MORE THAN 90% of hospitalized patients receive I.V. therapy during their hospital stay, typically as a continuous infusion. Among the reasons a patient may receive I.V. therapy are to:

- replace blood or other fluids lost through surgery, trauma, diarrhea, or vomiting
- maintain fluid balance, as when patients are N.P.O. or can’t drink enough fluid for other reasons
- correct electrolyte imbalances
- provide a medium for administering medications and nutritional support.

In this article, I’ll discuss when various I.V. fluids are appropriate, and why. Let’s start by reviewing the principles behind fluid and electrolyte balance.

Back to basics
Water makes up about 60% of an adult’s body weight and about 80% of a neonate’s body weight. The amount of water normally varies somewhat based on such factors as age, sex, and percentage of body fat.

Most fluid—about 40% of body weight—is in the intracellular compartment, or inside the cells. The balance is in the extracellular compartment, which consists of:

- intravascular fluid (in the blood vessels)
- interstitial fluid (between the blood vessels and cells)
- transcellular fluid (cerebrospinal, pleural, peritoneal, and synovial fluids).

Fluid moves between the fluid compartments by osmosis, a process that regulates water and electrolytes so that their distribution and composition in the compartments remain stable. The rate of osmosis depends on the osmotic pressure within the patient’s tissues. This pressure draws water through semi-permeable membranes, such as a cell membrane.

Responding to osmotic pressure, fluid can move into or out of the cell. The amount of osmotic pressure depends on the ratio between the concentration of ions in the infused solution and the concentration of ions in cell fluid. Water moves from an area of low ion concentration (a hypotonic solution) to an area of higher ion concentration (a hypertonic solution).

When the number of protein molecules in plasma is low, such as in proteinuria seen with uncontrolled diabetes or protein-calorie malnutrition known as kwashiorkor, fluid moves into and stays in the interstitial spaces, where it’s unavailable to meet the body’s hydration needs. This is a type of third-space fluid shift, also called third-spacing. This condition sequesters fluid in the interstitial and intracellular spaces and in a third-body space (such as the intestinal lumen) where it doesn’t support circulation.

Taking stock of tonicity
An I.V. solution’s effect on body fluid movement depends in part on its tonicity, or the concentration of solutes in solution. Parenteral solutions are classified according to their tonicity relative to normal blood plasma. The Infusion Nurses Society (INS) classifies a solution as isotonic if its tonicity falls within (or near) the normal range for blood serum—between 280 and 300 mOsm/liter. A hypotonic solution has an osmolality lower than that of serum. It shifts fluid out of the intravascular compartment, hydrating cells and the interstitial compartments.

Hypertonic solution (greater than 300 mOsm/liter)
A hypertonic solution has an osmolality higher than that of serum. It draws fluid into the intravascular compartment from the cells and the interstitial compartments.

QUICK GUIDE TO I.V. SOLUTIONS
Solutions used for I.V. therapy may be isotonic, hypotonic, or hypertonic. The type you give depends on whether you want to change or maintain body fluid status.

Isotonic solution (280-300 mOsm/liter)
An isotonic solution has an osmolality about equal to that of serum. Because it stays in the intravascular space, it expands the intravascular compartment.

Hypotonic solution (less than 280 mOsm/liter)
A hypotonic solution has an osmolality lower than that of serum. It shifts fluid out of the intravascular compartment, hydrating cells and the interstitial compartments.

Hypertonic solution (greater than 300 mOsm/liter)
A hypertonic solution has an osmolality higher than that of serum. It draws fluid into the intravascular compartment from the cells and the interstitial compartments.
tion has an osmolarity greater than 300 mOsm/liter. Here’s how the three fluid types act in the body.

• When an isotonic solution is infused, water neither moves into nor is pulled out of cells because roughly the same concentration of solute is on both sides of the membrane (the tonicity is equivalent). That’s why isotonic solutions such as 0.9% sodium chloride, Ringer’s lactate, Ringer’s acetate, and dextrose 5% in water (D$_3$W), are given to expand circulating volume and replace actual fluid losses. Because these solutions expand the intravascular compartment, closely monitor the patient for signs and symptoms of fluid overload, especially if he has a history of hypertension or heart failure.

Although D$_3$W is isotonic in the bag, it acts like a hypotonic solution once it enters the bloodstream because simple sugars such as dextrose are the preferred energy source for cells. The low concentration of dextrose in D$_3$W is quickly consumed by the cells lining the vein and circulating in the bloodstream. Use this solution with caution in patients at risk for increased intracranial pressure (ICP).

The liver converts lactate to bicarbonate, so don’t give lactated Ringer’s solution if the patient has a serum blood pH above 7.5 or liver disease—he won’t be able to metabolize the lactate, worsening his alkalosis.

• Commonly infused hypotonic solutions include 0.45% sodium chloride or 0.25% sodium chloride (with or without D$_3$W). Potassium chloride may be added in low concentrations to replace losses from the gastrointestinal system. When a hypotonic solution is administered, it puts more water in the serum than is found inside cells. As a result, water moves into the cells, causing them to swell.

Although hypotonic solutions help replace intracellular fluid, the extra water also moves into the cells of the tunica intima of the vein at the catheter insertion site. This may cause the cells to swell and burst, exposing the vein’s basement membrane and potentially leading to phlebitis and infiltration. Watch all I.V. sites carefully for signs of phlebitis (erythema at the site with or without pain and edema, palpable venous cord, streak formation, and purulent drainage) and infiltration (coolness, swelling, and discomfort).

Because hypotonic solutions have the potential to cause sudden fluid shifts from blood vessels into cells, don’t administer them indefinitely. Stop infusing a hypotonic solution once the patient can drink enough to meet his fluid needs. Failing to do so could cause cardiovascular collapse from intravascular fluid depletion and increased ICP from fluid shift into brain cells.

Don’t give hypotonic fluids to patients already at risk for increased ICP, such as those being treated for stroke or head trauma and those who’ve had neurosurgery. Also avoid giving hypotonic solutions to patients at risk for third-space fluid shifts, such as those with severe burns, traumatic injuries, or low-serum protein levels from malnutrition or liver disease.

• When hypertonic fluids are infused, water moves out of the cells in an attempt to dilute the infusate, shrinking the cells. When they shrink at the I.V. infusion site, the basement membrane of the vein’s lining is exposed, creating the risk of phlebitis and infiltration as described above for hypotonic infusions.

Hypertonic solutions, used to help reestablish equilibrium in electrolyte and acid-base imbalances, include electrolyte replacement solutions and parenteral nutrition solutions. But because hypertonic solutions can cause severe damage to the vein, the INS’s standards of practice mandate that all fluids with an osmolarity greater than 600 mOsm/liter be infused through a central venous access device for greater hemodilution. This includes solutions containing more than 10% dextrose, 5% protein hydrolysate, and high electrolyte concentrations. If you’re unsure of a solution’s final concentration, check with your pharmacy.

Closely monitor any patient receiving a hypertonic solution for circulatory overload. Don’t give hypertonic solutions to a patient with any condition that causes cellular dehydration, such as diabetic ketoacidosis. Nor should any patient with impaired heart or kidney function receive an infusion of hypertonic solution—his system just can’t handle the extra fluid.

SELECTED REFERENCES


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