Continuing Education
Material:

BLOOD ELECTROLYTES:
NA+ and K+

ABP, Inc.

BLOOD ELECTROLYTES: Na+ and K+

OBJECTIVES

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This continuing education material, Blood Electrolytes: Na+ and K+, will earn the participant 2.0 contact hours. If you have any questions regarding this information or would like further information on other continuing education opportunities, please contact:

ABP, Inc.
P.O. Box 127
Granger, IN. 46530
Phone (574) 277-0691
Fax (574) 277-4624
www.abpincorp.com

BLOOD ELECTROLYTES – POTASSIUM (K+) AND SODIUM (NA+)

SODIUM is the most common electrolyte in extracellular fluid. Its reference range is 135 to 145 mEq/L. The main role of sodium is in controlling water distribution and fluid balance in the body because it is the primary determinant of extracellular fluid osmolality. ***Osmolality and Osmolarity*** often get confused. *Osmolality*, which is used to describe fluids inside the body, refers to the solute concentration in fluid by weight – the number of milliosmols in a kilogram of solution. *Osmolarity* refers to the solute concentration in fluid by number of milliosmols per liter of solution. Because 1liter of water weighs 1 kilogram, the normal ranges are the same and the terms are often used interchangeably. Water follows sodium, so high levels of sodium in a fluid compartment with take water with it.

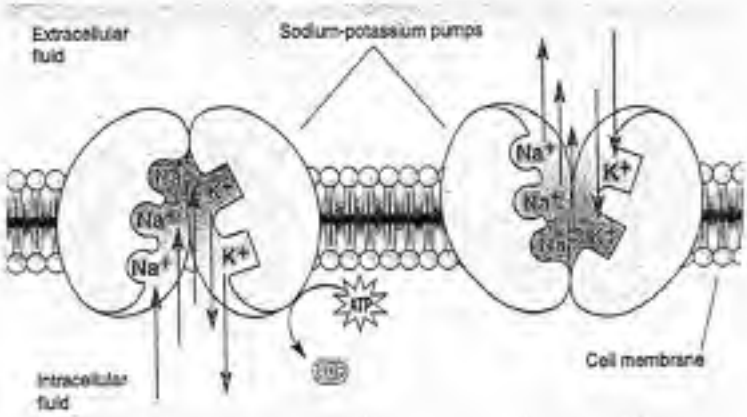
Other functions of sodium include:

- promote transmission of nerve impulses
- maintain intracellular osmolality
- activate several enzymatic reactions
- assist with regulation of acid-base balance
- promote myocardial, skeletal, smooth muscle contractility

Sodium is absorbed by the intestines and excreted by the kidneys. If sodium levels begin to rise, the body will make adjustments by stimulating a thirst mechanism so that the person will want to drink additional water. Sodium levels are influenced by the antidiuretic hormone (ADH). Increased secretions of ADH causes more water to be reabsorbed in the kidneys and decreased ADH secretion allows more water to be excreted. Sodium levels are also influenced by aldosterone. High aldosterone levels promote the reabsorption of sodium in the kidneys' distal tubules. Acid –base balance is maintained by the sodium combining with chloride and bicarbonate ions. Sodium, which is mainly extracellular, works with potassium, mainly intracellular, to maintain the balance in intracellular and extracellular fluids through the sodium-potassium pump. This pump system has an important role in conducting impulses in muscle and nerve fibers.

The Sodium-Potassium Pump

The sodium-potassium (Na+/K+) pump moves sodium from inside cells to the extracellular compartment, and returns K+ from the extracellular compartment into cells, using ATP as an energy source. The Na+ concentration outside cells is about 14 times greater than inside the cells; the concentration of K+ inside cells is about 35 times greater than outside cells. The Na+/K+ pump prevents osmotically active particles from accumulating inside cells, which would cause them to swell from the influx of water following sodium.



Hyponatremia, a condition in which the sodium level is below 135 mEq/L, can be due to low levels of sodium or to excess water in relation to the amount of sodium. Postoperative patients commonly have hyponatremia. Common causes of hyponatremia include: profuse diaphoresis, draining wounds, excessive diarrhea or vomiting, trauma with significant blood loss, low sodium intake, hormonal changes associated with Addison disease, hypothyroidism and overuse of thiazide diuretics. Low sodium levels are also seen in patients with aldosterone deficiency and are also a common electrolyte imbalance in postoperative patients. A drop in sodium causes cellular edema which affects the central nervous system and leads to depression and cerebral edema. It is important to monitor the patient for mental status changes, headache, personality changes and irritability. Gastrointestinal symptoms of hyponatremia include nausea, vomiting, abdominal discomfort and diarrhea. In cases where the sodium is 115 mEq/L or less, the patient will have muscle tremors and twitching, focal weakness, signs of intracranial pressure and possible coma.

The treatment is to determine the underlying cause and replace the lost sodium. Eating and drinking can easily replace the lost sodium. IV administration of lactated Ringers or normal saline may be needed in those who cannot take sodium orally. In extreme case an oral medication called Tolvaptan may be used. It is important not to use hypertonic saline too rapidly to correct hyponatremia. Severe brain damage and death may result. Blood and urine electrolytes, as well as serum osmolality must be closely monitored.

Hypernatremia, a condition in which the sodium levels are above 145 mEq/L, is generally associated with a hyperosmolar state where a fluid volume deficit exists. The increase in extracellular sodium causes intracellular fluid to shift out of the cells into the extracellular spaces which results in cellular dehydration. Common causes of hypernatremia include: inadequate water intake, excessive fluid loss, administration of tube feedings without adequate water supplements, diarrhea and excessive steroid use. Medical conditions associated with hypernatremia include hyperaldosteronism, Cushing syndrome, diabetes insipidus and renal failure. Clinically the patient may exhibit muscle weakness and twitching, personality changes, agitation, hallucinations and decreased level of consciousness. Cardiac output is reduced due to decreased myocardial contractility leading to heart failure. Patients with hypernatremia may have symptoms associated with hypovolemia to include: dry, sticky mucous membranes, intense thirst, flushed skin, oliguria, tachycardia, postural hypotension, and fever. Dehydration with hypernatremia is a primary reason for behavior changes in older adults. Blood vessels become fragile in severe cases and can result in intracerebral, subarachnoid, and subdural hemorrhage and permanent brain damage. Treatment is to treat the underlying cause and restore fluid balance. The patient will be treated with salt free fluids either orally or by IV. Rapid reduction of sodium may cause serum osmolality in the brain to be temporarily greater than that of plasma osmolality causing cerebral edema. It is important to monitor levels closely and reduce the sodium gradually. Hypotonic sodium solutions (0.45% NaCl) are considered safer than D_5W because they allow a more gradual reduction of serum sodium, reducing the risk of cerebral edema.

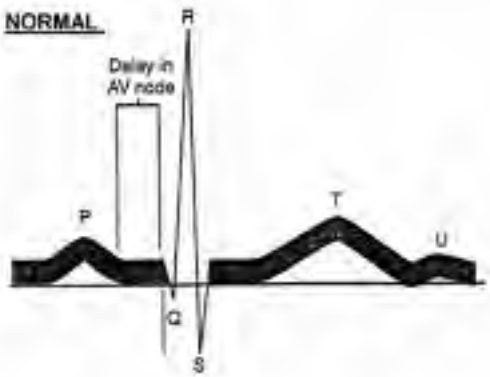
POTASSIUM is the major element in intracellular fluid. The reference range of potassium is 3.5 to 5.0 mEq/L. Potassium plays an important role in cellular metabolism, especially in protein and glycogen synthesis and in the enzymatic processes necessary for cellular energy. It also aids in maintaining cellular electrical neutrality and osmolality.

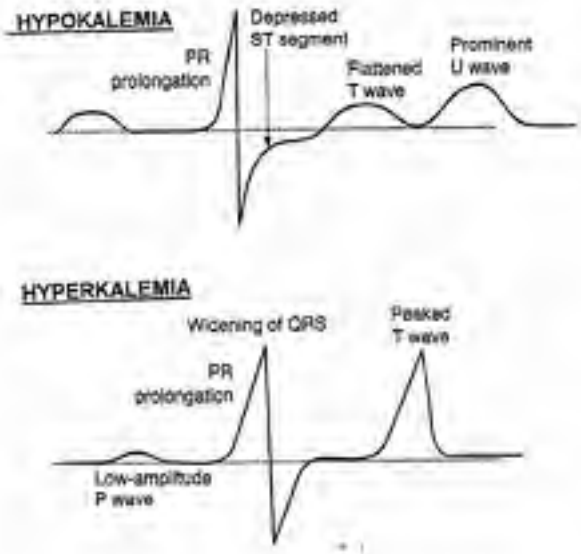
Other functions of potassium include:

- acid-base balance
- nerve impulse conduction
- maintenance of normal cardiac rhythm
- skeletal and smooth contraction

The body has no effective way to store potassium so it must be consumed daily. Potassium levels are regulated by kidney excretion with excess levels removed through feces and sweat. The sodium- potassium pump regulates extracellular potassium levels by pumping sodium out of cells and allowing potassium to flow back into cells. In the kidneys sodium and potassium have a reciprocal relationship. Acting on the distal tubules, aldosterone triggers potassium excretion and reabsorption of sodium. The kidneys have no way to detect a potassium deficiency and will continue to excrete potassium even when levels are low. Acid-base changes affect serum potassium levels because potassium is exchangeable with hydrogen ions.

Hypokalemia is a condition where the serum potassium level is below 3.5 mEq/L. Gastrointestinal loss is the most common cause of hypokalemia. When extracellular potassium is lost from diarrhea, vomiting, diaphoresis, laxative or diuretic overuse, gastric suctioning or alkalosis, the body compensates by shifting potassium from the intracellular spaces. Potassium can also be lost through kidney excretion in association with metabolic alkalosis and hyperaldosteronism. Potassium levels below 3 mEq/L. can cause a problem with cardiovascular and neuromuscular function causing respiratory function to be compromised. Prolonged low levels of potassium impair the kidneys' ability to concentrate urine which results in polyuria and urine with a low specific gravity. Hypokalemia also depresses insulin release from the pancreas, resulting in glucose intolerance. Cardiac and/or respiratory arrest can also result from very low levels of potassium. Patients need to have vital signs closely monitored and watched for irregularities in the apical pulse. The **ECG in hypokalemia** with show flattened T waves, depressed ST segments and prominent U waves as well as life-threatening dysrhythmias. Neuromuscular assessments should be done to look for the absence of deep tendon reflexes and myalgia. Other symptoms include skeletal muscle cramps and weakness, progressing from mild lower extremity weakness to more generalized paralysis. Nausea, vomiting, anorexia, constipation, the absence of bowel sounds and a paralytic ileus are common GI effects. Prolonged hypokalemia affects the kidneys' ability to concentrate urine so the patient's input and output must be monitored. It is also important to monitor all the serum electrolytes. If the patient takes digoxin, he must be monitored for signs of toxicity, i.e. anorexia, nausea, vomiting, cardiac dysrhythmias and seeing yellow-green halos. Loss of potassium in extracellular fluid increases myocardial sensitivity to digitalis by potentiating digoxin's effects. Treatment involves restoring the body to a normal potassium level. This is done by a providing the patient with a diet high in potassium to include whole grains, green leafy vegetables, potatoes, beans and fruits. Oral and IV replacement is also an option.





Hyperkalemia is a condition where the serum potassium level is above 5.0 mEq/L. Hyperkalemia is most often related to kidney failure due to inadequate kidney function. Other causes include over use of oral potassium or salt substitute products, hypoaldosteronism and Addison's disease. Certain medications such as potassium chloride, angiotensin-converting enzyme inhibitors and nonsteroidal anti-inflammatory drugs can cause the potassium to increase. Excess serum potassium can be created in cases of severe infections, burns, metabolic acidosis and in traumatic crush injuries. **ECG changes associated with hyperkalemia** include peaked T waves, prolonged PR interval, and widening of the QRS complex. At any point ventricular dysrhythmias and cardiac arrest are possible.

It is important to be aware of **pseudohyperkalemia,** a falsely elevated potassium level, because if discovered in a presurgery workup, it can unnecessarily delay surgery and result in additional testing and a longer hospital stay. It can also mask a real illness which can lead to medical mistakes due to the administration of wrong medication or wrong treatment. Certain medical conditions, such as diabetes, renal failure, can elevate a patient's potassium. Many medications used to treat heart conditions, anti-inflammatory drugs and heparin can alter potassium levels. Hemolysis, rupture of red blood cells, can release excess potassium into the blood. Pre-collection factors such as fist pumping and prolonged tourniquet application can falsely elevate a patient's potassium. Collection factors that can falsely elevate potassium include drawing through vascular access devices, not letting alcohol dry on the skin prior to puncture, use of a syringe with excessive pulling on the plunger, forcing the blood from the syringe into an evacuated tube instead of using a syringe transfer device and shaking the blood after collection instead of gently inverting. Collection of specimens using the wrong order of draw, i.e. drawing a green tube or SST for electrolytes after a tube containing EDTA because of the carry over from the EDTA tube. The longer that a specimen is allowed to clot the more potassium that can diffuse out of the red blood cells into the blood. Another significant factor in pseudohyperkalemia is improper centrifugation especially in the tubes with gel barriers. It is important to allow serum separator tubes to clot for at least 30 minutes, as per manufacturer instructions, and then centrifuge for the required number of minutes at the required speed. The most clinically dangerous problem associated with hyperkalemia is on myocardial tissue because of the effect on cardiac conduction. The higher the potassium level, the higher and more peaked the T wave will appear on the ECG. There will also be a prolonged PR interval and a widening of the QRS complex which can lead to life threatening ventricular dysrhythmias. Patients with hyperkalemia will exhibit cardiac problems, muscle weakness and paralysis, respiratory problems, nausea, diarrhea and intestinal problems. Treatment involves bringing the serum potassium levels back to normal. Dietary restrictions of potassium can help along with removing medications containing potassium. IV administration of diuretics can be used as long as blood pressure and heart rate are monitored. In extreme cases hemodialysis or peritoneal dialysis may be needed to remove excess potassium.

References

1. Balancing Act Na+ and K+, NURSING 2011, July, Wolters Kluwer, Lippincott Williams and Wilkins.
2. Investigating elevated potassium values, MLO, November 2006.

BLOOD ELECTROLYTES: NA+ and K+ – Self-Assessment Quiz

Please place all answers on the Continuing Education Registration Form. Mail form to ABP, Inc. to be graded so that you can get your P.A.C.E. certificate.

1. The most common electrolyte in extracellular fluid is:

   a. sodium b. potassium c. chloride d. magnesium

2. The most common electrolyte in intracellular fluid is:

   a. sodium b. potassium c. chloride d. magnesium

3. Which of the following is NOT a function of sodium?

   a. To control fluid balance in the body
   b. To promote transmission of nerve impulses
   c. To assist with the regulation of acid-base balance
   d. To maintain normal cardiac rhythm

4. The function of the Sodium - Potassium Pump is to:

   a. Move sodium from outside to inside the cells
   b. Move potassium from inside to outside the cells
   c. Maintain the balance of intracellular and extracellular fluids
   d. Cause a person to drink more water

5. Which of the following statements is NOT correct about sodium?

   a. Hyponatremia is common in post - operative patients.
   b. Hyponatremia with dehydration is a reason for behavioral changes in older adults.
   c. A medical condition associated with hypernatremia is Cushing syndrome.
   d. Rapid reduction of sodium can cause cerebral edema.

6. The most common cause of hypokalemia is:

   a. Addison's disease
   b. severe infection
   c. gastrointestinal loss
   d. Cushing Syndrome

7. All of the following ECG changes are associated with hyperkalemia EXCEPT:

   a. peaked T waves
   b. prominent U waves
   c. prolonged PR interval
   d. widening of the QRS complex

8. Which of the following is NOT a cause of pseudohyperkalemia?

   a. improper centrifugation in tubes with gel barriers
   b. prolonged tourniquet application
   c. drawing a SST tube for electrolytes before a tube with EDTA
   d. not using a syringe transfer device to transfer blood to evacuated tubes

9. The most clinically dangerous problem associated with hyperkalemia is:

a. the effect on myocardial tissue conduction
b. chronic diarrhea
c. inadequate kidney function
d. intestinal problems

10. Patients exhibiting cardiac dysrhythmias, nausea, vomiting, anorexia and seeing yellow-green halos are most likely showing toxicity to what medication?

a. potassium chloride
b. sodium chloride
c. digitalis
d. digoxin