SODIUM METABOLISM AND HYPERTENSION

LEARNING OBJECTIVES

At the end of the lecture, student should be able to understand:
• The various forms of sodium intake in diet
• Its Normal daily requirement
• Distribution of sodium in extracellular vs intracellular compartments
• Role of sodium in cellular pumps
• Relationship of sodium with hypertension.

SODIUM: BACKGROUND

• The difference between "sodium" and "salt" can be confusing.
• Sodium is a mineral found in various foods including table salt. (NaCl - sodium chloride)
• Table salt is 40% sodium (sodium chloride).
• Also combined with other chemicals and added to manufactured foods.

SODIUM: EXAMPLES OF FOOD ADDITIVES

- Monosodium Glutamate (MSG)
- Sodium Bicarbonate (baking soda)
- Sodium Phosphate
- Sodium Carbonate
- Sodium Benzoate
- Sodium Caprate
- Sodium Erythrobate
- Sodium Proprinate
- Sodium Nitrite/nitrate
- Sodium Sulfite
- Sodium Lactate
- Sodium Diacetate
- Sodium Caseinate

**SODIUM: ESSENTIAL ROLE**

- Essential mineral required to maintain good health.
- Sodium must be consumed regularly in adequate amounts.
- Vital component of all fluids in the human body.

**Electrolyte**
- Possesses a mild electrical charge helping to transmit nerve impulses throughout the body.

**Kidneys work to regulate sodium balance**
- Excess sodium passes through urine
- High sodium = more urine production

**BODY DISTRIBUTION OF SODIUM**

* Sodium is the chief electrolyte which is found in large conc. in extracellular fluid compartment

Approx. body distribution of sodium is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Total m Mol</th>
<th>Conc. M Mol/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total body</td>
<td>3150</td>
<td>---</td>
</tr>
<tr>
<td>Intracellular</td>
<td>250</td>
<td>10</td>
</tr>
<tr>
<td>Extracellular</td>
<td>2900</td>
<td>140</td>
</tr>
<tr>
<td>Plasma</td>
<td>400</td>
<td>140</td>
</tr>
</tbody>
</table>
Normal requirement of salt daily

- **adults**: 1-3.5g of Na
- **Infants**: 0.1-0.5g
- **Children**: 0.3-2.5g

**ABSORPTION OF SODIUM**

- Sodium is absorbed by sodium pump situated in basal and lateral plasma membrane of intestinal and renal cells.
- Na-pump actively transports Na into extracellular fluid.

**SODIUM PUMP**

- This is also called as \( \text{Na}^+ - \text{K}^+ \text{ATPase} \).
- It requires ATP and \( \text{Mg}^{++} \).
- \( \text{Na-pump is an enzyme, Na}^+ - \text{K}^+ \text{ATPase} \).  
- It is a glycoprotein composed of 2 \( \alpha \) and 2 \( \beta \) chains.
• Its activity depends on presence of Na\(^+\) and K\(^+\).

**EXCRETION OF NA**

- Every 24 hours approximately 25000 mmol of sodium are filtered by the kidney.
- However, due to tubular reabsorption less than 1% of this sodium appears in the urine (100-200 mM/day).
- Approximately 70% of the filtered sodium is reabsorbed in proximal tubule.
- Further 20-30% of filtered sodium is reabsorbed by ascending loop of Henle.

**FUNCTIONS OF SODIUM**

- **Fluid balance:**
  Sodium maintains crystalloid osmotic pressure of extracellular fluids and helps in retaining water in E.C.F.

- **Neuromuscular excitability:**
  involved in neuromuscular irritability like other cations

- **Acid base balance:**
  Na\(^+\)-H\(^+\) exchange in renal tubule to acidify urine.

- **Maintenance of viscosity of blood:**
  The salts of Na with globulins are soluble and further Na\(^+\) and K\(^+\) both regulate in maintaining the degree of hydration of the plasma proteins.

- **Role in resting membrane potential:**
  Plasma membrane has a poor Na permeability and passive Na inflow through it. Na-pump keeps Na conc. Far higher outside than inside.

  This separation of charges is called *polarization* of the membrane. It potential difference of -70 to -95 millivolts across the membrane and is called as resting membrane potential.

- **Role in Action Potential:**
  A local depolarization of nerve or muscle fibre is observed in stimulation. This rapidly increases its permeability to Na causing considerable transmembrane influx of Na down its inward conc. Gradient.
CLINICAL ASPECT

Normal plasma sodium concentration: 135 - 145 mEq/L

HYPERNATREMIA

• A high plasma sodium concentration, that the extracellular sodium is excessive relative to water.
• Decrease in body water and increase in body sodium.
• Simple dehydration
• Diabetes insipidus
• Osmotic loading/osmotic diuretics
• Excess sodium intake
• Mineralcorticoid excess
• Steroid therapy

SIGNS AND SYMPTOMS

• Irritability, restlessness, Coma, Seizures
• Thrombosis, Intracranial hemorrhage.
• Thirst, dry mucus membranes, poor skin turgor.

HYPONATREMIA

• Hyponatremia is defined as a serum level of less than 135 mEq/L
• Considered severe when the serum level is below 125 mEq/L.
• Diuretic medications (thiazides)
• Excessive sweating
• Chronic diarrhea or vomiting
• Kidney diseases
• Adrenal gland insufficiency (Addison’s disease, syndrome of inappropriate antidiuretic hormone SIADH)
• Excess water accumulation (in congestive heart failure, SIADH, or polydipsia)

SIGNS/SYMPTOMS

Lethargy, apathy secondary to cerebral edema, Headache
Muscle twitching, cramps; Seizures Na⁺ < 110 mEq/L
Role of sodium with CVS

Excess sodium can cause:

• The body to retain fluid
• Swelling of body tissues
• Increase in blood pressure/hypertension

BLOOD PRESSURE

• 120/80 (NORMAL)

Top number (systolic)
- Measures the force of blood on arteries when the heart beats

Bottom number (diastolic)
- Measures force of blood on arteries between beats

WHAT IS HIGH BLOOD PRESSURE?
(HYPERTENSION)

• Blood pressure that stays elevated
  – More than 140/90
  – More than 130/80 if you have:
    • Diabetes
    • Mild kidney disease
    • Heart disease

What does High Blood Pressure do to my Body?

• Stroke
• Congestive heart failure
• Kidney failure
• Heart attack
• Heart rhythm problems
• Aneurysm
REGULATION OF BLOOD PRESSURE VIA Na AND RENIN-ANGIOTENSIN SYSTEM

EFFECT OF SODIUM INTAKE ON HYPERTENSION
HOW TO COUNCIL OUR PATIENTS ON SODIUM INTAKE

• Daily dietary sodium intake of **2300mg or less**

• encourage fresh choices most of the time.

LIMIT SODIUM AND SALT

• **Research shows that eating less sodium and salt lowers blood pressure**

• Lower your sodium intake by:
  – Eating out less often
  – Buying fresh, frozen or unsalted canned foods
  – Choosing foods with less than 400 mg/serving
  – Buying low- or reduced-sodium, or no salt added foods
  – Using less salt

GET ENOUGH POTASSIUM

• **Potassium helps lower blood pressure**
  – Helps balance the amount of sodium in your body
  – If you don’t get enough potassium, you can accumulate too much sodium

• **Foods high in potassium include:**
  – Fruits, vegetables, dairy foods, and fish
POINTS TO REMEMBER IN RELATION TO HYPERTENSION

• Lifestyle changes that can prevent and control high blood pressure include:
  – Healthy eating - emphasizing fruits, vegetables and low-fat dairy foods
  – Choosing and preparing foods with less salt and sodium
  – Losing weight if overweight
  – Increasing physical activity
  – Drinking in moderation if you drink alcoholic beverages

SELF ASSESSMENT

Q1. Give the normal plasma sodium concentration.
Q2. Elaborate the important functions of sodium in our body.
Q3. How sodium is related to CVS?
Q4. How can we control the blood pressure by lifestyle modification?