Intravenous Fluid Selection

LEARNING OBJECTIVES
By the end of this chapter, you should be able to:

☑ Describe and differentiate colloid and crystalloid IV fluids
☑ Understand osmosis as it pertains to water movement with IV therapy
☑ Define tonicity and the actions of isotonic, hypotonic, and hypertonic crystalloids in the body
☑ Identify the three most common IV solutions used in the prehospital setting, and classify them as isotonic, hypotonic, or hypertonic
☑ Describe how an IV fluid is packaged and important information located on the label of the IV fluid

KEY TERMS
5% Dextrose in water—A carbohydrate solution that uses glucose (sugar) as the solute dissolved in sterile water. Five percent dextrose in water is packed as an isotonic solution but becomes hypotonic once in the body because the glucose (solute) dissolved in sterile water is metabolized rapidly by the body’s cells.

Colloid solutions—IV fluids containing large proteins and molecules that tend to stay within the vascular space (blood vessels).

Crystalloid solutions—IV fluids containing varying concentrations of electrolytes.

D₅W—See 5% dextrose in water.

Extracellular space—Space outside the cells consisting of the intravascular and interstitial spaces.
Intravenous fluid selection

**Hypertonic crystalloid**—A crystalloid solution that has a higher concentration of electrolytes than the body plasma.

**Hypotonic crystalloid**—A crystalloid solution that has a lower concentration of electrolytes than the body plasma.

**Intracellular space**—Space within the cells.

**Intravascular volume**—Volume of blood contained within the blood vessels.

**Intravenous fluids**—Chemically prepared solutions that are administered to a patient through the IV site.

**Isotonic crystalloid**—A crystalloid solution that has the same concentration of electrolytes as the body plasma.

**Lactated Ringer’s**—An isotonic crystalloid solution containing the solutes sodium chloride, potassium chloride, calcium chloride, and sodium lactate, dissolved in sterile water (solvent).

**LR**—See Lactated Ringer’s.

**Normal saline solution**—An isotonic crystalloid solution that contains sodium chloride (salt) as the solute, dissolved in sterile water (solvent). The specific concentration for normal saline solution is 0.9%.

**NS**—See Normal saline solution.

**NSS**—See Normal saline solution.

**Osmosis**—The movement of water across a semipermeable membrane from an area of lower solute concentration to an area of higher solute concentration. This movement of water allows the equalization of the solute-to-solution ratio across the membrane.

**Oxygen-carrying solutions**—Chemically prepared solutions that can carry oxygen to the cells.

**Plasma**—Fluid surrounding the cells of the body.

**Ringer’s lactate**—See Lactated Ringer’s.

**Solute**—Particles that are dissolved in the sterile water (solvent) of an IV fluid.

**Solvent**—The liquid portion of an IV solution that the solute(s) dissolves into. The most common solvent is sterile water.

**Total body water**—Water contained within the cells, around the cells, and in the bloodstream. Water comprises about 60% of the body’s weight.

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**Case Study**

You are staffing a first aid center for the city’s 5-kilometer run for charity. With the temperature at 96°F and the humidity at 92%, the first aid center is overwhelmed with patients suffering from dehydration. Because IV therapy is within your scope of practice, the lead physician instructs you to start an IV and administer IV fluid to a 32-year-old female who is seriously dehydrated and extremely weak.
After accessing the patient’s airway, breathing, and circulation and applying high-flow oxygen, you proceed to the medical supply area to get the IV fluid. There you find a variety of fluids, including isotonic crystalloids, hypertonic crystalloids, hypotonic crystalloids, and a refrigerator of colloid solutions. What fluid will you select for this patient?

In this chapter, different types of IV fluids are presented, along with their specific actions within the body. The manner in which IV fluids are packaged is also discussed. At the end of the chapter, we return to this case and apply our knowledge.

QUESTIONS
1. How might the clinical condition of dehydration affect your ability to locate and access a vein for IV therapy?
2. Would 5% dextrose in water (D5W) be an acceptable IV fluid to use for the rehydration of this patient?
3. If 0.9% NSS was not available, what other isotonic crystalloid would be acceptable to use in its place?

INTRODUCTION
Intravenous fluids are chemically prepared solutions that are administered to the patient. They are tailored to the body’s needs and used to replace lost fluid and/or aid in the delivery of IV medications. For patients that do not require immediate fluid or drug therapy, the continuous delivery of a small amount of IV fluid can be used to keep a vein patent (open) for future use. IV fluids come in different forms and have different impacts on the body. Therefore, it is important to have an understanding of the different types of IV fluids, along with their indications for use.

How Intravenous Fluids Are Created
There are several types of IV fluids that have different effects on the body. Some IV fluids are designed to stay in the intravascular space (intra, within; vascular, blood vessels) to increase the intravascular volume, or volume of circulating blood. Other IV fluids are specifically designed so the fluid leaves the intravascular space and enters the interstitial and intracellular spaces. Still others are created to distribute evenly between the intravascular, interstitial, and cellular spaces. The properties that an IV solution has within the body depends on how it is created and the specific materials it contains. It also determines the best type of IV solution to use in relation to the patient’s needs.

The majority of an IV solution is sterile water. Chemically, water is referred to as a “solvent.” A solvent is a substance that dissolves other materials called “solute.” Within IV solutions, the solutes can be molecules called electrolytes (charged particles such as sodium, potassium, and chloride) and/or other larger compounds such as proteins or molecules.
Together, the **solvent** (water) and **solute**s (electrolytes, proteins, or other molecules dissolved in the water) create the IV solution. Consider a cup of coffee to which sugar is added for sweeteness. The coffee is the solvent, which dissolves the solute sugar.

### Intravenous Fluids

IV fluids come in four different forms:

- **Colloids**
- **Crystalloids**
- **Blood and blood products**
- **Oxygen-carrying solutions**

Understanding these IV fluids is important because each has a different impact on the body and particular indications for use:

- **Colloid Solutions.** Colloid solutions are IV fluids that contain solutes in the form of large proteins or other similarly sized molecules. The proteins and molecules are so large that they cannot pass through the walls of the capillaries and onto the cells. Accordingly, colloids remain in the blood vessels for long periods of time and can significantly increase the intravascular volume (volume of blood). The proteins also have the ability to attract water from the cells into the blood vessels. However, although the movement of water from the cells into the bloodstream may be beneficial in the short term, continual movement in this direction can cause the cells to lose too much water and become dehydrated. Colloids are useful in maintaining blood volume, but their use in the field is limited. Colloids are expensive, have specific storage requirements, and have a short shelf life. This makes their use more suitable in the hospital setting. However, familiarity is important because in a mass casualty incident the EMT may be required to assist with the administration of colloids either in a field hospital or during the transport of critically injured patients. Commonly used colloid solutions include plasma protein fraction, salt poor albumin, dextran, and hetastarch. To learn more about colloidal solutions, the EMT should consult a critical care or paramedic textbook.

- **Crystalloid Solutions.** Crystalloid solutions are the primary fluid used for prehospital IV therapy. Crystalloids contain electrolytes (e.g., sodium, potassium, calcium, chloride) but lack the large proteins and molecules found in colloids. Crystalloids come in many preparations and are classified according to their “tonicity.”

  A crystalloid’s tonicity describes the concentration of electrolytes (solute) dissolved in the water, as compared with that of body **plasma** (fluid surrounding the cells). When the crystalloid contains the same amount of electrolytes as the plasma, it has the same concentration and is referred to as “isotonic” (*iso*, same; *tonic*, concentration). If a crystalloid contains more electrolytes than the body plasma, it is more concentrated and referred to as “hypertonic” (*hyper*, high; *tonic*, concentration).
Consider the example of coffee and sugar. The more sugar that is added to the coffee, the more concentrated the sugar becomes relative to the amount of coffee, and the sweeter tasting the coffee becomes.

Conversely, when a crystalloid contains fewer electrolytes than the plasma, it is less concentrated and referred to as “hypotonic” (*hypo*, low; *tonic*, concentration). The less sugar a cup of coffee contains, the lower its concentration or tonicity, and the less sweet the coffee may taste.

Depending on their concentration, crystalloids can affect the distribution of water within the body. To better understand this, the EMT must first know what **total body water** (TBW) is. TBW describes the entire amount of water contained within the body and accounts for approximately 60% of body weight. It is distributed among the intracellular and extracellular compartments. The **intracellular space** is the space within all the body cells (*intra*, within; *cellular*, cell). The **extracellular space** is the space outside the cells (*extra*, outside; *cellular*, cells). The extracellular compartment can be further divided into the intravascular space (space within the blood vessels) and the interstitial space (space between the cells but not within the blood vessels) (Figure 3.1).

The different compartments are separated by membranes through which the body water can easily pass. As a general rule, body water is pulled toward the solution with a higher concentration of dissolved molecules. The movement of water across a semipermeable membrane that selectively allows certain structures to pass while inhibiting others (i.e., a capillary wall or cellular wall) is known as **osmosis**. The osmotic movement of water occurs as the body attempts to create a balance between the different solute concentrations that exist on either side of a semipermeable membrane. What this means is that the water will easily cross the semipermeable membrane from the side that has a lower concentration of particles to the side that has a higher concentration of particles. The net movement of water stops when each side of the membrane becomes equal in its concentration of water and particles. With this in mind, isotonic, hypertonic, and hypotonic IV fluids cause the following shifts of body water:

- **Isotonic.** Isotonic crystalloids have a tonicity *equal* to the body plasma. When administered to a normally hydrated patient, isotonic crystalloids do not cause a significant shift of water between the
blood vessels and the cells. Thus, there is no (or minimal) osmosis occurring (Figure 3.2).

- **Hypertonic.** Hypertonic crystalloids have a tonicity higher than the body plasma. The administration of a hypertonic crystalloid causes water to shift from the extravascular spaces into the bloodstream, increasing the intravascular volume. This osmotic shift occurs as the body attempts to dilute the higher concentration of electrolytes contained within the IV fluid by moving water into the intravascular space (Figure 3.3).

- **Hypotonic.** Hypotonic crystalloids have a tonicity lower than the body plasma. The administration of a hypotonic crystalloid causes water to shift from the intravascular space to the extravascular space, and eventually into the tissue cells. Because the IV solution being administered is hypotonic, it creates an environment where the extravascular spaces have higher concentrations of electrolytes. The osmotic change results in the body moving water from the intravascular space to the cells in an attempt to dilute the electrolytes. Refer to Figure 3.4 for further explanation.

Of the different types of IV solutions, crystalloids are the mainstay of IV therapy in the prehospital setting. The particular type of IV solution selected beyond this depends on the patient’s needs. For instance, based on the osmotic movement of water as described previously, a person with a low volume of blood may benefit from a hypertonic or isotonic crystalloid solution that will increase blood volume, whereas a hypotonic crystalloid would be more appropriate for a person suffering from
cellular dehydration. The EMS system’s medical director will determine which crystalloids will be used for prehospital IV therapy.

The most common isotonic solutions used in prehospital care are

- **Lactated Ringer’s.** Lactated Ringer’s (LR) is an isotonic crystalloid that contains sodium chloride, potassium chloride, calcium chloride, and sodium lactate in sterile water.

- **Normal saline solution.** Normal saline solution (NSS) is an isotonic crystalloid that contains 0.9% sodium chloride (salt) in sterile water.

- **5% Dextrose in water.** 5% Dextrose in water (D₅W) is packaged as an isotonic carbohydrate (sugar solution) that contains glucose (sugar) as the solute. D₅W is useful in keeping a vein open by delivering a small amount of the fluid over a long period of time and/or supplying sugar, which is used by the cells to create energy. However, once D₅W enters the body, the cells rapidly consume the glucose. This leaves primarily water and causes IV fluid to become hypotonic in relation to the plasma surrounding the cells. Accordingly, the now hypotonic solution causes an osmotic shift of water to and from the bloodstream and into the cells.

In the prehospital setting, LR and NSS are commonly used for fluid replacement because of their immediate ability to expand the volume of circulating blood. However, over the course of about 1 hour, approximately two-thirds of these IV fluids eventually leave the blood vessels and move into the cells. Some authorities recommend that for every 1 liter of blood lost, 3 liters of an isotonic crystalloid be administered for replacement. This is only a guide, and the volume of IV fluid administered should be based on medical direction or local protocol, as well as the patient’s clinical response to fluid administration.

- **Blood and Blood Products.** Blood and blood products (e.g., platelets, packed red blood cells, plasma) are the most desirable fluids for replacement. Unlike colloids and crystalloids, the hemoglobin (in the red blood cells) carries oxygen to the cells. Not only is the intravascular volume increased, but the fluid administered can also transport oxygen to the cells. Blood, however, is a precious commodity and must be conserved to benefit the people most in need. Its use in the field is generally limited to aeromedical services or mass casualty incidents. The universal compatibility of O-negative blood makes it the ideal choice for administration in emergent situations. To learn more about blood and blood products, consult a critical care or paramedic textbook.

- **Oxygen-Carrying Solutions.** Oxygen-carrying solutions are synthetic fluids that carry and deliver oxygen to the cells. These fluids, which remain experimental, show promise for the prehospital care of patients who have experienced severe blood loss or are otherwise suffering from hypovolemia. It is hoped that oxygen-carrying solutions will be similar to crystalloid solutions in cost, storage capability, and ease of administration, and be capable of carrying oxygen, which presently can only be accomplished by blood or blood products.
Intravenous Fluid Packaging

Most IV fluids are packaged in soft plastic or vinyl bags of various sizes (10, 50, 100, 250, 500, 1,000, 2,000, and 3,000 milliliters) (Figure 3.5). The EMT will most likely be using 250-, 500-, and 1,000-milliliter bags. Some IV solutions are premixed with medications that are not compatible with plastic or vinyl and must be packaged in glass bottles. Glass bottles are not common to prehospital IV therapy but may be encountered during interfacility or critical care transports.

Every IV fluid container must contain a label. The label provides important information that you must examine before administering the fluid to a patient. This information includes

- Type of IV fluid (by name and by type of solutes contained within).
- Amount of IV fluid (expressed in milliliters or “mL”).
- Expiration date.

Always carefully read the label to ensure you are administering the correct IV solution. Many different IV fluids are packaged in similar containers, including those containing premixed medications. Administering an inappropriate IV fluid may be detrimental or even fatal to the patient, resulting in disciplinary and/or legal action. Like any other medication, IV solutions have a shelf life and must not be used after their expiration date (Figure 3.6).

The IV fluid container contains a medication injection site and administration set port. Both ports are located on the bottom of the IV bag when

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**Figure 3-5.** Different volumes of IV bags are used in the prehospital environment.
holding it upright. The medication injection port permits the injection of medication into the fluid for use by advanced life support (ALS) or hospital personnel after the EMT has initiated the IV. The administration set port receives the spike from the IV administration set (IV tubing) (see Figure 3.6). Different types of IV administration sets are discussed in Chapter 5.

Case Study Follow-Up

You have been asked to start an IV and administer IV fluid to a 32-year-old female who is dehydrated after running a marathon in hot and humid weather. In the medical supply area, you find a variety of IV fluids, including isotonic crystalloids, hypertonic crystalloids, hypotonic crystalloids, and a refrigerator of colloid solutions.

Knowing that the patient requires IV fluid to both increase the blood volume and rehydrate the cells, you look at the crate containing isotonic crystalloids. In the crate, you find and retrieve a 1,000-milliliter bag of 0.9% NSS. Your assistant, who is not an EMT, asks why you did not use any of the other solutions. You inform him that a colloid solution and a hypertonic crystalloid would just increase the blood volume by pulling water into the blood vessels from the cells. Although the blood volume would be increased, the cells could become further dehydrated. You continue by stating that the low concentration of solutes in a hypotonic solution would cause water to shift from within the blood vessels to the cells. This would be advantageous to the cells, but the volume of blood would not be increased and may even be further reduced.

After administering the IV fluid to the patient, she states that she feels much better and is eventually released by the physician. Later, your assistant tells you that he is so impressed with your knowledge that he has decided to enroll in the next EMT class.
SUMMARY

There are several different types of fluids used for IV therapy. Depending on their specific type and makeup, IV fluids can cause the shift and redistribution of body water between the intracellular and extracellular compartments. Therefore, it is important for the EMT to have a basic understanding of the different IV fluids and to choose the fluid most appropriate to the patient’s needs. Because most IV fluids are packaged in similar-looking plastic bags, it is imperative for the EMT to carefully examine the label on the bag to ensure the right fluid has been selected. Administering an inappropriate IV fluid can result in undesirable complications, as well as a less than optimal patient outcome.

REVIEW QUESTIONS

1. All IV fluids have the same impact within the body.
   A. True
   B. False

2. In a fluid used for IV therapy, the sterile water into which electrolytes, proteins, or other materials are dissolved is referred to as the
   A. tonicity.
   B. solvent.
   C. solute.
   D. concentration.

3. Which of the following are types of IV solutions?
   A. Colloids
   B. Crystalloids
   C. Blood
   D. All of the above are types of IV solutions

4. An IV solution contains the electrolyte sodium. Which of the following statements is true concerning the sodium?
   A. The sodium is the solution.
   B. The sodium is the solute.
   C. The sodium is the solvent.
   D. All of the above are true concerning the sodium.

5. You are administering an IV solution that contains large proteins and molecules. As such, what category of IV solution are you administering?
   A. Extravascular solution
   B. Crystalloid solution
   C. Colloid solution
   D. Hypotonic crystalloid solution
6. The most commonly administered IV fluid given prehospitaly is a colloid solution.
   A. True
   B. False

7. A crystalloid solution typically contains sterile water and ____________.
   A. proteins
   B. blood
   C. oxygen crystals
   D. electrolytes

8. Which of the following best describes a hypertonic solution?
   A. Concentration higher than the body plasma
   B. Concentration lower than the body plasma
   C. Contains less electrolytes than the body plasma
   D. Contains more oxygen crystals than the body plasma

9. Match the following IV solutions to their description:
   ____ Hypertonic crystalloid A. Concentration the same as the body plasma
   ____ Isotonic crystalloid B. Concentration less than the body plasma
   ____ Hypotonic crystalloid C. Concentration greater than the body plasma

10. Identify the crystalloid solution.
    A. Hetastarch
    B. Lactated Ringer’s
    C. Blood
    D. Oxygen-carrying solution

11. The most commonly used fluids for prehospital IV therapy are
    A. colloids, crystalloids, and blood
    B. lactated Ringer’s, blood, and 5% dextrose in water (D₅W)
    C. blood, 5% dextrose in water (D₅W), and sterile water
    D. Normal saline solution and lactated Ringer’s

12. It is important to read the label on every IV bag because
    A. different IV solutions are packaged similarly.
    B. the label contains the expiration date of the IV fluid.
    C. the name of the IV solution is on the label.
    D. all of the above are reasons why the EMT should read the label on every IV bag.
13. The tonicity of an IV solution is described as
   A. the amount of oxygen that it can carry to the cells.
   B. the type of water contained within the solution.
   C. the concentration of the solution as compared with the body plasma.
   D. the amount of blood contained within the solution.

14. As long as an isotonic solution is used, it makes no significant difference if the solution contains glucose molecules instead of electrolytes.
   A. True
   B. False

15. Osmosis is the movement of water from an area of high concentration of molecules and/or electrolytes to an area containing less of a concentration of molecules and/or electrolytes.
   A. True
   B. False