WATER AND ELECTROLYTES BALANCE

BY

BAMIDELE OLUBAYODE

DEPARTMENT OF PHYSIOLOGY

BOWEN UNIVERSITY, IWO
WATER BALANCE

• Body is made up of 60 - 70% of water.
• Distribution of water in the body fluid compartments is equal to solute content of each compartment.
• The total body water is 42 L which is about 60% of total body weight.
• Extracellular Fluid - 14L which is about 20% of body weight. It is divided into Plasma (2.8L) and Interstitial Fluid (11.2L).
• Intracellular Fluid - 28L which is about 40% of body weight.
WATER BALANCE

• The principle input = output is called balance.
• Water in the body is balanced when the water input is equal to water output.
• This applies to a normal non-growing, non pregnant adult.
Water gets into the body via 3 sources and get out of the body via 4 sources

<table>
<thead>
<tr>
<th>WATER INPUT</th>
<th>WATER OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Water in food (800-1000 ml/day)</td>
<td>1. Insensible water loss (800 - 1000 ml/day)</td>
</tr>
<tr>
<td>2. Water generated from oxidation of food (300 - 400 ml/day)</td>
<td>2. Sweat (200 ml/day)</td>
</tr>
<tr>
<td>3. Water ingested as a liquid (1000 - 2000 ml/day)</td>
<td>3. Feces (100 -200 ml/day)</td>
</tr>
<tr>
<td>TOTAL = 2100 -3400 ml/day</td>
<td>Urine (1000 -2000 ml/day)</td>
</tr>
<tr>
<td></td>
<td>TOTAL = 2100 -3400 ml/day</td>
</tr>
</tbody>
</table>
WATER INPUT

• Water in food and water generated from the oxidation of food vary widely depending on the type of food.
• Water ingested as a liquid remain fairly constant.
• The water ingested as a liquid is controlled by thirst.
WATER OUTPUT

• The insensible water loss and sweat depend on weather.

• Water in feces vary widely as a result of several factors which include: type of diet and health status.

• The fairly constant water on the output side is water in urine which averages 1 -2 l/day.

• Water in urine is controlled by plasma level of ADH.
REGULATION OF BODY WATER

- Both thirst and plasma level of ADH are controlled by the hypothalamus.
- When the plasma osmolality is increased, there is sensation of thirst and the release of ADH.
- Therefore, there is water ingestion and water reabsorption in the kidney.
- Plasma osmolality is brought back to normal.
- On other hand when there is overhydration, thirst centre is inhibited and ADH production is also switched off.
- This result in elimination of large amount of urine.
REGULATION OF BODY WATER

An increase in osmolality of plasma

- Produces ADH secretion
  - Leads to
    - Increased water reabsorption from renal Tubules
      - causing
        - Decreases urine output

Decrease in osmolality

- Produces decreased ADH secretion
  - Leads to
    - Decreased water reabsorption
      - causing
        - Increases Urine output
• Plasma osmolality → largely dependent on the sodium concentration

hence, sodium indirectly controls the amount of water in the body.

- In **DIABETES INSIPIDUS**: Deficiency of ADH

  Increased loss of water
ELECTROLYTES BALANCE

- The kidney help to regulate the concentrations of plasma electrolytes (Sodium, Potassium, Chloride, Bicarbonate and Phosphate) by matching the urinary excretion of these compounds to the amounts ingested.

- The regulation of plasm $\text{Na}^+$ is important in the control of blood volume and pressure, the control of plasma $\text{K}^+$ is required to maintain proper function of cardiac and skeletal muscles.
**ELECTROLYTES COMPOSITION OF BODY FLUIDS**

<table>
<thead>
<tr>
<th></th>
<th><strong>EXTRACELLULAR FLUID (PLASMA)</strong></th>
<th></th>
<th><strong>INTRACELLULAR FLUID (MUSCLE)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CATIONS</strong></td>
<td><strong>ANIONS</strong></td>
<td><strong>CATIONS</strong></td>
<td><strong>ANIONS</strong></td>
</tr>
<tr>
<td>Na⁺</td>
<td>142</td>
<td>Cl⁻</td>
<td>103</td>
</tr>
<tr>
<td>K⁺</td>
<td>5</td>
<td>HCO₃⁻</td>
<td>27</td>
</tr>
<tr>
<td>Ca₂⁺</td>
<td>5/2</td>
<td>HPO₄²⁻</td>
<td>27</td>
</tr>
<tr>
<td>Mg₂⁺</td>
<td>3</td>
<td>SO₄²⁻</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>PROTEINS</td>
<td>PROTEINS</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>ORGANIC ACIDS</td>
<td>ORGANIC ACIDS</td>
<td>6</td>
</tr>
<tr>
<td><strong>155</strong></td>
<td><strong>155</strong></td>
<td><strong>202</strong></td>
<td><strong>202</strong></td>
</tr>
</tbody>
</table>
ROLE OF ALDOSTERONE IN Na⁺ /k⁺ BALANCE

- Nearly about 90% of the filtered Na⁺ and k⁺ is reabsorbed in the early part of the nephron before the filtrate reaches the distal tubule.
- The reabsorption occurs at a constant rate and is not subject to hormonal regulation.
- The final concentration of Na⁺ and K⁺ in the urine is varied according to the needs of the body by processes that occur in the late distal tubule and in the cortical region of the collecting duct.
- Reabsorption of Na⁺ and secretion of K⁺ by the kidneys are regulated by aldosterone secreted by adrenal cortex.
ROLE OF ALDOSTERONE IN Na⁺ /K⁺ BALANCE

• Aldosterone stimulate Na⁺ reabsorption to some degree in the late distal convoluted tubule.
• But the primary site of Aldosterone action is in the cortical collecting duct.
• The amount of K⁺ secretion into the late distal tubule and cortical collecting duct depends on:
  ➢ the amount of Na⁺ delivered to these region of the nephron
  ➢ the amount of aldosterone secreted.
• If the blood concentration of K⁺ rises, this will stimulate increased aldosterone section from the adrenal cortex.
• The aldosterone then stimulates increased reabsorption of Na⁺.
REGULATION OF SODIUM AND WATER BALANCE

• MAJOR REGULATORY FACTORS ARE:
  - Hormones (Aldosterone, ADH)
  - Renin-Angiotensin system.

**ALDOSTERONE** (mineralocorticoid Zona Glomerulosa of adrenal cortex)

regulates

$\text{Na}^+ - \text{K}^+$ exchange and $\text{Na}^+ - \text{H}^+$ exchange at the Renal Tubules.

Net effect is **SODIUM RETENTION**.
CONTROL OF ALDOSTERONE SECRETION

• Since aldosterone promotes Na+ retention and K+ loss, increase in aldosterone secretion occurs when there is a low Na+ or a high K+ concentration in the blood.

• JUXTAGLOMERULAR APPARATUS:
  • Region in each nephron where afferent arteriole comes in contact with the last of the thick ascending limb of Henle.
  • This region has different appearance.
JUXTAGLOMERULAR APPARATUS

• Made up of three parts: juxtaglomerular cells, macula densa and messengial cells.
• **Juxtaglomerular cells** within the afferent arteriole secrete RENIN into the blood.
• Renin catalyzes the conversion of angiotensinogen into angiotensin I.
• Angiotensin I is then converted to angiotensin II by angiotensin converting enzyme (ACE) present in the lungs.
• **Angiotensin II** formed, stimulates the adrenal cortex to secrete aldosterone which promote the reabsorption of Na\(^+\) from CD into the blood.
REGULATION OF RENIN SECRETION

- Low intake of salt (NaCl) → decrease in blood volume
- Due to decrease in plasma osmolality which inhibits ADH secretion.
- Low level of ADH → less water reabsorption through CD → more water excretion in urine.
- Fall in blood volume and renal blood flow cause increase in renin secretion.
- Renin secretion is also stimulated by:
  ✓ low blood pressure
  ✓ sympathetic nerve activity
- Increased renin secretion acts via angiotensin II to stimulate aldosterone secretion which causes less Na\(^+\) excretion.
ROLE OF THE MACULA DENSA

• It helps to inhibit renin secretion when the blood Na\(^+\) concentration is high.

• The cells of **macula densa** respond to Na\(^+\) in the filtrate delivered to the distal tubule.

• Increase in plasma Na\(^+\) in the filtrate or GFR, increase the rate at which Na\(^+\) is delivered to the distal convoluted tubule.

• **Macula densa** senses the increase in Na\(^+\) filtered inhibits juxtaglomerular cells from secreting renin.

• Aldosterone secretion thus decreases and Na\(^+\) is less reabsorbed in the cortical collecting duct and get excreted in the urine.
THANK YOU