Fluid and Electrolyte Management Across the Age Continuum

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Optional function of body systems depends upon fluid and electrolyte balance; however, across the lifespan, disorders of fluid and electrolytes offset this, and the causative factors are varied. Nurses play a major role in the management of fluid and electrolyte balance. This article focuses on the role total body water content, plasma proteins, kidney function, and drug metabolism have on the age-related physiology impacting fluid and electrolyte balance, and on nursing implications.

Key Words: **Fluid and electrolyte balance, body water content, plasma proteins, kidney function, drug metabolism.**

Disorders of fluid and electrolytes are common in patients across the lifespan. Many factors have been found to be associated with the development of these imbalances. Dehydration, over-hydration, and salt and water deficits and overload have been associated with morbidity and mortality with populations at each end of the lifespan experiencing an increased risk (El-Sharkawy, Sahota, Maughan, & Lobo, 2014). This article focuses on the role total body water content, plasma proteins, kidney function, and drug metabolism have on the age-related physiology impacting fluid and electrolyte balance.

Total Body Water Content

Total body water varies with body fat content, age, and sex. Body water represents approximately 60% of body weight in young, lean males and 50% of body weight in females (Metheny, 2012). Body water is divided into two major compartments: extracellular fluid (ECF) and intracellular fluid (ICF). ECF is further divided into intravascular fluid (also known as plasma) and interstitial fluid. The interstitial fluid surrounds the cells. ECF comprises approximately 20% of an adult's body weight (Gooch, 2015; Metheny, 2012). Transcellular fluids are also a component of ECF and are found in the cerebrospinal column, pleural cavity, lymph system, joints, glandular secretions, and eyes. There is no significant daily gain or loss of transcellular fluid.

ICF is located inside the cells and comprises approximately 40% of an adult's body weight (Metheny, 2012). While capillary walls and cell membranes separate ICF and ECF, ECF must be balanced with ICF. ECF is more readily lost from the body than ICF (McLafferty, Johnstone, Hendry, & Farley, 2014).

Fluid Losses

Fluid losses are categorized as sensible or insensible losses. Sensible losses are those that can be measured and include urine, feces, blood, wound and gastric drainage, and emesis. Insensible losses cannot be measured and include perspiration and fluid losses through breathing. Fever, increased respiratory rate and depth, and humidity impact the loss of fluid in individuals (McLafferty et al., 2014).

Age Considerations: Birth to Puberty

The body surface area of an infant is greater than that of an adult, relative to weight. Thus, infants generally lose a greater portion of water from the skin than adults. Infants have a high body fluid content that is approximately 70% of their body weight (Metheny, 2012). Infants also have more ECF, which makes them more vulnerable to fluid volume losses and deficits. By the end of the second year of life, the total body fluid percentages near those of adults. At puberty, total body water composition is attained, and the onset of sex differences related to body weight percentages occurs (Metheny, 2012).

Age Considerations: Adulthood

After age 40 years, mean total body water decreases in relation to body weight, yet sex difference body weight percentages remain. Between ages 40 to 60 years, total body water decreases to 55% in the male population and 47% in women (Metheny, 2012). By age 60 years, the male population has a total body water percentage of approximately 52%, with 46% in the female population (Metheny, 2012; Severs, Rookmakker, & Hoorn, 2015).

Plasma Proteins

Plasma proteins (albumin, fibrinogen, prothrombin, and gamma globulins) constitute approximately 6% to 7% of the blood plasma. Plasma proteins maintain osmotic pressure,

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__Note:__ The Learning Outcome, additional statements of disclosure, and instructions for CNE evaluation can be found on page 497.

increase blood viscosity, and assist in maintaining blood pressure (McGloin, 2015). The liver synthesizes all plasma proteins except for gamma globulins, thus explaining the rationale for coagulopathies and proteins imbalances commonly found in patients with liver dysfunction and failure. Albumin plays an important role in maintaining fluid homeostasis. When fluid filters through a capillary, albumin remains in the decreasing volume of water because the large molecular size of albumin does not pass through the capillary membrane with ease. This increased concentration of albumin pulls fluid back into the capillaries (plasma colloid osmotic pressure). Essentially, albumin plays the role of a "fluid magnet."

Kidney Function

The kidneys play a vital role in fluid, electrolyte, and acid-base balance. A healthy kidney filters approximately 180 liters of plasma a day and produces approximately 1.8 liters of urine a day (McGloin, 2015). As kidney function declines in patients with chronic kidney disease (CKD), individuals lose the ability to filter the plasma, and fluid and electrolyte imbalances result. The greatest electrolyte concerns for patients with CKD are imbalances in potassium and calcium levels due to the impact on cardiac function.

Age Considerations: Birth to Early Childhood

Infants and young children excrete urine at a higher rate than adults because the higher metabolic rates in children produce more waste. Additionally, an infant's kidneys cannot concentrate urine until around 3 months of age and remain less efficient than adult kidneys until around age of 2 years (Bekhof, van Asperen, & Brand, 2013).

Age Considerations: Adulthood

As the adult ages, the kidney loses function. This leads to an impaired ability to secrete potassium, excrete hydrogen ions, retain sodium, and reabsorb water resulting in dysnatremia and hypovolemia (Lindner, Pfortmüller, Leichtle, Fiedler, & Exadaktylos, 2014). The older adult also experiences decreases in renal blood flow, glomerular filtration, creatinine clearance, and the ability to concentrate urine. In the presence of dehydration or hypovolemia, decreased blood flow to the kidney also places the individual at risk for acute kidney injury (AKI).

Drug Metabolism

The cytochrome P-450 enzyme system in the small bowel and liver is the most important known system for drug metabolism (Metheny, 2012). Drug metabolism and elimination vary with age, and with kidney and liver function, and depend upon the drug, route of administration, and dose.

Age Considerations

Phenytoin, barbiturates, analgesics, and cardiac glycosides have plasma half-lives two to three times longer in neonates than adults (Lindner et al., 2014). As liver and kidney elimination decrease with age, drug levels increase, and toxicity may slowly develop. Diuretics are of particular concern and will be discussed later in this article.

Nursing's Role in Fluid and Electrolyte Balance

Nurses must employ several strategies to optimize fluid and electrolyte balance in individuals entrusted to their care. Such strategies include assessment of fluid and electrolyte status, prevention strategies, and fluid and electrolyte replacement. These strategies focus on managing fluid volume excess and fluid volume deficit because fluid balance is determined by daily gains and losses. Most daily intake of water is oral, with a small percentage coming from food and metabolic processes. The majority of body fluid losses comes from the formation of urine.

Assessment of Fluid Volume Excess

Compromised regulatory systems, such as heart failure, kidney failure, cirrhosis, and steroid use, may contribute to fluid volume excess. High-sodium diets and drugs, or preparations rich in sodium, such as Fleet® enema, sodium bicarbonate, and Alka-Seltzer®, lead to fluid retention and fluid volume excess. Further, overzealous administration of 0.9% sodium chloride or Ringer's lactate solution can contribute to fluid volume excess and may be compounded if cardiac, kidney, or liver function is impaired. Assessment findings in an individual with fluid volume excess are found in Table 1 (McGloin, 2015).

Assessment of Fluid Volume Deficit

The loss of fluid can be related to many pathophysiological causes or a decrease in oral intake. Gastrointestinal (GI) fluids may be lost due to vomiting, diarrhea, excessive ostomy drainage, or gastric suctioning. Polyuria is another etiological factor that leads to fluid volume deficit. Polyuria may be related to diuretic, kidney failure, hyperosmolar tube feedings, diabetes insipidus, and diabetes mellitus (Metheny, 2012). Conditions such as excessive sweating and fevers result in increased fluid losses.

Fluid loss from a process called third-spacing may also occur when fluid accumulates in areas that normally have little to no fluid. In third-spacing, fluid shifts from the intravascular space into the interstitial space between cells. Third-spacing of fluid results in decreased fluid in the vascular space as plasma is shifted into the interstitial space. Third-spacing of fluid may occur in the presence of trauma, surgery, burns, sepsis, pancreatitis, GI obstruction, and liver failure that leads to ascites. Assessment findings in an individual with fluid volume deficit are found in Table 2 (McGloin, 2015).

Electrolyte Balance

There are several electrolytes in the human body, and each electrolyte

Table 1
Fluid Volume Excess – Assessment Findings

- Weight gain
- Peripheral edema
- Generalized edema
- Crackles in the lungs upon auscultation
- Dyspnea
- Orthopnea
- Cough
- Distention of peripheral veins
- Bounding pulse
- Engorged carotid vessels
- Low BUN and hematocrit
- Changes in vital signs (increase in blood pressure, respiratory rate, and heart rate)
- Headache
- S_3 gallop

Sources: Metheny, 2012; Reid et al., 2004; Severs, Rookmaaker, & Hoorn, 2015.

Table 2
Fluid Volume Deficit – Assessment Findings

- Decreased skin and tongue turgor
- Decreased oral cavity moisture
- Decreased urine output and urine specific gravity
- BUN rises out of proportion to serum creatinine
- Changes in vital signs (increased heart rate, respiratory rate, and temperature, and a decreased blood pressure)
- Decreased capillary refill time
- Thirst may be present, but often absent in the older adult population
- Decreased weight
- Dry, cracked, mucous membranes
- Dizziness, syncope
- Orthostatic hypotension

Sources: Metheny, 2012; Reid et al., 2004; Severs, Rookmaaker, & Hoorn, 2015.

Table 3
Sodium Imbalances

Hyponatremia	Hypernatremia
• Gastointestinal losses • Adrenal insufficiency • Sweating • Drug-induced • Head trauma • Excessive water intake • Syndrome of Inappropriate antidiuretic hormone section • Treat with water restriction and sodium replacement (strict guidelines for hypertonic saline solution	• Water deprivation • Insensible water loss • Watery diarrhea • Excessive sodium intake • Diabetes insipidus (polyuria and polydipsia) • Treat by adding water or removing sodium • Fluid therapy is over 48 hours to prevent neurologic complications

Sources: Lindner, Pfortmüller, Leichtle, Fiedler, & Exadaktylos, 2014; Metheny, 2012.

has specific functions. Electrolytes are found in the intracellular and extracellular spaces and move to maintain balance and electroneutrality. The extracellular electrolytes include sodium, chloride, calcium, and sodium bicarbonate. The intracellular electrolytes include potassium, phosphate, and magnesium.

Sodium. The role of sodium is to attract fluid and preserve ECF volume. Sodium has a vital role in maintaining fluid balance and is responsible for the osmolarity of plasma (McLafferty et al., 2014). Sodium also helps transmit impulses in the nerves and muscle fibers. Sodium imbalances can be related to a number of pathophysiologic conditions (see Table 3) or certain drugs. Drug-induced hyponatremia may result from the use of non-steroidal anti-inflammatory drugs (NSAIDs), selective serotonin reuptake inhibitors, cyclophosphamides, omeprazole, desmopressin, and oxytocin. Drug-induced hypernatremia may result from 3% and 5% hypertonic saline solution, sodium bicarbonate, and excessive administration of 0.9% sodium chloride (Lindner et al., 2014).

Chloride. Chloride is mainly produced in the stomach as hydrochloric acid, so chloride levels may be impacted by GI disorders because most of it is absorbed in the intestines, with a small portion lost in the feces. Chloride and bicarbonate have an inverse relationship. Diuretics increase the risk of chloride loss and deficiencies.

Calcium. Ninety-nine percent (99%) of calcium is found in the bones, while 1% is in the teeth and soft tissues (McLafferty et al., 2014). Serum protein abnormalities can influence total serum calcium levels. Ionized calcium levels measure the various forms of calcium located in the extracellular fluid. Calcium and phosphate have an inverse relationship. Children have higher levels of serum calcium than adults, and older adults have a decreased normal calcium range. The pathophysiology of hypocalcemia and hypercalcemia are shown in Table 4 (Gooch, 2015; Lindner et al., 2014; Methany, 2012).

Table 4
Calcium Imbalances

Hypocalcemia	Hypercalcemia
• Surgical hypoparathyroidism • Acute pancreatitis • Hyperphosphatemia • Inadequate vitamin D • Alcoholism • Sepsis • Loop diuretics, phenobarbital, dilantin, citrate, calcitonin • Do not mix IV calcium with sodium bicarbonate or phosphate (precipitate forms)	• Malignancies • Primary hyperparathyroidism • Kidney transplant • Immobilization • Thiazides, lithium, large doses of vitamins A and D, theophylline • Hydration, mobilization, risk for cardiac arrest, risk for fracture, risk for digoxin toxicity

Sources: Gooch, 2015; Metheny, 2012.

Table 5
Hypokalemia and Hyperkalemia

Hypokalemia	Hyperkalemia
• Decreased dietary intake • Excess fluid loss • Kidney losses (diuretics, steroids, diuretic phase of acute kidney injury) • Nausea, vomiting, diarrhea • Laxative abuse or overuse • Shift of potassium from extracellular fluid to cells (hypothermia, sodium polystyrene sulfonate, insulin and sodium bicarbonate administration)	• Increased dietary intake • Rapid infusion of potassium containing solution • Salt substitutes (potassium chloride) • Decreased kidney function • Release of potassium from tissue trauma, burns, crush injuries, catabolism, and hemolysis • Shift of potassium from cells to the extracellular fluid (beta-blockers, acidosis)

Sources: Crawford, 2014; Eliacik et al., 2015; Metheny, 2012.

Table 6
Medications that Cause Hyperkalemia

• ACE inhibitors • Angiotensin receptor blockers • Antifungals • Beta-blockers • Calcium channel blockers • Antibiotics (penicillin G) • Cyclosporine • Digoxin • Aldosterone antagonist • Heparin • Hypertonic solutions (mannitol, glucose) • Non-steroidal anti-inflammatory drugs (NSAIDs) • Pentamidine • Tacrolimus • Potassium sparing diuretics

Sources: Crawford, 2014; Eliacik et al., 2015; Metheny, 2012.

Bicarbonate. Bicarbonate plays an important role in respiratory function. Lack of bicarbonate causes acidosis, and the respiratory rate increases to blow off more carbon dioxide. Excess bicarbonate causes alkalosis, and the respiratory rate decreases to retain carbon dioxide. A change in pH impacts electrolyte balance, enzyme activity, muscle contractions, and cellular function.

Potassium. Potassium is the most abundant intracellular cation (Eliacik et al., 2015). Potassium plays a role in maintaining normal action potentials in muscle and nerve cells, as well as playing a role in maintaining acid base balance (Crawford, 2014). Small changes in serum potassium levels impact neuromuscular and cardiac functions. Kidney disease, injury, drugs, treatments, GI losses, cellular shifts, sweating, and nutritional intake affect potassium levels (see Table 5) (Crawford, 2014; Eliacik et al., 2015; Metheny, 2012). Medications that may lead to hyperkalemia are found in Table 6 (Crawford, 2014; Eliacik et al., 2015; Metheny, 2012).

Phosphorus. Phosphate plays in important role in cell membrane, muscle, and neurologic functions. Eighty-five percent (85%) of phosphate is found in the bones and teeth, 14% is found in the soft tissues, and 1% in the ECF. Alcoholism, burns, kidney function, refeeding syndrome, and dietary intake influence phosphate levels (Gooch, 2015). Antacids, laxatives, and herbal supplements can impact the absorption of phosphate (McLafferty et al., 2014). In infants, the use of cow's milk instead of breastfeeding or formula can elevate phosphate levels.

Magnesium. Magnesium does not get a great deal of attention as an electrolyte. It plays an important role in carbohydrate metabolism and protein synthesis. Magnesium and albumin are linked. Low serum albumin levels (often from poor dietary intake or liver disease) result in low magnesium levels (Velissaris, Karamouzos, Pierrakos, Aretha, & Karanikolas, 2015). Gastrointestinal and kidney function losses, alcoholism, refeeding syndrome, and certain drugs, such as magnesium–containing laxatives, diuretics, cyclosporine, and mannitol, may impact magnesium levels (Velissaris et al., 2015).

Fluid and Electrolyte Imbalance Prevention Strategies

Strategies to manage fluid and electrolyte imbalances occur across the life span and should involve education, medication review, accurate intake and output measurements and recordings, and fluid and electrolyte replacement. Management in each of these categories may vary based upon the age of the individual and the setting.

Accuracy of Intake and Output Measurement and Recordings

In the acute care setting, several studies have focused on the importance of accurate intake and output measurement and recordings. Reid and colleagues (2004) discovered that staff shortages, lack of proper training, and limited time were barriers to accurate intake and output measurement and recordings.

Best practice indicates that intake and output measurement and recordings are an interprofessional responsibility. They are not primarily the responsibility of the nursing assistant or patient care technician, but a responsibility of all staff. Success has been demonstrated in improving accuracy when measurement and recordings are incorporated into hourly rounds. Providing cups that have fluid volume markers and easy-to-use charts can help involve patients. Subtotaling of intake and output amounts should be ongoing or several times as day, as opposed to at the end of an 8- or 12-hour shift (Reid et al., 2004).

Children

Education related to maintaining fluid and electrolyte balance in children is often targeted at parents or guardians. Such education should include the important fact that children can quickly become dehydrated or fluid overloaded. In 1957, Holliday and Segar developed a paradigm for fluid replacement in children that estimates water losses based on weight, energy expenditure, and healthy physiologic losses. This paradigm supported the use of hypotonic replacement solutions. Evidence over the last two decades indicates that this paradigm places the child at risk for hyponatremia and that isotonic solutions should be considered when using this replacement formula (Cavari, Pitfield, & Kissoon, 2013).

Nausea, vomiting, and diarrhea can lead to fluid volume deficit. Nutritional intake must be carefully investigated in a child with dehydration. The nurse should inquire about the type, method, amount, temperature, and frequency of fluid intake at home. Parents should be educated to avoid diluting formula and to understand that excessive water intake, especially if the child is febrile, will lead to hyponatremia (Bekhof et al., 2013). Tap water enemas can also cause hyponatremia. If the child has a decreased fluid intake, the nurse can educate parents to provide a comfort before offering fluid. Comfort may include a warm, dry environment with a stuffed animal. The airway should also be cleared prior to offering fluid.

Older Adults

Imbalances in older adults are often related to medication regimens, decreased dietary intake, and pathophysiologic conditions. The older adult should be educated that fluid and electrolyte imbalances may be related to prolonged laxative use and abuse for chronic constipation or diarrhea. Imbalances also occur from the use of diuretics often prescribed for cardiac and kidney disorders (Lindner et al., 2014). Diagnostic test preparations (particularly for GI studies) or periods of "nothing by mouth" can lead to imbalances. There is a growing body of evidence that supports the need for the older adult to take vitamin D supplements for deficiencies. Individuals are often prescribed a vitamin D supplement accompanied by a calcium supplement. When providing teaching and plans of care the patient may use in the home environment, keep in mind the sensory impairments that may be experienced by the older adult population (Lindner et al., 2014).

The nurse should conduct a careful medication reconciliation and review medications with the older adult or caregiver. Assess for medications that may cause fluid and electrolyte imbalances. Diuretics, cardiac medications, electrolyte supplements, and laxatives should be thoroughly reviewed as an essential safety measure. Diuretic agents can provide a wide range of electrolyte imbalances based upon the type of diuretic. Thiazides inhibit sodium reabsorption and can lead to the loss of sodium, chloride, potassium, and a slight decline in calcium levels. Loop diuretics act in the Loop of Henle in the kidney (Lindner et al., 2014). This classification causes loss of sodium, chloride, and potassium. Some patients on loop diuretics require increased consumption of dietary potassium or potassium supplements (Lindner et al., 2014). Potassium-sparing diuretics conserve potassium by inhibiting the action of aldosterone. This diuretic classification reduces potassium excretion, and elevated potassium levels may result. Potassium supplements are contraindicated with potassium-sparing diuretics due to the risk of hyperkalemia (Lindner et al., 2014). Potassium-sparing diuretics are often combined with thiazides.

Fluid and Electrolyte Balance

Nurses play a major role in the management of fluid and electrolyte balance. While the concept is simple, the fundamentals of fluid and electrolyte balance focus on increasing fluid intake when fluid loss increases (unless it is contraindicated for reasons related to cardiac, liver, respiratory, or kidney disorders) and decrease fluid intake in many cases when fluid loss decreases. Nurses play a key role in offering fluids to young children, individuals with physical or cognitive impairments, and older adults. Acutely ill patients also rely on nurses to provide fluid (McGloin, 2015). This population may include patients with sepsis, diuresis from AKI, respiratory acidosis, burns, and excessive gastrointestinal or wound losses because these individuals are at risk for dehydration. Fluid therapy should be guided by the same principles as drug therapy regarding administration principles and monitoring of the patient's response. Researchers continue to investigate the fluid and solutions to be administered to achieve the best outcomes. Severs and colleagues (2015) concluded that infusions of normal saline solution led to more kidney injury, need for renal replacement therapies, blood transfusions, and perioperative infections than balanced crystalloids Balanced crystalloids, such as Ringer's lactate solution with acetate, Hartmann solution, and Plasma-Lyte, loosely resemble the ionic composition of plasma.

Conclusion

Maintaining balance of fluid and electrolytes in the body is essential to overall functioning and health. A slight imbalance in fluid and/or electrolytes may have a profound impact on a patient. Symptoms related the fluid and/or electrolyte imbalances vary based upon the deficiency, and nursing management is patient- and age-specific. As members of the interprofessional team, nurses play an important role in patient care and management. Electrolyte deficits are often managed by replacement, while electrolyte excesses are treated by restricting additional intake of electrolytes and/or administering medications or fluids to decrease the electrolyte concentration. For example, patients with hyperkalemia may be administered sodium polystyrene sulfonate (Kayexalate) to facilitate excretion of potassium via the gastrointestinal tract.

Patients experiencing fluid volume deficiencies often receive fluid replacement therapy. Patients experiencing fluid volume excess are often placed on fluid restrictions. Diuretic therapy may be implemented for fluid volume excess unless contraindicated. Careful monitoring for changes in fluid and electrolyte status, comfort, vital signs, and physical assessment findings are essential nursing care priorities.

References

Bekhof, J., van Asperen, Y., & Brand, P.L. (2013). Usefulness of the fluid balance: A randomized controlled trial in neonates. *Journal of Paediatrics and Child Health, 49*(6), 486-492. doi:10.1111/jpc.12214

Cavari, T., Pitfield, A.F., & Kissoon, N. (2013). Intravenous maintenance fluids revisited. *Pediatric Emergency Care, 29*(11), 1225-1228. doi:10.1097/PEC.0b013e3182aa4e2a

Crawford, A.H. (2014). Hyperkalemia: Recognition and management of a critical electrolyte disturbance. *Journal of Infusion Nursing, 37*(3), 167-175. doi:10.1097/NAN.0000000000000036

Eliacik, E., Yildirim, T., Sahin, U., Kizilarslanoglu, C., Tapan, U., Aybal-Kutlugun, A., … Arici M. (2015). Potassium abnormalities in current clinical practice: Frequency, causes, severity and management. *Medical Principles and Practice, 24*(3), 271-275. doi:10.1159/000376580

El-Sharkawy, A.M., Sahota, O., Maughan, R.J., & Lobo, D.N. (2014). The pathophysiology of fluid and electrolyte balance in the older adult surgical patient. *Clinical Nutrition*, *33*(1), 6-13. doi:10.1016/j.clnu.2013.11.010

Gooch, M.D. (2015). Identifying acid-base and electrolyte imbalances. *Nurse Practitioner, 40*(8), 37-42. doi:10.1097/01.NPR.0000469255.98119.82

Holliday, M.A., & Seger, W.E. (1957). The maintenance need for water in parenteral fluid therapy. *Pediatrics, 19*(5), 823-832.

Lindner, G., Pfortmüller, C.A., Leichtle, A., Fiedler, G., & Exadaktylos, A.K. (2014). Age-related variety in electrolyte levels and prevalence of dysnatremias and dyskalemias in patients presenting to the emergency department. *Gerontology*, *60*(5), 420-423. doi:10.1159/000360134

McGloin, S. (2015). The ins and outs of fluid balance in the acutely ill patient. *British Journal of Nursing, 24*(1), 14-18. doi:10.12968/bjon.2015.24.1.14

McLafferty, E., Johnstone, C., Hendry, C., & Farley, A. (2014). Fluid and electrolyte balance. *Nursing Standard, 28*(29), 42-49.

Metheny, N.M. (2012). *Fluid and electrolyte balance: Nursing considerations* (5th ed.). Sudbury, MA: Jones & Bartlett Learning. doi:10.7748/ns2014.03.28.29.42.e5531

Reid, J., Robb, E., Stone, D., Bowen, P., Baker, R., Irving, A.S., & Waller, M. (2004). Improving the monitoring and assessment of fluid balance. *Nursing Times*, *100*(20), 36-39.

Severs, D., Rookmaaker, M.B., & Hoorn, E.J. (2015). Intravenous solutions in the care of patients with volume depletion and electrolyte abnormalities. *American Journal of Kidney Disease, 66*(1), 147-153. doi:10.1053/j.ajkd.2015.01.031

Velissaris, D., Karamouzos, V., Pierrakos, C., Aretha, D., & Karanikolas, M. (2015). Hypomagnesemia in critically ill sepsis patients. *Journal of Clinical Medicine Research, 7*(12), 911-918. doi:10.14740/jocmr2351w

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