Intravenous Therapy: Crystalloids Versus Colloids

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Abstract

At least 90% of hospital patients receive some form of intravenous therapy during a hospital stay, and a significant number of those patients require fluid replacement in the form of volume expanders. There are two types of volume expanders, crystalloids and colloids, and each has advantages and disadvantages. Understanding the purpose and usage of each will allow nurses to provide patients the most effective treatment possible.
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Statement of Need
Nurses, depending on a variety of clinical scenarios, commonly administer crystalloid and colloid intravenous solutions. The choice and efficacy of these solutions is a requirement for nurses to understand.

Course Purpose
To provide nursing professionals with a basic knowledge of intravenous solutions, including indications, efficacy and potential contraindications.
Learning Objectives

1. Understand the purpose of volume expanders.
2. Differentiate between crystalloid IV solutions and colloid IV solutions.
3. Identify the varied crystalloid and colloid solutions.
4. List indications to administer a crystalloid or colloid solution.

Target Audience

Advanced Practice Registered Nurses, Registered Nurses, Licensed Practical Nurses, and Associates

Course Author & Director Disclosures

Jassin M. Jouria, MD, William S. Cook, PhD, Douglas Lawrence, MA, Susan DePasquale, CGRN, MSN, FPMHNP-BC – all have no disclosures

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There is no commercial support for this course.

Activity Review Information

Reviewed by Susan DePasquale, CGRN, MSN, FPMHNP-BC

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Please take time to complete the self-assessment Knowledge Questions before reading the article. Opportunity to complete a self-assessment of knowledge learned will be provided at the end of the course.
1. Volume expanders are types of IV fluids that are given when the amount of fluid in the ________________ is low.
   a. interstitial fluid
   b. intravascular space
   c. intracellular fluid
   d. electrolyte disturbances.

2. Which of the following best describes osmotic pressure?
   a. The pressure that moves fluid across a semi-permeable membrane from an area of higher concentration to an area of lower concentration.
   b. The pressure that moves fluid across a semi-permeable membrane from an area of lower concentration to an area of higher concentration.
   c. The pressure that the fluid exerts against the walls of the cells.
   d. The amount of substance required to suspend particles within a solution.

3. For which patient would the use of hydroxyethyl starch be contraindicated, according to the U. S. FDA?
   a. A burn victim
   b. A patient who has undergone a 7-hour surgery
   c. A patient in renal failure
   d. An accident victim who has lost a significant amount of blood

4. Which of the following is an example of a hypertonic solution?
   a. 3% NaCl
   b. 0.9% NaCl
   c. D5W
   d. LR
5. **Gelofusine is a type of colloid fluid that cannot be used among patients:**
   a. who have an allergy to gelatin products or to eggs.
   b. who are intolerant to blood products.
   c. who have a decrease of intravascular volume.
   d. who require synthetic versus natural compounds.
Introduction

Approximately 60 percent of the body’s weight is made up of water, the fluid essential to life. Water within the body is separated into various segments that comprise the circulatory system, the fluid found surrounding the cells, and fluid within the cells.\(^{19}\) Body fluids are made up of combinations of water and electrolytes. All of these components work together to maintain various functions throughout the body. The goal of fluid management is homeostasis, in which there is a balance in the concentration of solutes found in the fluid of the circulatory system and the fluid in the cells.\(^{22}\) At times, illness or injury causes this process to come out of balance and intravenous (IV) fluid therapy is necessary.

Intravenous therapy involves administering fluids, medications, nutrients, and electrolytes through the veins. IV solutions are made up of fluid, also called the solvent, and the elements within the fluid, which are also called solutes.\(^{11}\) IV therapy may be used for correcting electrolyte imbalances, increasing the volume of fluid in the circulatory system, and replacing fluids that are lost through illness or injury.\(^{16}\) The type of fluid given depends on the patient’s status and fluid balance between the intravascular and intracellular fluids. Because administration of prescribed intravascular fluids is a very common practice in acute clinical care, nurses must be aware of the appropriate types of fluid to administer and
understand the recommendations for care. One of the essential roles of the nurse is to collaborate and communicate with physicians and pharmacies about best practices for administration of IV fluids.25

**The Purpose of Volume Expanders**

Volume expanders are types of IV fluids that are used to increase the amount of fluid in the circulatory system. They are given when the amount of fluid in the intravascular space is low, in a condition known as hypovolemia.\(^1\) Volume expanders work by moving fluid from the solution surrounding the cells into the circulatory system. In this way, the volume of circulation is increased.\(^3\)

**Circulatory System**

The circulatory system is imperative for distributing oxygenated blood to the organs and tissues in the body. The cardiac cycle is the process of each contraction and relaxation of the heart as it pumps blood. The continuous transfer of blood requires the vessels of the circulatory system to transport blood that contains oxygen to the body’s tissues. Additionally, blood that contains carbon dioxide is then transported back to the heart to be exchanged for more oxygen through the respiratory system. Blood also
moves nutrients from the digestive system into the tissues and transfers waste products and toxins to the kidneys for filtering.\(^4\)

When hypovolemia occurs, there is less volume in the intravascular space, which can lead to poor cardiac output with each cardiac cycle. The decreased amount of blood pumped from the heart with each heartbeat results in decreased perfusion to the body’s tissues.\(^10\) If the hypovolemia becomes severe enough, the body begins to compensate through vasoconstriction. The blood vessels become smaller in order to maintain blood pressure despite the diminished volume of fluid.\(^13\) Significant vasoconstriction as a compensatory mechanism can ultimately impact blood flow and can diminish circulation. Providing volume expanders will increase cardiac output because the added fluid to the circulatory system increases the preload of the heart, which is the amount of blood that enters the heart to be pumped by the ventricles.\(^4,10\)

Fluid in the body is divided into intracellular and extracellular fluid. Intracellular fluid is that which is found within the different types of cells, while extracellular fluid is further split into two different categories known as interstitial and intravascular. The interstitial fluid is that which surrounds the cells, while the intravascular fluid is the fluid found within the circulatory system.\(^19\) The intravascular fluid that carries the blood cells is also called plasma.\(^22\)

The body maintains homeostasis of fluid and electrolytes between the intracellular, interstitial, and intravascular spaces through the process of osmosis. Osmosis is how water moves through a semi-permeable membrane, from an area with a lower concentration of solutes to an area that has a higher concentration of solutes. The semi-permeable membranes
in this discussion include vessel walls and cell walls. These membranes only allow a certain amount of fluid and solutes to pass through. How much osmosis occurs depends on osmotic pressure, which is the pressure that moves fluid across the semi-permeable membrane, from the side with lower concentration of solutes to the side with a higher concentration.\textsuperscript{23}

Understanding osmosis and osmotic pressure is important to recognize the effects of the differences in solute amounts within fluids given during IV therapy. Because fluids that are administered will contain different amounts of solutes, their use will have different effects on osmosis and osmotic pressure within the intravascular and interstitial spaces.

**Fluid Replacement**

Volume expanders may also be used as part of fluid replacement for the patient who has fluid or electrolyte imbalances. Some patients may need fluid replacement if they have low fluid volume because they are unable to eat or drink liquids that would normally replace some of their fluids. For example, patients who have had surgery and are not awake may miss long periods of time to take in fluid orally and are subject to fluid losses through the process of surgery, so they will need fluid replacement through IV therapy.\textsuperscript{2} Other situations that might indicate a need for fluid replacement
include NPO (nil per os) status during hospitalization, bowel preparations, insensible water loss, the use of some types of medications, and stress.\textsuperscript{15}

It is the responsibility of the clinician to determine the cause of hypovolemia in order to decide what type of fluid replacement is necessary. Some patients have low blood volume in the intravascular space and the interstitial space is also depleted. This might occur in such instances as a large amount of blood loss through trauma, a state of diabetic ketoacidosis, or dehydration. Alternatively, some patients have hypovolemia in the intravascular space, but the interstitial space is not depleted. Burns or sepsis are conditions in which this might occur.\textsuperscript{5} The type and amount of IV fluid given depends on the patient’s underlying condition that requires fluid replacement to correct hypovolemia.

Health care providers have options regarding the type of fluids they may use for fluid volume replacement and volume expansion. The types of fluids available are typically classified as either colloids or crystalloids.\textsuperscript{8}

**Colloids**

Colloids are types of intravenous solutions that are used to maintain an adequate amount of volume in the circulatory system, as well as the pressure within the blood vessels.\textsuperscript{7} Normally, the body produces substances within the blood vessels that maintain volume and pressure, which is usually the work of albumin, fibrinogen, and globulin.\textsuperscript{6} If these substances are not working properly, or if the patient has lost a significant amount of blood or body fluids, IV fluids in the form of colloids may be necessary. Colloids may be natural or synthetic compounds. Natural colloids include whole blood, plasma, or packed red cells. Synthetic colloid compounds are those that are
created with properties similar to natural colloid fluids and that serve the same purpose.17

**Characteristics**

Colloids help to maintain intravascular volume because they contain proteins that increase oncotic pressure within the vessels.9 Colloid oncotic pressure refers to the pressure exerted from the protein particles within the bloodstream against the walls of the vessels. These particles are so large that they do not pass through the semi-permeable membranes between the cells and the intravascular space. Because of this, they remain in the intravascular space to provide volume. They may remain in the blood vessels for a long time, allowing their effects to last longer than crystalloid solutions.11 Additionally, lesser amounts of colloid solutions will produce a desired effect in a patient when compared to crystalloids.18

*Increase Intravascular Volume*

Colloids are able to increase intravascular volume because they stay within the intravascular space due to the size of their proteins and starches. They also draw fluid into the intravascular space from the interstitial spaces due to their oncotic pressures.11 Colloids are useful for expanding fluid volume by utilizing a lesser amount of fluid overall. Thus, they may be more appropriate for patients who cannot tolerate a large amount of fluid infusion, such as through several infusions of crystalloid solutions. Additionally, colloids may be administered to patients
who are malnourished or who need extra protein because they already contain protein as part of their make up.¹

**Types**

Depending on the type of colloid used, certain principles of transfusion may apply. If a colloid is from a natural or human compound, such as fresh frozen plasma (FFP) or packed red blood cells, precautions should be in place when administering these fluids to monitor for transfusion reactions. Other types of colloids are synthetic compounds and while they do not necessarily require monitoring for transfusion reactions, they still increase intravascular volume and the nurse must monitor for signs of overcorrection of fluid volume deficit, which could lead to hypervolemia. Whether synthetic or natural, colloid solutions successfully expand fluid volume in the intravascular space to correct deficits.

**Hydroxyethyl Starch**

Also called Hetastarch, hydroxyethyl starch is a fluid made from synthetic components and used as a colloid infusion to increase the volume of plasma.²⁴ An example of hydroxyethyl starch is Hespan®.⁹ Despite its successful use as a volume expander in patients with hypovolemia, the U.S. Food and Drug Administration issued a safety precaution in 2013 for the use of hydroxyethyl starch, stating that there may be an increased risk of mortality with its use among some patients, including those with sepsis or renal failure. Hydroxyethyl starch may cause damage to the kidneys or increase the risk of bleeding among these patients.¹²

Alternatively, hydroxyethyl starch can consistently replace volume among patients who have significant loss, such as among patients who have had major surgery that required a considerable amount of suction or where there
was significant blood loss. Hydroxyethyl starch may also be used for volume resuscitation among burn patients. When lab work is necessary surrounding patient care, hydroxyethyl starch does not interfere with the results of many types of laboratory studies, although some other colloid solutions do.11

**Gelofusine®**

Gelofusine is a type of colloid fluid that is used as a volume expander; it is considered a plasma substitute and used among patients who have experienced hypovolemia as a result of severe bleeding or fluid loss due to burns. Gelofusine contains a mixture of 4% succinylated gelatin, sodium, and chloride.26 The modified gelatin works in a manner similar to that of plasma. It is ideally used for people who need fluid volume replacement, but for various reasons cannot tolerate blood products. For this reason, there is less risk of transfusion reaction, although it cannot be used among patients who have an allergy to gelatin products or to eggs.

Administration of Gelofusine requires strict monitoring to avoid the negative effects of too much volume expansion, or hypervolemia. It is typically only administered in situations that require close monitoring of the patient, such as in the perioperative period or intensive care.26

**Crystalloids**

Crystalloids are fluids used both to expand fluid volume in the intravascular space, as well as to provide maintenance fluids. They may be used to treat hypovolemia and as volume expanders; similarly, they also protect against other measures that may lead to hypovolemia, such as insensible water loss or decreased oral intake of fluids.28 Some crystalloids contain electrolytes, so they may also be used to correct electrolyte disturbances.6
**Characteristics**

Crystalloids can be mixed with other fluids or they may be dissolved within other solutions. Their solutes contain small enough particles that can pass through semi-permeable membranes, so they have the capacity to impact the volume of fluid in the intravascular or interstitial spaces.\(^{11}\) Crystalloid solutions may be classified differently, depending on their concentration of solutes.

*Increase Intravascular Volume*

Isotonic crystalloid solutions are those that do not cause a fluid shift between the intracellular and extracellular spaces. An isotonic solution is that which has about the same concentration of solutes as plasma. The osmotic pressure is the same inside the cell as it is outside the cell, so fluid does not shift between the two spaces. Because the fluid does not shift between spaces, isotonic solutions are useful for correcting fluid volume deficits and hypovolemia. Normal Saline (0.9% NaCl) is an example of an isotonic solution.\(^{11,27}\)

*Increase Interstitial Volume*

Hypertonic crystalloid solutions are those that have higher levels of osmolality and higher concentrations of solutes when compared to plasma. When administered through an IV, hypertonic solutions remain in the intravascular space and pull fluid out of the intracellular space. This pull of
fluid then increases interstitial volume, as well as corrects low blood volume in the intravascular space.

Hypertonic solutions contain the electrolytes sodium and chloride, and some types may contain dextrose. They are useful for treating sodium imbalances among patients with hyponatremia because their sodium content is greater than that which is already found in the bloodstream. Patients who have severe hypoglycemia may also receive hypertonic crystalloid solutions that contain dextrose, as the extra dextrose is in a greater concentration than found in the intravascular space. Examples of hypertonic solutions include 3% sodium chloride or D10W.

*Increase Intracellular Volume*

Fluids that have a lower level of osmolality and fewer solutes than isotonic solutions are known as hypotonic solutions. When hypotonic solutions are given, they enter the intravascular space because they are administered through an IV site. Because of their low osmolality, though, the fluid then shifts from the intravascular space to the intracellular spaces. The fluid may also shift to the interstitial spaces. Hypotonic solutions are not useful for correcting fluid volume deficit because the fluid does not stay within the intravascular space. Because they tend to flow into intracellular spaces, they can then provide hydration and increase the volume of cell fluid.11
Hypotonic solutions maintain cell fluid volume and are useful for maintenance fluids among patients. The only electrolytes they usually contain are sodium and chloride; they are not sources of other types of electrolytes to correct imbalances. Hypotonic solutions are used for patients who need extra fluid within the cells, such as patients with diabetic ketoacidosis. However, if a patient presents with hypovolemia, administering hypotonic solutions may make the condition worse, and so they should be given carefully or another solution should take their place. Examples of hypotonic solutions include 0.45% sodium chloride (0.45% NaCl) and 0.2% sodium chloride (0.2%NaCl).\(^{11}\)

**Less Expensive than Colloids**

Crystalloid solutions are much less expensive to use when compared to colloid solutions.\(^{6}\) They do not contain the proteins found in colloids and are made in a process that is much easier and cheaper to process. Additionally, crystalloid solutions are not made from natural or man-made products, compared to colloids such as FFP or packed red blood cells, so they do not require donation or harvesting of fluids to be produced. Instead, a significant proportion of their content is water, which is much less expensive to use.

**Types**

There are various types of crystalloid solutions available. They are often classified according to their tonicity, as described above. Tonicity refers to the measure of osmotic pressure within a solution, and will characterize a solution as being isotonic, hypertonic, or hypotonic.
**Saline**

Normal Saline (0.9% Sodium Chloride) solution is a type of isotonic fluid that when administered, helps to increase intravascular volume. Because it is isotonic, Normal Saline does not move into or out of the cells, but instead stays in the blood vessels in which it was infused. Normal Saline contains water, sodium, and chloride, and it is similar in concentration of sodium as what is already found in the intravascular space. It is used as a volume expander for patients with hypovolemia; and, it may also be ordered for other patients who need extra volume in the extracellular space, including those with shock or metabolic acidosis.11

**Ringer’s Solution**

Similar to lactated Ringer’s (LR), Ringer’s solution contains concentrations of the electrolytes sodium, potassium, calcium, and chloride in measures similar to that of blood plasma. It is also an isotonic solution that does not move fluid between the intracellular space and the vessels, so it is ideal for fluid volume replacement. Ringer’s solution and LR may be used among patients for fluid resuscitation efforts and during maintenance fluid therapy during surgery. Ringer’s solution does not contain lactate that is found in LR, so it is not used among patients with lactic acidosis. However, it may be used among a variety of other patients who present with conditions such as burns or dehydration.11

**D5W**

D5W is a combination of 5% dextrose in water. It is a fluid that is classified as either an isotonic or hypotonic solution. It is isotonic in that the amount of dextrose contained in the fluid is similar to that found in the blood vessels. However, the body quickly uses the dextrose found in D5W and so
the remaining water can pass through the semi-permeable membranes and enter the interstitial and intracellular spaces. D5W is useful for providing calories, but it does not contain electrolytes, and so is not useful for correcting electrolyte imbalances. It is also typically not used as part of fluid resuscitation or to correct severe hypovolemia because the fluid does not stay in the intravascular space. Instead, it may be utilized as a form of maintenance fluid, although the 5% dextrose is not sufficient for calories or long-term nutrition.11

**Summary**

Intravenous therapy involves the administration of fluids, medications, nutrients, and electrolytes through the veins. Nurses supporting IV therapy must understand basic principles of correcting electrolyte imbalances, expanding fluid volume in the circulatory system, and fluid replacement during physical illness or injury. The type of IV fluid is selected based on the patient’s physical status and requirements to maintain proper fluid balance.

Intravenous therapy is a common and important component of nursing care. When patients present with needs for fluid and electrolyte balance because of surgery, injury, or illness, it is the nurse’s responsibility to collaborate with the physician regarding the most appropriate type and rate of administration. Understanding the types of IV solutions to be given is essential for patient safety and for best care practices.

Please take time to help the NURSECE4LESS.COM course planners evaluate nursing knowledge needs met following completion of this course by completing the self-assessment Knowledge Questions after reading the article. Correct Answers, page 20.
1. Volume expanders are types of IV fluids that are given when the amount of fluid in the ________________ is low.
   a. interstitial fluid
   b. intravascular space
   c. intracellular fluid
   d. electrolyte disturbances.

2. Which of the following best describes osmotic pressure?
   a. The pressure that moves fluid across a semi-permeable membrane from an area of higher concentration to an area of lower concentration.
   b. The pressure that moves fluid across a semi-permeable membrane from an area of lower concentration to an area of higher concentration.
   c. The pressure that the fluid exerts against the walls of the cells.
   d. The amount of substance required to suspend particles within a solution.

3. For which patient would the use of hydroxyethyl starch be contraindicated, according to the U. S. FDA?
   a. A burn victim
   b. A patient who has undergone a 7-hour surgery
   c. A patient in renal failure
   d. An accident victim who has lost a significant amount of blood

4. Which of the following is an example of a hypertonic solution?
   a. 3% NaCl
   b. 0.9% NaCl
   c. D5W
   d. LR
5. Gelofusine is a type of colloid fluid that cannot be used among patients:
   a. who have an allergy to gelatin products or to eggs.
   b. who are intolerant to blood products.
   c. who have a decrease of intravascular volume.
   d. who require synthetic versus natural compounds.

Correct Answers:

1. b
2. b
3. c
4. a
5. a
REFERENCE SECTION

The reference section of in-text citations include published works intended as helpful material for further reading. Unpublished works and personal communications are not included in this section, although may appear within the study text.


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