# Pharmaceutical Calculation Lecture-7

**Intravenous Infusions, Parenteral Admixtures, and Rate-of-Flow**

**Assist. Prof. Dr. Wedad K. Ali**

# 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 nomogram

# Injections

- 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), joint fluid (intrasynovial), spinal column (intraspinal), spinal fluid (intrathecal), arteries (intra-arterial), and in an emergency, even the heart (intracardiac).

- However, most injections are administered into a vein (intravenous, I.V., IV), muscle (intramuscular, I.M., IM), skin (intradermal, I.D., ID, intracutaneous), or under the skin (subcutaneous, sub Q, SQ, hypodermic).
- Depending upon their use, injections are packaged in small volumes in ampuls or in prefilled disposable syringes for single-dose use; in vials and pen-injectors for single- or multiple-dose use; or in large volume plastic bags or glass containers for administration by slow intravenous infusion.

- Some injections are available as prepared solutions or suspensions with their drug content labeled as, for example, ‘‘10 mg/mL.’’
- Others contain dry powder for reconstitution to form a solution or suspension by adding a specified volume of diluent prior to use and are labeled as, for example, ‘‘10 mg/vial.’’

- Small-volume injections may be administered as such or they may be used as additives to large-volume parenteral fluids for intravenous infusion.
- The term parenteral is defined as any medication route other than the alimentary canal and thus includes all routes of injection.

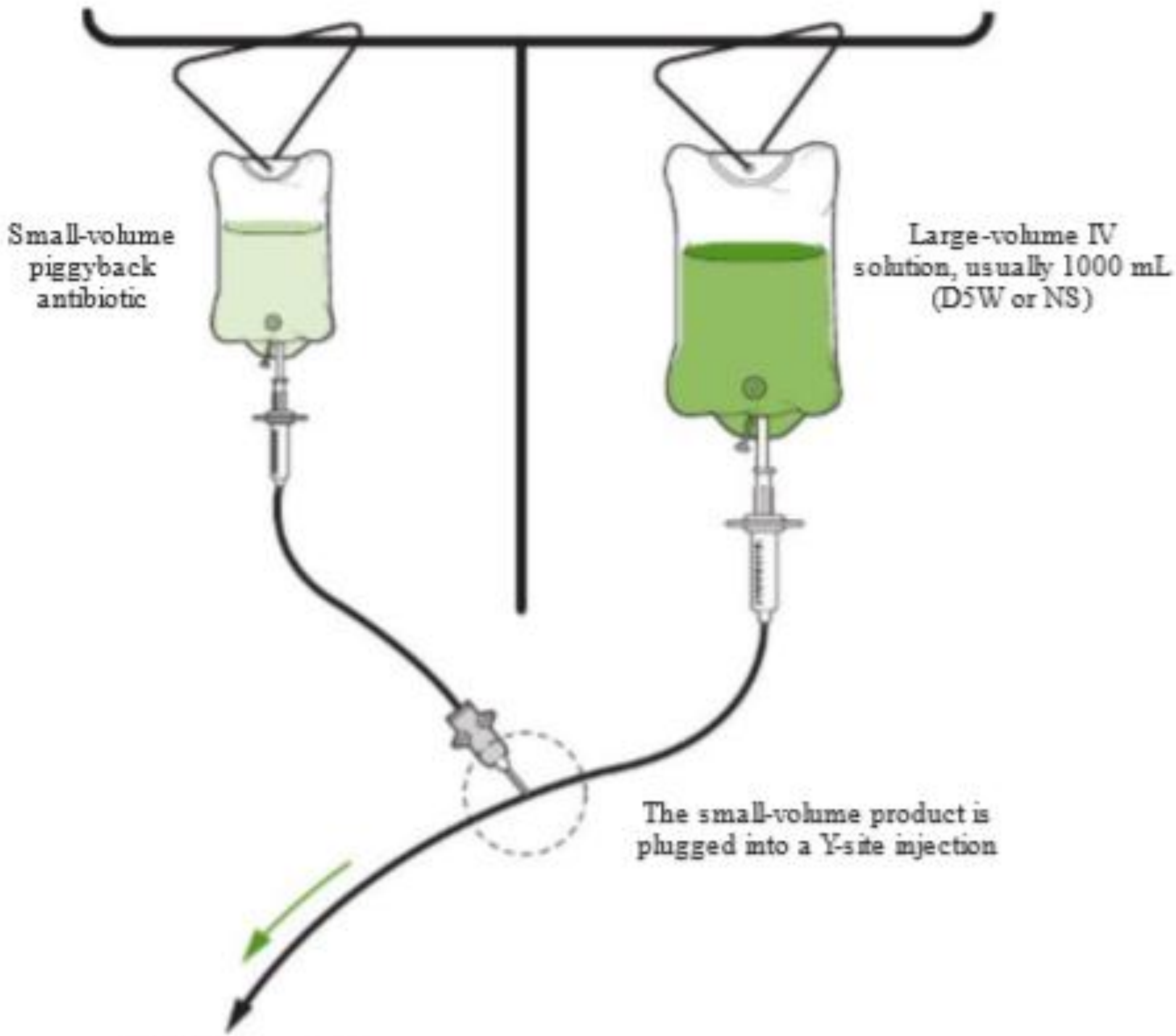
# Intravenous infusions

- Intravenous (IV) infusions are sterile, aqueous preparations administered intravenously in relatively large volumes. They are used to extend blood volume and/or 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

- Intravenous infusions are widely employed in emergency care units, in hospitals and other patient care institutions, and in home care.
- Pharmacists participate in the preparation and administration of institutional as well as home intravenous infusion therapy.
- The United States Pharmacopeia has established requirements for the compounding of sterile preparations.

- Most intravenous infusions are solutions; however, some are very fine dispersions of nutrients or therapeutic agents, or blood and blood products.
- Although some intravenous solutions are isotonic or nearly isotonic with blood, isotonicity is not absolutely necessary because the volumes of fluid usually administered are rapidly diluted by the circulating blood.

- 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, and 1000 mL.
- The smaller volumes find particular application in treating pediatric patients and adults who require relatively small volumes to be infused.
- When a smaller IV bag is attached to the tubing of a larger IV being administered, it is referred to as an IV piggy back (IVPB).




FIGu Re 13.2 • A typical intravenous infusion setup with a piggybacked antibiotic. (Courtesy of Lacher B. Pharmaceutical Calculations for the Pharmacy Technician. Baltimore, MD: Lippincott Williams & Wilkins, 2008.)

- The abbreviation LVP is commonly used to indicate a large-volume parenteral, and SVP indicates a small-volume parenteral.
- Some common solutions for intravenous infusion are listed in Table 13.1. In practice, additional components or additives frequently are added to these basic solutions.
- Drugs and other additives administered by infusion are rapidly distributed throughout the circulation.

## 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 (the solution is hung on a stand well above the portal of entry) or by electronic volumetric infusion pumps.
- Some infusion pumps can be calibrated to deliver microinfusion volumes, such as 0.1mL per hour, to as much as 2000 mL per hour, depending on the drug being administered and the requirements of the patient.

- Electronic controllers can be used to maintain the desired flow rate.
- In the administration of infusions, special needles or catheters provide intravenous entry for the intravenous fluid.
- Large-, intermediate-, and small-gauge (bore) needles or catheters are used, with the portal of entry selected based on the patient’s age (i.e., adult, child, infant, or neonate) and the clinical circumstances.
- The narrower the gauge, the slower the flow rate and thus the longer period required to infuse a specified volume.

- 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, whereas intermittent infusions are administered during scheduled periods.
- The rapid infusion of a medication into a vein is termed <u>IV push</u> and is usually conducted in less than a minute.

# Common Intravenous Infusion Solutions

- Aqueous solutions of dextrose, sodium chloride, and lactated Ringer's solution are the most commonly used intravenous fluids.
- Table 13.1 describes the content of these solutions, which may be administered as such, or with additional drug or nutritional components.

# 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 ½ NS for intravenous infusion?
- D5 means 5% Dextrose = 5/100 = 0.05 g/mL
- ½ NS means 0.45% nornaml slain = 0.0045g/mL

250 mL × 0.05 (5% w/v) = 12.5 g dextrose, and
250 mL × 0.0045 (0.45% w/v) = 1.125 g sodium chloride, *answers.*

- Compare:

(a) the number of drops and

(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.

Microdrip set:
(a) 60 drops/mL × 50 mL = 3000 drops
(b) 3000 drops ÷ 60 drops/minute = 50 minutes, *answers.*

Standard set:
(a) 15 drops/mL × 50 mL = 750 drops
(b) 750 drops ÷ 60 drops/minute = 12.5 minutes, *answers.*

Or, by dimensional analysis:

$$50 \text{ mL} \times \frac{60 \text{ drops}}{1 \text{ mL}} \times \frac{1 \text{ min}}{60 \text{ drops}} = 50 \text{ minutes, } \textit{answer.}$$

Or, by dimensional analysis:

$$50 \text{ mL} \times \frac{15 \text{ drops}}{1 \text{ mL}} \times \frac{1 \text{ min}}{60 \text{ drops}} = 12.5 \text{ minutes, } \textit{answer.}$$

# 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 out put, respiration, or other life-threatening conditions.

- Intravenous push medications frequently are administered in less than one minute.
- The safe administration of a drug by IV push depends on precise calculations of dose and rate of administration.
- When feasible, a diluted injection rather than a highly concentrated one (e.g., 1 mg/mL versus 5 mg/mL) may be administered as an added safety precaution.

# Example Calculations of IV Push Drug Administration

- 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?

$$\frac{1.25 \text{ mg}}{1 \text{ mL}} = \frac{2 \text{ mg}}{x \text{ mL}};\ x = 1.6 \text{ mL (1 mL from one syringe and 0.6 mL from another)}, \textit{answer.}$$

Or, by dimensional analysis:

$$2 \text{ mg} \times \frac{1 \text{ mL}}{1.25 \text{ mg}} = 1.6 \text{ mL}, \textit{answer.}$$

- 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?

$$\frac{5 \text{ mg}}{1 \text{ mL}} = \frac{2 \text{ mg}}{x \text{ mL}}; \ x = 0.4 \text{ mL, } \textit{answer.}$$

Or, by dimensional analysis:

$$2 \text{ mg} \times \frac{1 \text{ mL}}{5 \text{ mg}} = 0.4 \text{ mL, } \textit{answer.}$$

- 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.

$$200 \text{ lb} \div 2.2 \text{ lb/kg} = 90.9 \text{ kg},$$
$$90.9 \text{ kg} \times 0.1 \text{ unit/kg} = 9.09 \text{ units, and}$$
$$90.9 \text{ kg} \times 0.4 \text{ unit/kg} = 36.36 \text{ units, } \textit{answers.}$$

# 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. Calculate it:

$$\frac{60 \text{ mg}}{100 \text{ mL}} = \frac{x \text{ mg}}{5 \text{ mL}};\ x = 3 \text{ mg or } 3000 \text{ mcg dopamine administered per hour}$$

$$3000 \text{ mcg} \div 60 \text{ min/hr} = 50 \text{ mcg dopamine administered per minute}$$

Since the 50 mcg/min are administered to a 10-kg child, the dose, per kg per minute, is:

$$\frac{50 \text{ mcg}}{10 \text{ kg}} = \frac{x \text{ mcg}}{1 \text{ kg}};\ x = 5 \text{ mcg dopamine/kg/min, } \textit{answer.}$$

Or, by dimensional analysis:

$$\frac{60 \text{ mg}}{100 \text{ mL}} \times \frac{1000 \text{ mcg}}{1 \text{ mg}} \times \frac{5 \text{ mL}}{1 \text{ hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} =$$

$$50 \text{ mcg/min (dose for 10-kg child)} = 5 \text{ mcg/kg/min}$$

# Example Calculations of Pediatric Infusions

- 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.
- 1 pound = 16 ounces,
- 8/16 = 0.5 pound

3 lb. 8 oz. = 3.5 lb. ÷ 2.2 lb./kg = 1.59 kg or 1.6 kg

1.6 kg X 60 mL = 96 mL, answer.

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

$$96 \text{ mL} \times \frac{60 \text{ drops}}{1 \text{ mL}} \times \frac{1 \text{ minute}}{20 \text{ drops}} =$$

= 288 minutes, or 4 hours 48 minutes, answer.

- 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.

(a) 2.5 mg/kg X 1.5 kg = 3.75 mg gentamicin sulfate

(b) 50 mL ÷ 30 minutes = 1.67 mL/minute, answers.