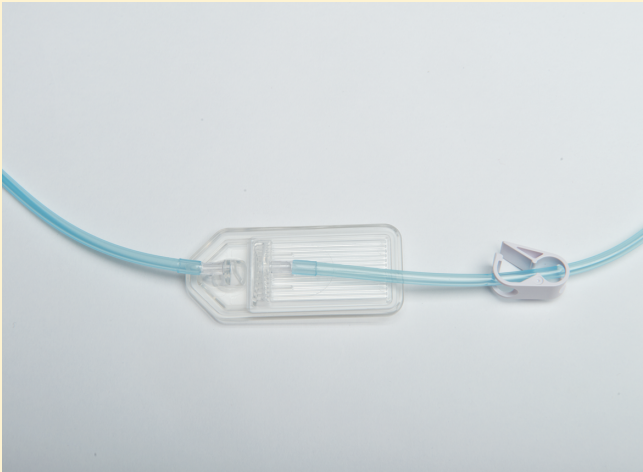
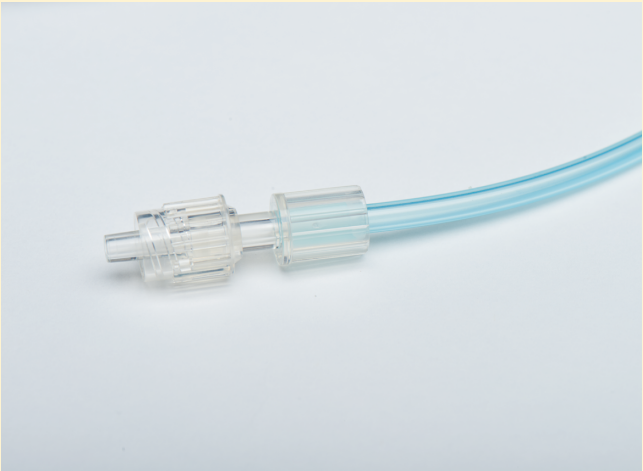
Source: Author created.

Drip chamber	• A pliable enlarged plastic chamber connecting the tubing of the administration set to the drop orifice and receiving drops of solution • Serves to establish flow rate as drops per unit time
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Tubing	• Long straight PVC (polyvinyl chloride) tubing connecting the drip chamber to the infusion site • Carries clamps, injection ports, connectors, and built-in in-line filters to control flow, allow piggyback and direct medication administration, and filtration of solution during infusion
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Injection ports (Figure 5.12)	• Located in the administration set below the drip chamber, providing connection for intermittent and direct injection of drug administration • Have the shape of the letter “Y” and, as such, are referred to as <i>Y injection ports</i>; possess a self-sealing rubber diaphragm to seal following injection
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Filters (Figure 5.13)	• Sterile membrane type filters of 5, 1.2, 0.45, and 0.22 micron porosity as a built-in part of the administration set • Filters solution during infusion to remove particles, including bacteria, depending on pore size, and minimize blood vessel irritation that can cause phlebitis
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Table 5.3 Parts of a Commonly Used Primary Intravenous Administration Set (continued)	
Part	Description
 	
Figure 5.12 Y Injection Port (Site). Source: Ian Crysler. Figure 5.13 Sterile In-Line Membrane Filter Units. Source: Ian Crysler.	
Back-check valve	Part of the primary administration set serves to automatically open or close during intermittent administration of a drug preventing backflow of drug up the primary IV administration set
Connector tip (Figure 5.14)	Located at end of the administration set, connecting the set to a catheter or needle entering the patient's blood vessel
Clamps (Figure 5.15)	- Varied configurations and effectiveness in controlling flow - Roller type most common and most effective in controlling flow - Also available as sliding type; however, not as easy to manipulate and less effective than the roller type
 	
Figure 5.14 Luer-Lock Type of Primary Intravenous Administration Set Connector Tip. Source: Ian Crysler. Figure 5.15 Types of Clamps on a Primary Intravenous Administration Set. Source: Ian Crysler.	

Source: Celeste, M. L., et al. (1993). *Infusion Technology Manual: A Self-Instructional Approach*. Bethesda, MD: American Society of Hospital Pharmacists; Turco, S., and King, R. E. (1979). *Sterile Dosage Forms* (2nd ed.). Philadelphia, PA: Lea & Febiger.

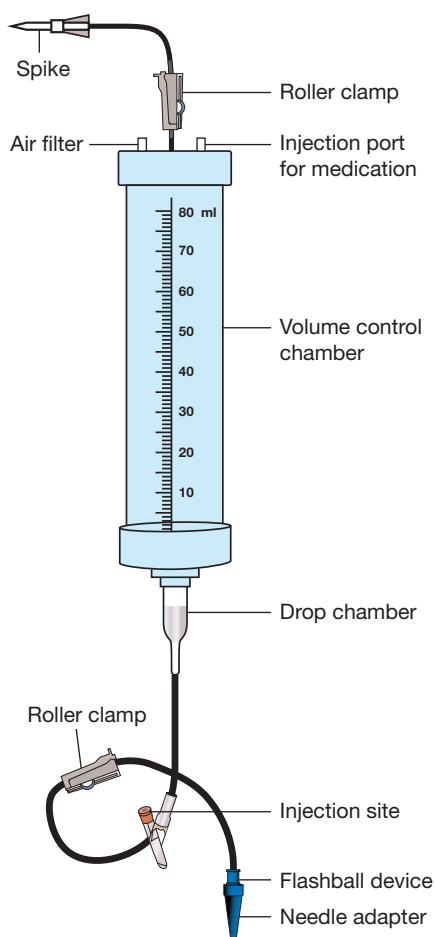


Figure 5.16 Volume Control Set.

Source: Author created.

Flow Regulators

Flow regulators are sophisticated flow control devices that are placed in-line with the primary IV administration set to regulate fluid flow in increments of 5 to 10 mL/hr. They work by responding to pressure fluctuations caused by patient movements and make automatic flow adjustments within $\pm 10\%$ accuracy. They reduce the need for manual flow rate adjustments by nurses (Celeste et al, 1993).

Volume Control Sets

Volume control devices offer an alternative intermittent medication delivery system. They are composed of a calibrated, clear, semi-rigid plastic chamber built into the set. The volume control chamber holds a specific volume of fluid and admixed drug. The chamber's top end is attached to a short IV tubing with a spiked end that is used to attach the set to the infusion fluid container. The bottom part of the calibrated chamber has a drop orifice delivering fluid into a drip chamber, which is attached to a long tubing delivering the fluid and dissolved drug to the patient. As with the primary IV administration set, there are proximal and distal clamps on the tubing, and these clamps are used to control the fluid flow rate. The medication is added to a measured volume in the chamber through an injection port (site) on the top of the chamber using a syringe and needle (Celeste et al, 1993; Turco & King, 1979; Perry & Potter, 2006) (Figure 5.16).

Volume control sets offer the following advantages:

- Are useful in pediatric and intensive care settings
- Enable critical measurement of fluid to be infused
- Allow drug dilution into primary fluid and make it easy to monitor and control drug concentration and fluid volume
- Allow use of minimum fluid volume for unstable drugs and shorter infusion times
- Are less expensive than other intermittent systems (Celeste et al, 1993; Turco & King, 1979; Perry & Potter, 2006)

Volume control sets have certain limitations, as listed below:

- Potential incompatibilities if multiple drugs/additives are added into the same chamber
- Possible inadequate mixing
- Potential lack of drug identity if chamber is not labelled
- Risk of bacterial/fungal contamination due to non-aseptic conditions during manipulation
- Long travel distance before drug enters patient's body
- More nursing time compared with premixed and labelled products from pharmacy (Celeste et al, 1993; Turco & King, 1979; Perry & Potter, 2006)

L05 Describe the vascular devices used for peripheral and central IV administration of drug solutions.

VASCULAR ACCESS DEVICES

The IV administration of drug admixtures requires the appropriate device to enter the **vascular** system. These devices are catheters of varied sizes and configurations to accommodate the site of infusion and type of medication fluid infused. Vascular access devices are

made of silicone plastic and thus are flexible and compatible with blood vessels. Thickness and length vary, depending on the area of infusion. They are inserted into a vascular channel (blood vessel) and connected to the connector tip of the primary IV administration set. They are named on the basis of the location of their terminal tip (peripheral vascular or central vascular location); intended life span; whether short-term, long-term, or permanent use; site of insertion; whether in a peripheral blood vessel, central subclavian blood vessel, or femoral blood vessel; pathway to the vascular vessel; and whether the setup is tunnelled or non-tunnelled. In addition, they may be named on the basis of their physical length (long or short) and structural make-up (whether double lumen), and/or barium/antibiotic impregnated type (Celeste et al, 1993; Cain et al, 2003).

Vascular devices are used to administer IV medications and related fluids either centrally or peripherally. Table 5.4 describes the vascular access devices used to administer sterile solutions intravenously.

percutaneously: introduced through the skin.
radiological: procedure using radiology to diagnose a condition and/or disease type of photograph made by sunlight on a film.

Table 5.4 Vascular Access Devices		
Vascular Access Device	Description	Application
Central venous access devices (central venous catheters)	• Long 30–75 cm in length • Made of biological compatible silicone or polyurethane material • Impregnated with radiological material (i.e., barium) for positioning confirmation in the blood vessel • Classified as tunnelled, nontunnelled, and peripherally inserted central catheters (PICCs) • Common brands in use include: Hickman, Broviac, and Groshong central catheters	• Inserted into large blood vessels, such as the subclavian and vena cava veins, for long-term infusions
Tunnelled (Figure 5.17)	• Long silicone or polyurethane central catheter • Can be disconnected from primary IV administration set, flushed with heparin and normal saline mixture, and capped after infusion to allow patient motility • Require entry area dressing and maintenance to minimize infection	• Inserted surgically commonly through the subclavian vein into the vena cava, then tunnelled under the skin to exit at chest, and secured to chest wall by special cuff • Long-term application (i.e., months, years)
Nontunnelled	• Same as tunnelled type	• Inserted percutaneously into the subclavian, jugular, or femoral vein but not tunnelled under the skin • Short duration (i.e., weeks, months)
PICC (Figure 5.18)	• Similar composition as the tunnelled and nontunnelled types • Contains radiological material to confirm position in blood vessel	• Inserted peripherally into the antecubital vein (cephalic or basilica vein) through an introducer needle and a cannula • Catheter tip terminates into the superior vena cava
Implantable ports	• Have a reservoir connected to a silicone catheter and a septum on the reservoir for injection of drugs • Catheter and reservoir completely under the skin	• Surgically implanted under the skin and secured in place

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Table 5.4 Vascular Access Devices (continued)

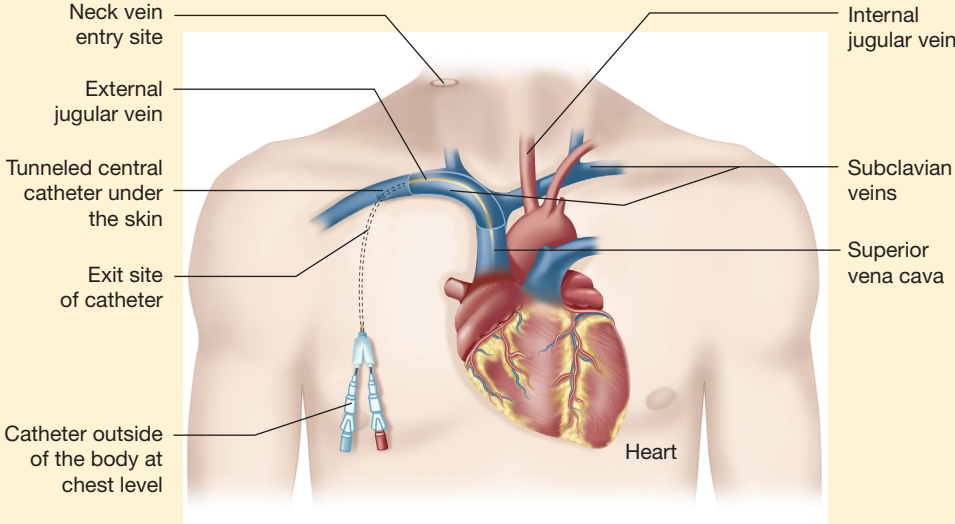
Vascular Access Device	Description	Application
		

Figure 5.17 Tunnelled Central Venous Catheter.

Source: Author created.

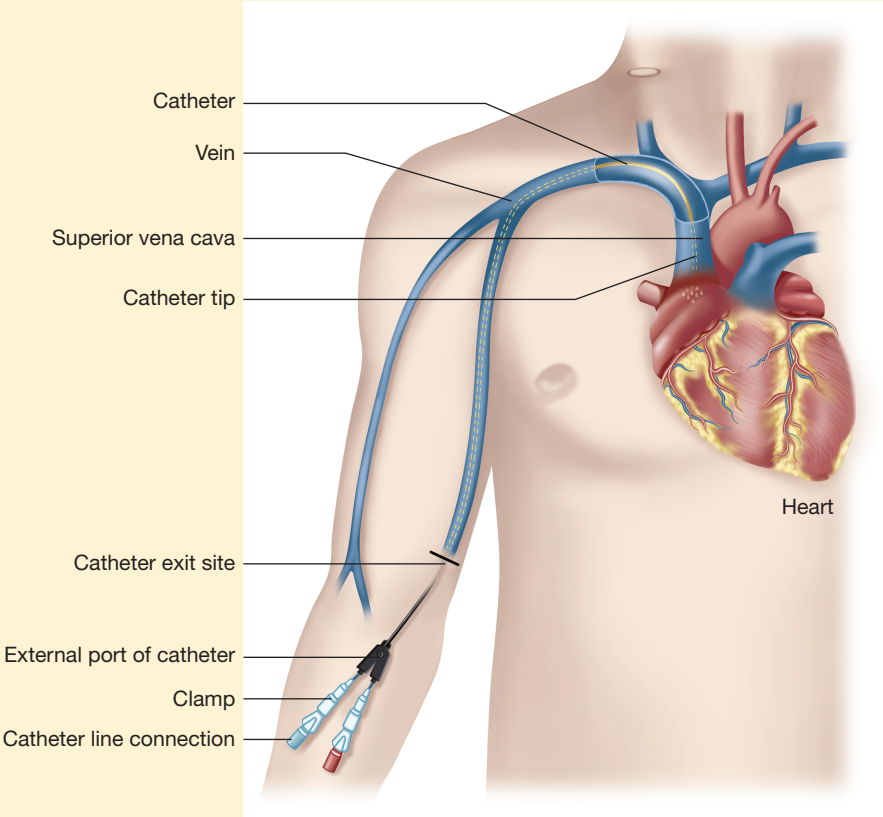
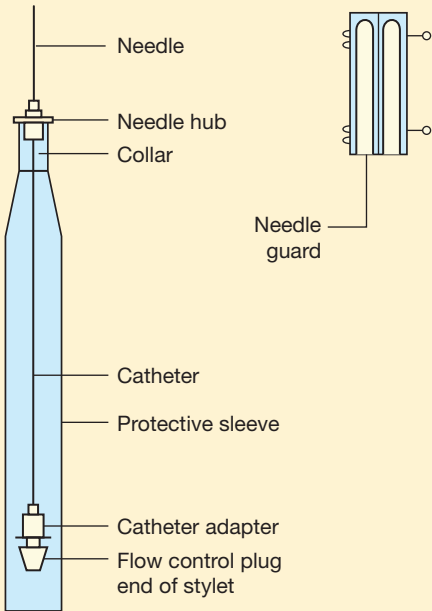


Figure 5.18 Peripherally Inserted Central Catheter.

Source: Author created.

Table 5.4 Vascular Access Devices (continued)		
Vascular Access Device	Description	Application
	• Use of a specially designed needle, the Huber needle, attached to the IV administration set; the needle pierces the skin and infuses the drug solution through the reservoir septum. • Following drug infusion, needle with administration set is removed, and catheter is flushed with heparin and normal saline, allowing patient mobility • Commonly used for long-term, intermittent, and continuous IV therapy, particularly cancer chemotherapy	
Midline catheters	• Considered a peripheral catheter of 7.5–20 cm long for 2- to 4-week infusion period • Made of soft polyurethane or silicone material • No site rotation requirement and thus minimal patient discomfort	• Threaded through a hollow cannula into the blood vessel and the terminal tip positioned in the axillary vein
Needles	• Made of stainless steel, needles are of varied length and thickness, with similar parts as an “ordinary” needle that can be attached to the connector tip of the IV administration set and/or a syringe • Commonly used needles are winged vein needles, butterfly needles, and scalp vein needles • Flexible wings are used to anchor the needle to the insertion site, and a medium or short length of plastic tubing with an injection port or Luer-lock adaptor is used for attachment to the tip of an IV administration set • Referred to also as <i>heparin locks</i>, as they contain heparin or normal saline to prevent blood clotting when the catheter is not being used. • Used for short-term peripheral IV drug administration	• Inserted into a hand and/or arm vein
Short plastic peripheral catheters	• There are two types of soft and flexible catheters a) Over-the-needle type b) Through-the-needle type	• Inserted into hand and/or arm vein
a) Over-the-needle type catheter	• Over-the-needle catheter has an introducer needle, which is located inside the flexible plastic catheter tubing and is used to enter the blood vessel and insert the catheter into the blood vessel	

(Continued)

Table 5.4 Vascular Access Devices (continued)		
Vascular Access Device	Description	Application
b) Through-the-needle type catheter) (Figure 5.19)	• Needle is withdrawn and completely removed and the catheter is connected to the tip of the IV administration set • Protective needle guard secures needle and catheter • Through-the-needle type catheter has an introducer needle, which is over the plastic catheter • Once catheter is in place, the needle is retracted from the catheter and covered by a protective needle guard • The catheter is connected by an adapter to the connector tip of the IV administration set	
 Figure 5.19 Through-The-Needle Catheter. Source: Celeste M. Lindley C. M. and Deloatch, K. H. (1993). <i>Infusion Technology Manual. A Self-Instructional Approach</i>. Bethesda, MD: American Society of Hospital Pharmacists.		

Source: Celeste, M. L., et al. (1993). *Infusion Technology Manual: A Self-Instructional Approach*. Bethesda, MD: American Society of Hospital Pharmacists; Cain, D., and Kelly, H. L. (2003). *Home Infusion Pharmacy Certificate Program, Module 3. Overview of Infusion Devices, Vascular Access Devices, and Ancillary Supplies*. Alexandria, VA: National Home Infusion Association; Jeejeebhoy K. N. (1983). *Total Parenteral nutrition in the Hospital and Home*. Boca Raton, FL: CRC Press.

L06 Differentiate between electronic and non-electronic IV administration devices.

ELECTRONIC AND NON-ELECTRONIC INTRAVENOUS INFUSION METHODS

Intravenous infusion methods of medication admixtures utilize both electronic and non-electronic systems. Table 5.5 describes these methods, including their advantages and limitations.

Table 5.5 Common Electronic and Non-electronic Intravenous Drug Infusion Methods	
Infusion Method	Description
Non-electronic devices	
Gravity flow	- Simple intravenous (IV) infusion utilizing gravity to pull down the solution from the IV container hanging on an IV pole through an IV administration set into a patient's vein - Utilizes the clamps and drip chamber on the administration set to control infusion rate in drops per minute - Relatively high error rate requiring frequent observation and adjustments of flow rate
Elastomeric reservoir infusion pumps	- Small, inexpensive, and lightweight disposable devices, made of an elastic reservoir encased in a rigid plastic outer shell - Elasticity of the reservoir exerts constant pressure at ~ 10 pounds per square inch (PSI), forcing solution through a flow restrictor and the PVC (polyvinyl chloride) tubing into the patient's vein - Commonly used to administer cancer drug infusions
Electronic devices	
Positive pressure pumps	- Generate positive pressure at ~ 2–12 PSI to push solution through the administration set into the patient's vein - Provides accurate flow rate and the ability to accommodate fine infusion rate adjustments - No impact of minor occlusions and resistance due to back pressure and solution viscosity - Has alarm system and intelligence to alert nurse of significant tubing occlusions, empty container, presence of air in the tubing, flow rate issues, and related infusion problems - Devices include: - Peristaltic pumps with an infusion rate accuracy of 5–10% or less utilizing a special silicon tubing, which is less prone to distortions - Cassette patient-controlled anesthesia (PCA) portable pumps utilizing special administration set; commonly used to administer infusions of narcotic analgesics - Syringe-type devices of 60 mL capacity or less; utilizing electronic power to push syringe plunger at ~ 2 PSI pressure, at specific infusion rate of X millilitres per minute

Source: Celeste, M. L., et al. (1993). *Infusion Technology Manual: A Self-Instructional Approach*. Bethesda, MD: American Society of Hospital Pharmacists; Turco, S., and King, R. E. (1979). *Sterile Dosage Forms* (2nd ed.). Philadelphia, PA: Lea & Febiger; Perry, A. G., and Potter, P. A. (2006). *Clinical Nursing Skills and Techniques* (6th ed.). Toronto, Canada: Mosby.

CLINICAL AND PHARMACEUTICAL COMPLICATIONS OF INTRAVENOUS THERAPY

Parenteral therapies are invasive in nature and more likely to cause serious complications compared with oral and topical therapies. Complications range from mild to life-threatening situations. However, most complications can be prevented or minimized by strict adherence to standards of practice.

L06 Recall the physical and clinical adverse effects of IV therapy.

oxidation: a chemical reaction in which a substance combines with oxygen.

hydrolysis: a chemical reaction in which a substance combines with water to produce either an acid or a base.

photodegradation: the breakdown of a substance by light.

photolysis: loosening and/or dissolving of a substance by light.

Pharmaceutical complications involve the stability/compatibility of formulations and admixture preparations.

Stability is a consideration to ensure that a sterile preparation would be safe and clinically effective. However, when a number of components are admixed together, consideration must also be given to incompatibility issues. *Compatibility* refers to the state of two or more substances mixed together maintaining both physical and chemical stability in the admixture. *Incompatibility* refers to a physical and/or chemical phenomenon that results in reducing the concentration of the active ingredient(s).

Physical incompatibility is visual, such as precipitation, cloudiness, colour, viscosity, and so on, whereas chemical incompatibility is a chemical process that results in the breakdown of the active ingredient(s). It includes **oxidation**, **hydrolysis**, **photodegradation**, and **photolysis**, which are often irreversible and produce either inactive or toxic products, including gas evolution.

There are certain criteria that must be considered with respect to acceptable levels of stability. These criteria are:

- Physicochemical
 - Active ingredients must retain their chemical integrity and potency of labelled strength within specified limits, and the physical properties of the preparation should maintain acceptable appearance, uniformity, dissolution, and related characteristics within acceptable specified limits.
- Microbiological
 - Absence of microbial contamination also is part of a preparation's stability in that sterility, or resistance to microbial growth, is retained, and, where necessary, the preparation may require antimicrobial preservatives to ensure antimicrobial stability during product manipulation.
- Therapeutic
 - A sterile preparation must also retain its intended therapeutic effect, with no changes in potency that would impact on the clinical effect of the product.
- Toxicological
 - The sterile preparation must not develop undesirable substances during storage, such as leached chemicals from the container and degradation products that will increase the toxicity of the product.

These stability criteria are key to establishing a proper expiration date for the sterile preparation. The *expiration date* is the shelf-life assigned to a product reflecting the longest time during which the product will meet compendia requirements under the stated conditions. During this period, the product must retain minimum 90% of its labelled strength (Buchanan et al, 2009).

"Expiration date" is a relatively new term, based on the United States Pharmacopeia (USP) Chapter 797 (Pharmaceutical Compounding—Sterile Preparations) requirements, given to a compounded product following dilution, reconstitution, transfer, and so on and signifies the "beyond-use date." Determination of this date would be based on professional experience and interpretation of reliable sources of information.

The assigned beyond-use date is based on two factors:

1. The chemical stability of active ingredient(s) and the maximum time period in which 90% or greater of the labelled strength of the active ingredient is measurable
2. The sterility limitations of the preparation

The stability and compatibility of a sterile compounded product is affected by a number of factors (Table 5.6).

Table 5.6 Factors Affecting Stability of an Intravenous Admixture Solution

Factor	Interpretation
pH	• Effect of acidity/alkalinity on solubility and stability of admixture components, including the physicochemical behaviour of these components
Electrolytes	• Mineral elements carrying a positive or negative charge that can interact with the drug and other admixture components, forming insoluble substances, such as precipitates
Light	• Light and particular sunlight emits ultraviolet (UV) radiation that can cause degradation of light-sensitive drugs following exposure
Temperature	• Affects physicochemical stability if inappropriate during admixture storage, producing crystals or degradation of the drug
Degree of dilution	• Level of drug dilution can affect solubility and stability of admixture components
Contact time	• Degree of contact with container, such as the polyvinyl chloride (PVC) type, can result in sorption, adsorption, and absorption of drug, rendering it clinically unavailable
Type of solution vehicle	• Type of IV solution vehicle for the drug can impact the stability of a drug
Number of additives	• Number of substances other than the drug added to the IV admixture, which can increase admixture complexity and create an unstable environment for the drug
Buffer capacity of solution	• Certain solutions have good buffering capacity to maintain drug stability • Other solutions may require addition of buffer to adjust admixture pH prevent incompatibility and improve drug stability
Order of mixing	• The admixing order of solution components can affect stability and incompatibility of admixture

Source: Buchanan, E. C., and Schneider, P. J. (2009). *Compounding Sterile Products* (3rd ed.). Bethesda, MD: American Society of Health System Pharmacists; Turco, S., and King, R. E. (1979). *Sterile Dosage Forms* (2nd ed.). Philadelphia, PA: Lea & Febiger.

➤ Safety Alert 5.1

Minimizing Additives in a Drug Admixture Minimizes Incompatibilities

When additives are considered for inclusion in an intravenous drug admixture for infusion, whether in the pharmacy or on the nursing unit, both the stability and compatibility of the drug admixture must be examined prior to preparation/administration to avoid adverse effects. Most drugs are to be administered separate from other agents, by intermittent infusion and/or intravenous push. However, there are occasions when nurses are required to add certain additives. Since the pharmacy personnel have the expertise and resources, they must communicate to and/or counsel nurses of any potential incompatibilities when additives are to be used by nurses on the nursing unit.

INFUSION FLOW RATES

Intravenous admixtures are administered by infusion over a period of time at a specific flow rate that is expressed in drops per minute (drops/min), millilitres per hour (mL/hr), or milligrams per kilogram of body weight per minute (mg/kg/min). Flow rates using gravity are

L07 Describe IV drug infusion by gravity flow and the factors that can affect the accuracy of this method of drug infusion.

thromboembolism: blocking of a blood vessel by a blood clot (thrombus) that broke off from the place where it started.

edema: fluid collection in the interstitial spaces of tissues.

adverse effects: undesired and/or toxic effects.

acceptable for most IV admixture infusions for adults but are not as accurate and/or precise as using an electronic pump or other similar devices that can automatically control flow rate.

Accuracy of flow rate is important for the following reasons:

- Ensuring patient safety
- Ensuring drug efficacy
- Minimizing toxic outcome
- Preventing inadequate dose at any one time to meet therapeutic blood levels
- Minimizing phlebitis
- Preventing **thromboembolism**
- Preventing **edema**
- Preventing **adverse effects** of the medication

A number of factors can affect the accuracy of the flow rate of IV infusion by gravity. Table 5.7 highlights those factors.

Table 5.7 Factors Affecting Flow Rate Accuracy by Gravity	
Factor	Effect on Flow Rate
Clamps of intravenous (IV) administration set	• Cause distortions of administration tubing affecting flow • Clamp repositioning on tubing due to gravity effects can result in runaway flow
Diameter and length of IV administration set	• Length increases flow resistance, thus reducing flow rate • Large diameter increases flow rate
In-line filters	• Depending on particulate retention level, decrease flow rate and could totally block flow
Patient body movements, blood pressure, and fluid infiltration	• Movements of hand position can reduce and/or impede flow • Changes in blood pressure increase resistance and reduce flow • Infiltration into interstitial spaces increases resistance and reduces flow
Height of IV solution container	• Height of IV solution bag on IV pole can increase/decrease flow (Note: once flow rate is set, no changes can be made to IV container height)
Clot formation	• Blood clot in the catheter/cannula will impede flow
Kinked tubing of IV administration set	• Patient lying/sitting on tubing can block flow
Pressure changes in IV container	• Volume changes in the solution container alter infusion pressure and thus flow rate • Addition of additives of varied volumes will impact on infusion pressure and the flow rate
Temperature and nature of solution	• Solution temperature will affect blood vessel physiology, with cold solutions causing vasoconstriction, which results in increased resistance and reduced flow rate • Solution viscosity affects flow rate by affecting drop size and thus the solution volume leaving the drip chamber • Administration sets have been calibrated with water; thus solutions with physical composition different from water will affect drop size, volume, and thus flow (i.e., total parenteral nutrition (TPN) solution is more dense thus smaller drop size)

Source: Turco, S., and King, R. E. (1979). *Sterile Dosage Forms* (2nd ed.). Philadelphia, PA: Lea & Febiger.

CALCULATIONS OF FLOW RATES

Intravenous infusion flow rates are expressed as a unit of volume per unit of time. Common units of volume are in millilitres per hour or drops per minute. This calculation expresses the rate at which the sterile solution is infused into the patient. When expressed as drops per minute, it would be referred to as the *drip rate*.

Administration infusion rate is calculated using the following formula:

$$\text{Administration rate (AR)} = \frac{\text{Total volume (TV) to be infused (mL)}}{\text{Infusion time (IT) (hours or minutes)}}$$

L08 Calculate flow rate in millilitres per hour or drops per minute, as well as in milligrams per kilogram per minute, when using gravity IV drug infusion.

Example 5.1

Calculate the flow rate of the following IV order:

Rx: 1000 mL of 0.9% sodium chloride to be infused over 8 hours.

$$\begin{aligned}\text{Administration rate (AR)} &= \frac{\text{TV}}{\text{Infusion time (IT) (minutes)}} = \frac{1000 \text{ mL}}{8 \times 60} \\ &= \frac{1000 \text{ mL}}{480 \text{ minutes}} = 2.08 \text{ mL/min}\end{aligned}$$

Most nurses calculate the number of drops per minute, or the drip rate, to ensure correct infusion of the IV solution by utilizing the *drop factor* (drops/mL), which is stated on the label of the IV administration set. A drop factor is specific to a particular set and the manufacturer of that set. Not all IV administration sets have the same drop factor. Micro-drip IV sets are calibrated at 60 drops/mL, and macrodrip IV sets are calibrated at 10 or 20 drops/mL. Always ensure that you know the proper drop factor before beginning the conversion of flow rate to drops per minute.

Drip rate is calculated by using the following formula:

$$\text{Drip rate (DR)} = \frac{\text{Total volume (TV) to be infused (mL)}}{\text{Infusion time (IT) (min)}} \times \text{Drop factor (DF)} = \text{Drops/Minute}$$

Example 5.2

Rx: 500 mL of D5W (5% dextrose in water) to be infused over 4 hours using an IV administration set with a drop factor of 10 drops/mL.

Calculate the drip rate/flow rate in drops per minute.

Solution

Determine the total time in minutes required to infuse the 500 mL of D5W:

$$4 \text{ hr} \times 60 \text{ min/hr} = 240 \text{ min}$$

Set up the formula:

$$\text{Drip rate (DR)} = \frac{\text{Total volume (TV) to be infused (mL)}}{\text{Infusion time (IT) (minutes)}} \times \text{Drop factor (DF)} = \text{Drops/Minute}$$

$$500 \text{ mL}/240 \text{ min} \times 10 \text{ drops/mL} = X \text{ drops/min}$$

Cancel like-units before multiplying:

$$500 \cancel{\text{ mL}}/240 \text{ min} \times 10 \text{ drops}/\cancel{\text{ mL}} = X \text{ drops/min}$$

Multiply 500×10 , then divide by 240, and the resulting answer will be in drops/min:

$$5000/240 = 20.8 \approx 21 \text{ drops/min}$$

Example 5.3

Rx: 1000 mL of NS (normal saline) are to be infused over 8 hours using an IV administration set with a drop factor of 10 drops/mL.

Calculate the drip rate/flow rate in drops per minute.

Solution

Determine the total time to be infused:

$$8 \text{ hr} \times 60 \text{ min/hr} = 480 \text{ min}$$

Set up the formula:

$$\text{Drip rate (DR)} = \frac{\text{Total volume (TV) to be infused (mL)}}{\text{Infusion time (IT) (minutes)}} \times \text{Drop factor (DF)} = \text{Drops/Minute}$$

$$1000 \text{ mL}/480 \text{ min} \times 60 \text{ drops/mL} = X \text{ drops/min}$$

Cancel like-units before multiplying:

$$1000 \cancel{\text{ mL}}/480 \text{ min} \times 60 \text{ drops}/\cancel{\text{ mL}} = X \text{ drops/min}$$

Multiply 1000×60 , then divide by 480, and the resulting answer will be in drops/min:

$$60\,000/480 = 125 \text{ drops/min}$$

Example 5.4

Rx: NS 1000 mL, D5W 1000 mL, lactated Ringer solution (LR) 2000 mL; infuse one bag after the other over 18 hours.

Calculate the drip rate/flow rate in drops per minute using an administration set with a drop factor of 20 drops/mL.

Solution

First, we need to determine the total volume to be infused:

$$1000 \text{ mL} + 1000 \text{ mL} + 2000 \text{ mL} = 4000 \text{ mL}$$

Next, we convert the total infusion time of 18 hours to minutes:

$$18 \text{ hr} \times 60 \text{ min/hr} = 1080 \text{ min}$$

Set up the formula:

$$\text{Drip rate (DR)} = \frac{\text{Total volume (TV) to be infused (mL)}}{\text{Infusion time (IT) (minutes)}} \times \text{Drop factor (DF)} = \text{Drops/Minute}$$

$$4000 \text{ mL}/1080 \text{ min} \times 20 \text{ drops/mL} = X \text{ drops/min}$$

Cancel like-units before multiplying:

$$4000 \cancel{\text{ mL}}/1080 \text{ min} \times 20 \text{ drops}/\cancel{\text{ mL}} = X \text{ drops/min}$$

Multiply 4000×20 , then divide by 1080, and the resulting answer will be in drops/min:

$$80\,000/1080 = 74.07 \approx 74 \text{ drops/min}$$

IV rates should always be rounded to the nearest whole number (mL), since decimal values cannot be accurately measured.

Due to the high potency of medications used in clinical settings such as critical care units and emergency units, flow rates must be carefully and accurately monitored. Flow rates in these cases are calculated on the basis of the dose of the medication to be administered, in milligrams and/or microgram per kilogram of body weight of the patient per minute

(Osis, 2003). This dose would then be converted to millilitres per hour or drops per minute by using either a dosage chart or the following equation:

$$\begin{aligned}\text{Flow rate (FR)} &= \frac{\text{Amount of drug required (mcg or mg)} \times \text{Weight of patient (kg)} \times 60 \text{ min/hr}}{\text{Concentration of drug (mg or mcg/mL)}} \\ &= \text{FR (mL/hr)}\end{aligned}$$

Example 5.5

Calculate the flow rate for a dose of a parenteral drug infusion in mcg/kg/min, considering the following order:

Rx: Furosemide 0.02 mg/kg/min intravenously

Given: Patient weight: 60 kg

Furosemide IV admixture: 0.4 mg/mL in D5W

IV administration set with a drop factor of 15 drops/mL

$$\begin{aligned}\text{Flow rate (FR)} &= \frac{\text{Amount of drug required (mcg or mg)} \times \text{Weight of patient (kg)} \times 60 \text{ min/hr}}{\text{Concentration of drug (mg or mcg/mL)}} \\ &= \text{FR (mL/hr)}\end{aligned}$$

$$\begin{aligned}\text{FR} &= \frac{0.02 \text{ mg} \times 60 \text{ kg} \times 60 \text{ min}}{0.4 \text{ mg/mL}} = 180 \text{ mL/hr} = 3 \text{ mL/min} = 3 \text{ mL} \times 15 \text{ drops/mL} \\ &= 45 \text{ drops/min}\end{aligned}$$

Therefore the dose of 0.02 mg/kg/min will be delivered at a flow rate of 3 mL/min of 45 drops/min.

Example 5.6

Rx: Dobutamine 20 mcg/kg/hr IV infusion

Given: Patient weight: 70 kg

Dobutamine admixture: 0.5 mg/mL (500 mcg/mL) in D5W

Administration set drop factor: 10 drops/mL

Calculate the infusion rate in mL/min and drops/min.

Solution

$$\begin{aligned}\text{Flow rate (FR)} &= \frac{\text{Amount of drug required (mcg or mg)} \times \text{Weight of patient (kg)} \times 60 \text{ min/hr}}{\text{Concentration of drug (mg or mcg/mL)}} \\ &= \text{FR (mL/hr)}\end{aligned}$$

$$\begin{aligned}\text{FR} &= \frac{20 \text{ mcg} \times 70 \text{ kg} \times 60 \text{ min/hr}}{500 \text{ mcg/mL}} = 168 \text{ mL/hour} = 168/60 = 2.8 \text{ mL/min} \\ &= 10 \text{ drops/mL} \times 2.8 \text{ mL} = 28 \text{ drops/min}\end{aligned}$$

Therefore, to deliver the dose of 20 mcg/kg/hr, the xylocaine admixture must be infused at 2.8 mL/min or 28 drops/min.

An IV order identifies the flow rate of a sterile solution, so the task is to determine the volume required over a time interval. This aspect of IV therapy is referred as the *frequency* or *schedule* of an IV infusion. It is the time that it takes, in hours, to infuse a specific

volume of solution. When expressing an IV frequency/schedule, do not follow standard rounding rules. Always round the frequency/schedule of an IV down to the nearest whole number in hours, as this will ensure that the patient has enough IV to last over the scheduled period of time.

The IV frequency/schedule of a solution is calculated using the following formula:

$$\text{IV Frequency (F)} = \frac{\text{Total volume (TV) to be infused (mL)}}{\text{Flow rate (FR) (mL/hr)}} = \text{number of hours of infusion}$$

Example 5.7

Rx: NS 1 L to be infused at 145 mL/hr.

What is the frequency (F) of a 1-L IV bag?

Solution

$$1 \text{ L} = 1000 \text{ mL}$$

$$F = \frac{\text{Total volume (TV) (mL)}}{\text{Flow rate (FR) (mL/hr)}} = \frac{1000 \text{ mL}}{145 \text{ mL/hr}} = 6.9 \text{ hr}$$

Therefore, a 1-litre (L) bag will last 6.9 hours, or the frequency is q6h (every 6 hours). Thus, the number of 1-L bags that should be provided to cover a 24-hour therapy would be four bags, a little more than the specific amount of 3.4 bags (i.e., 24 hours/6.9 hours = 3.4 bags).

Example 5.8

What is the frequency of a 500-mL IV bag if the rate of infusion (flow rate) is 50 mL/hr?

Solution

$$F = \frac{\text{Total volume (TV) (mL)}}{\text{Flow rate (FR) (mL/hr)}} = \frac{500 \text{ mL}}{50 \text{ mL/hr}} = 10 \text{ hr}$$

Therefore, a 500-mL IV bag will last 10 hours, or the frequency is every 10 hours (q10h). Thus, the number of 500-mL bags that should be provided to cover a 24-hour therapy would be three bags, a little more than the specific amount of 2.4 bags (i.e., 24 hours/10 hours = 2.4 bags).

CHAPTER SUMMARY

In summary, this chapter has addressed the following key points:

- L01** Drugs can be administered through parenteral routes, including subcutaneous (SC), intramuscular (IM), intradermal (ID), and intravenous (IV) injections.
- L02** Advantages and disadvantages of the parenteral administration methods, clinical risk factors, and their impact on patient safety are explained.
- L03** Drug delivery systems for continuous and intermittent IV infusions are described.

- L04** Common non-automated and automated devices include primary and secondary IV administration sets and their parts such as electronic and non-electronic systems of IV drug delivery.
- L05** Catheters and related vascular devices are used for central and peripheral IV administration of drug infusions.
- L06** Compatibility and stability issues, include clinical adverse effects caused by IV drug therapy.
- L07** Gravity flow rate and related factors, as well as physical and clinical factors, can affect the accuracy of IV drug administration.
- L08** Flow rate is calculated in millilitres per minute and/or drops per minute, as well as drug dose infusions in milligrams per kilograms of body weight per minute.

KEY TERMS

abscess (pg 000)
 adverse effect (pg 000)
 alimentary tract (pg 000)
 circulatory overload (pg 000)
 colloidal dispersion (pg 000)
 cyst (pg 000)
 depot (pg 000)
 edema (pg 000)
 embolism (pg 000)
 emulsion (pg 000)

hematoma (pg 000)
 hydrolysis (pg 000)
 hypodermic (pg 000)
 local anesthetic (pg 000)
 local infection (pg 000)
 necrosis (pg 000)
 nonvesicant (pg 000)
 oxidation (pg 000)
 paralysis (pg 000)
 percutaneously (pg 000)

phlebitis (pg 000)
 photodegradation (pg 000)
 photolysis (pg 000)
 radiological (pg 000)
 scapula (pg 000)
 systemic infection (pg 000)
 thromboembolism (pg 000)
 thrombosis (pg 000)
vascular (pg 000)
 vesicant (pg 000)

FOCUS ON ETHICS

Importance of System Activation to Ensure Drug Delivery

Intravenous (IV) delivery systems, such as Add-Vantage and Mini-Bag Plus, with attached medication from the pharmacy, must be activated by the nurse administering the medication to ensure that the attached medication has been reconstituted and/or admixed with the infusion fluid in the Add-Vantage and Mini-Bag Plus for proper administration. Pharmacy technicians must examine such systems returned to the pharmacy to verify that the medication dose has been administered and, if the medication had not been used, that the system is still intact and not activated. Inactivated systems can only be stored for 30 days; beyond this time they must be discarded.

1. What should the pharmacy technician working on a nursing unit look for when an IV medication attached to an Add-Vantage and/or Mini-Bag Plus system is returned him/her by a nurse to take back to pharmacy? **(NAPRA 3.2.3, 3.2.5, 4.2)**
2. How does the pharmacy technician verify that the medication was administered as prescribed? **(NAPRA 3.1.1, 3.1.6, 4.2)**
3. What should the pharmacy technician do when discovering a medication incident? **(NAPRA 9.2.3)**

CRITICAL THINKING

Mr. Brown, a 65-year-old man weighing 60 kg, is being treated in the hospital for a surgical infection. He is receiving continuous infusion of normal saline (NS) with electrolytes, 1000 mL over 12 hours daily, to maintain fluid and electrolyte balance. The NS plus electrolyte solution bag is attached to a primary intravenous (IV) administration set with a macrodrip chamber and a drop factor of 15 drops per millilitre.

He has been prescribed an antibiotic, cefazolin, 1 g IV q8h, to treat his infection to be infused over 30 minutes. . .

1. What common delivery system and method of IV administration would you choose to package and administer this medication? (NAPRA 3.2.5, 3.3.2)
2. What is the rate of infusion in millilitres per hour of the NS solution with electrolytes? (NAPRA 3.1.4, 3.1.5)
3. What is the rate of infusion in drops per minute of the NS solution with electrolytes? (NAPRA 3.1.4, 3.1.5)
4. What is the flow rate of infusion of cefazolin per kilogram per minute? (NAPRA 3.1.4, 3.1.5)

CASE STUDY

Identifying Intravenous Delivery Systems, Administration Method, Infusion Rate, Stability/Compatibility, and Labeling of an Intravenous Admixture

Mr. Blair, a 75-year-old man weighing 60 kg, was admitted to the Gastroenterology Unit of the Miracle Hospital with severe diarrhea due to food poisoning. After examining Mr. Blair, Dr. Clark ordered IV fluids of D5W 1000 mL q12h, for the next three days with added electrolytes, such as potassium, sodium, calcium, and magnesium, since Mr. Blair was severely dehydrated. In addition, suspecting *Salmonella* poisoning, Dr. Clark prescribed Septra, 500 mg IV q12h, to be mixed in the D5W electrolytes fluid admixture.

1. What considerations must be taken into account prior to admixing this order? (NAPRA 6, 8.3, 9.2)
2. If the drug is determined to be incompatible with D5W and electrolytes, what IV delivery system and/or administration method would you use to administer the medication? (NAPRA 2.3.4, 6.8.3, 9.2)
3. What would be the infusion rate of the drug admixture in millilitres per hour and drops per minute when a primary IV administration set was used with a drop factor of 10 drops/mL? (NAPRA 3.1.4, 3.1.5)
4. What is the dose rate of Septra in mg/kg/hr? (NAPRA 3.1.4, 3.1.5)

REVIEW QUESTIONS

1. What is a subcutaneous injection?
 - a. An injection into the dermis
 - b. An injection into the epidermis
 - c. An injection into a blood vessel
 - d. An injection into the skin layer below the dermis(NAPRA 6)

2. Which of the following parenteral drug administration routes would provide the fastest pharmacological effect of an injected drug?
- Intramuscular injection
 - Intravenous injection
 - Subcutaneous injection
 - Intradermal injection
- (NAPRA 6)**
3. Which of the following parenteral routes can be administered by continuous infusion?
- Intramuscular
 - Subcutaneous
 - Intravenous
 - a & b
 - b & c
- (NAPRA 6)**
4. What is a common complication seen with intramuscular injections?
- Paralysis of the muscle
 - Phlebitis
 - Hematoma
 - Scarring
- (NAPRA 6)**
5. Which of the following statements describes best the intravenous (IV) administration of a drug using the intermittent administration method?
- An IV push injection of a drug into a vein
 - An injection of a drug with no interruptions over the prescribed administration period
 - A most common IV administration method for an emergency drug
 - The administration of a drug at spaced intervals
 - The direct injection of a drug into a Y injection site
- (NAPRA 3.2.5, 6)**
6. Which of the following parenteral dosage forms can be administered by the intravenous route?
- Aqueous solutions
 - Suspensions
 - Fat emulsions
 - a & b
 - a & c
- (NAPRA 6)**
7. Which of the following factors has the potential to cause phlebitis or thrombophlebitis?
- Location of the catheter
 - Composition material of the catheter
 - Length of time catheter is in blood vessel
 - Particulate matter present in the intravenous drug admixture
 - All of the above
- (NAPRA 6)**
8. A physician orders an intravenous (IV) solution to run 120 mL/hr. The hospital is using an IV Administration set that has a drop factor of 15 drops/mL. Which of the following flow rates would be the correct flow rate?
- 30 drops/min
 - 20 drops/min
 - 40 drops/min
 - 12 drops/min
- (NAPRA 3.1.4, 3.1.5)**

9. A physician order states 1.5 g of cloxacillin in D5W, 1000 mL q12h. What would be the rate of drug infusion?
- a. 150 mg/hr
 - b. 125 mg/hr
 - c. 120 mg/hr
 - d. 100 mg/hr

(NAPRA 3.1.4, 3.1.5)

10. A physician order states that 120 millimoles (mmol) of sodium as sodium chloride in 1000 mL of D5W to be infused at a rate of 12 mmol/hr. What would be the rate of infusion (i.e., rounded) in drops per minute when using an administration set with a drop factor of 15 drops/mL?
- a. 12 drops/min
 - b. 25 drops/min
 - c. 15 drops/min
 - d. 24 drops/min

(NAPRA 3.1.4, 3.1.5)

11. A physician in the emergency department describes an intravenous (IV) medication order for dopamine 5 mcg/kg/min for a 60-kg male patient with myocardial infarction. The pharmacy has a premixed solution of 200 mg of dopamine in 250 mL of D5W. The emergency department nurse will use an administration set with a drop factor of 10 drops/mL. What would be the flow rate of the drug solution (in mL/min and drops/min)?
- a. ~0.5 mL/min or 5 drops/min
 - b. ~0.6 mL/min or 6 drops/min
 - c. ~0.2 mL/min or 2 drops/min
 - d. ~0.4 mL/min or 4 drops/min

(NAPRA 3.1.4, 3.1.5)

12. Which of the following descriptions is not true about a drop orifice of an intravenous (IV) administration set?
- a. Delivers same drop size of fluid irrespective of IV administration set
 - b. Opens into the drip chamber of an IV administration set
 - c. Important in establishing drip rate of infusion
 - d. Reflected as a drop factor on the package label of the IV administration set

(NAPRA 3.2.5, 6)

13. Which of the following intravenous admixture incompatibilities is not a physical incompatibility?
- a. Precipitation
 - b. Oxidation
 - c. Discoloration
 - d. Cloudiness

(NAPRA 6)

14. A peripherally inserted central catheter (PICC) is inserted:
- a. Centrally directly into the superior vena cava
 - b. Centrally into the subclavian vein
 - c. Peripherally, with the catheter tip into the superior vena cava
 - d. Peripherally into the basilica vein and tunnelled into the superior vena cava

(NAPRA 6)

15. What is an elastomeric reservoir pump?
- a. A pump that has a balloon-like reservoir to hold the intravenous (IV) drug solution and an electrical infusion controller
 - b. A syringe reservoir to hold the IV drug solution and an external balloon-like elastomer to apply pressure to infuse the drug solution
 - c. A pump with a balloon-like chamber that can hold a Mini-Bag and an elastomer to exert pressure on the Mini-Bag to infuse the solution
 - d. A disposable device made of an elastic reservoir encased in a rigid plastic outer shell.

(NAPRA 3.2.5, 3.3.2)

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