Fourth Stage

General Surgery

م.د. علي سلمان جاسم

Lecture 9

Electrolytes balance

sodium and water homeostasis are intimately related. The classic abnormalities described below relate to plasma sodium concentrations. These can occur in the presence of low, normal or high levels of total body sodium.

Daily requirements of sodium in a normal patient are around 120–140 mmol per day (i.e. 1 L of 'normal' saline).

Hypernatremia surgical relevance causes are:

- **Insufficient intake of water, e.g., perioperative fasting.**
- **Excessive insensible and respiratory water loss, e.g. pyrexia, tachypnoea secondary to respiratory complications.**
- **Administration of excess sodium, either with intravenous sodium solutions or medications containing large amounts of sodium.**
- **Diabetes insipidus (DI), which is either a failure of production (pituitary DI) or lack of response to ADH (nephrogenic DI).**

Treatment: Sodium concentration should be corrected gradually to minimize the risk of inducing cerebral oedema (as water shifts from the newly hypotonic or isotonic plasma). Treatment of DI depends on the underlying cause.

Hyponatremia causes in surgical practice is combined salt and water depletion. The disease processes are the same as those causing dehydration from excess fluid losses, particularly where the losses are solute rich. The decreased extracellular fluid stimulates water reabsorption under the influence of ADH. The processes involved in fluid overload can also result in hyponatremia, with more water being retained relative to sodium. The total body sodium is therefore increased, but not as much as the total body water, causing dilution and hyponatremia. Treatment is the same for fluid overload.

Potassium

Daily requirements of potassium are 60 mmol per day.

Hyperkaliemia A significantly raised serum potassium concentration (>7.0 mmol/L) can cause lifethreatening cardiac arrhythmias and urgent treatment is required to prevent it. Symptoms are rare until complications have occurred, so awareness and prevention are essential. Treatment is resuscitative, performing life support maneuvers where required. If complications have not yet occurred, treatment is directed at preventing complications and reducing serum potassium levels.

Calcium gluconate (10 mL of 10%) protects the heart from arrhythmias. Insulin drives potassium into the intracellular fluid. There is some debate as to whether glucose should be given simultaneously to prevent a fall in blood glucose concentration.

Treatment is then directed at the underlying cause, e.g., renal support may be required. Causes include either increased release or administration, or decreased excretion.

Renal insufficiency results in impairment of potassium excretion and acute renal failure can result in a sharp rise in serum potassium levels.

Drugs that affect distal tubular function can cause inefficient potassium excretion. An example is the class of diuretics that antagonizes the action of aldosterone

Hypokalemia

1- Insufficient intake: inadequate intravenous replacement

2- Excess gastrointestinal losses: diarrhea, fistulae, villous adenomas

3-Excess renal losses: diuretic therapy Treatment of hypokalemia is based on replacing the deficit either orally or in dilute intravenous fluids (never as a potassium salt bolus), and treatment of the underlying cause.

Fluid replacement

There is a long-standing debate over the relative value of fluid replacement with crystalloid and colloid solutions Crystalloid solutions are those with dissolved solutes. Dextrose Glucose solution is isotonic at 5%, and this is the standard fluid infused. It is transferred freely between all fluid compartments so that only 8% remains in the intravascular space. Saline Isotonic saline is 0.9%, and is called 'normal saline'. Each 500 mL bag contains 75 mmol of sodium, balanced with 75 mmol of chloride. Following intravenous infusion, it is distributed freely within the ECF, with 25% remaining intravascular. Colloid solutions contain large-molecular-weight substances that are designed not to cross the vascular endothelium and thus remain within the intravascular space. They are used to increase the colloid osmotic pressure causing retention of fluid in the circulation.

Blood

Where fluid loss is by way of significant hemorrhage, replacement with blood is appropriate.

Acid-base balance

For efficient cellular function to occur, the cellular and plasma pH, or hydrogen ion concentration, must be maintained between narrow limits (pH 7.36-7.44). Values outside these parameters result in cellular and system dysfunction, which become profound and can ultimately result in cell death and system failure.

Hydrogen ions are generated by several metabolic processes, and by equilibration of carbon dioxide (CO_2) in solution. Maintenance of normal pH is achieved through, a number of different systems: namely, buffering, respiration and renal excretion of hydrogen ions and bicarbonate. The main determinant of pH is the equilibration of CO_2 in solution. CO_2 is generated as a waste product in normal aerobic respiration. It is excreted by the lungs during respiration. Transport of CO_2 from the tissues to the lungs is performed by the blood, with the CO_2 being dissolved in solution. The enzyme carbonic anhydrase forms carbonic acid according to the Henderson- Hasselbach equation: This equation has to remain in equilibrium, and is therefore dependent on CO_2 excretion by the lungs and the bicarbonate (HCO_3^-) concentration in plasma. Bicarbonate concentration is controlled by renal excretion.

Other forms of acid are produced by tissues, e.g. lactic acid from anaerobic metabolism. These are buffered in plasma by bicarbonate, phosphate, hemoglobin and other plasma proteins. Renal excretion of hydrogen ions is important in their elimination. An important effect of the interaction between hydrogen ions and hemoglobin (Hb) is the reduction in the affinity of Hb for oxygen. As a result, when oxyhemoglobin reaches the tissues, where there is a higher concentration of carbonic and other acids, it more readily releases the oxygen it is carrying for use in that tissue. Abnormalities of acid-base balance Respiratory acidosis Decreased CO_2 excretion by the lungs results in increased plasma carbonic acid and hence hydrogen ion concentration. Causes include decreased respiratory drive (e.g. opiate overdose) and diseases of lung parenchyma that result in inefficient gas transfer. Respiratory alkalosis Overventilation increases CO_2 excretion, decreasing plasma carbonic acid and hence hydrogen ion concentration. Hyperventilation can be psychological, pathological (e.g. tachypnoea of respiratory tract infection) or iatrogenic (e.g. Overventilation of mechanically ventilated patients). Metabolic acidosis Metabolic acidosis is an increase in plasma hydrogen ion concentration derived from another source than CO_2. Examples include lactic acidosis and diabetic ketoacidosis.

Metabolic alkalosis This is a fall in plasma hydrogen ion concentration not related to carbon dioxide. It can result from many processes that cause either increased renal H^+ excretion or from excess plasma bicarbonate (e.g. iatrogenic administration, renal conservation of bicarbonate); gastrointestinal disorder associated with vomiting and loss of Hcl.