DISORDERS OF POTASSIUM BALANCE

Potassium is the major intracellular cation

98% of total body potassium is intracellular, whereas only 2% is extracellular

which is crucial to normal functioning of nerve, muscle and cardiac tissues

.

The major regulators of this internal redistribution . are: (a) insulin, (b) catecholamines and (c) .mineralocorticoids

- the kidney is responsible for the excretion of some 90% of the daily intake of potassium,
- typically 80-100 mmol/day.
- The movement of potassium from blood to lumen is dependent on active uptake across the basal cell ‹membrane by the Na,K-ATPase

Factors modifying transcellular K+ distribution

- Acid base status
- Pancreatic hormones : insulin , glucagon
- Catecholamines
- Aldosterone
- Plasma Osmolality
- Exercise
- Cellular K+ content

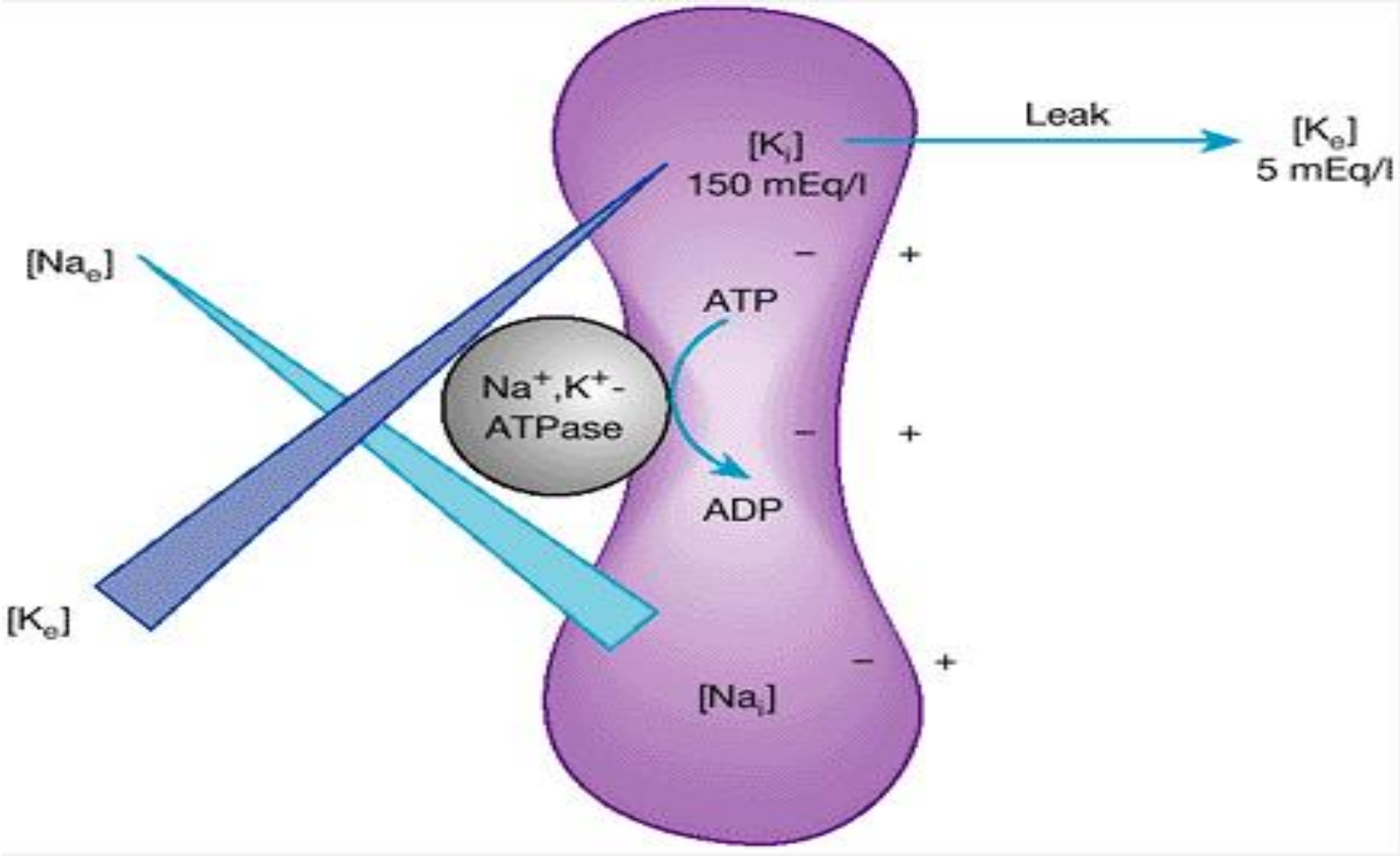
Disorders of potassium homeostasis

(3.5-5.5)

Hypokalemia: **Serum potassium <3.5 mmol/L**

(Potassium depletion: ICF or total potassium ↓)

Hyperkalemia: Serum potassium >5.5 mmol/L


Leak
[K$_i$]
150 mEq/l
[K$_e$]
5 mEq/l
[Na$_e$]
ATP
Na$^+$,K$^+$-
ATPase
ADP
[K$_e$]
[Na$_i$]
–
+
–
+
–
+

Acid Base Status

- Alkalemia promotes K+ uptake by cells
- Acidemia diminishes K+ uptake by cells

Pancreatic Hormones

- Insulin stimulates cellular uptake of K+ by activating Na+K+ATPase (decreasing plasma K+)
- Insulin affects K+ transport independently of glucose uptake

- Glucagon increase plasma K+ independently of changes in plasma glucose / insulin

Catecholamines

- Beta 2 adrenergic activity – hypokalemia

- Alpha adrenergic antagonists – hypokalemia

Osmolality

- Hyperosmolality (Mannitol infusion / hyperglycemia in DM) : increase plasma K+
- Each 10 mOsm / Kg rise in plasma osmolality, increases plasma K+ by 0.6 mmol/l

Exercise

- Recurrent contraction increases K+ egress from muscle
- Modest exercise : high K+ in ECF in local environment produces vasodilatation & thereby increased regional blood flow
- Severe exercise : increase plasma K+ modestly
- Physical training increases Na+K+ATPase activity in skeletal muscle which helps skeletal muscle to take up K+ again

Hyperkalemia :

Hyperkalemia is defined as a serum K^+ level greater than 5.5 mmol per liter .

(serum potassium >5.5mmol/L)

(2) Causes:

A. Diminished renal excretion

a. reduced GFR:
oliguria phase of acute renal failure
terminal phase of chronic renal failure

b. reduced tubular secretion of K^+
addison's disease; hypoaldosteronism
application of potassium sparing diuretic(spironolactone , triamterene).

B. Increased input of potassium

excessive or rapid parenteral infusion of KCl solution

C. Extracellular shifts

a. acidosis
b. cell destruction(trauma, burns, hemolysis, tumor lysis, rhabdomyolysis
c. Familial hyperkalemic periodic paralysis

Manifestations of hyperkalemia

- **Gastrointestinal manifestations**
  - **Anorexia, nausea, vomitting, intestinal cramps, diarrhea**
- **Cardiovascular manifestations**
  - **Ventricular fibrillation and cardiac arrest**
- **Neuromuscular manifestations**
  - **Paresthesias**
  - **Weakness**
  - **Muscle cramps**

Severe Hyperkalemia- •

Absence of P waves

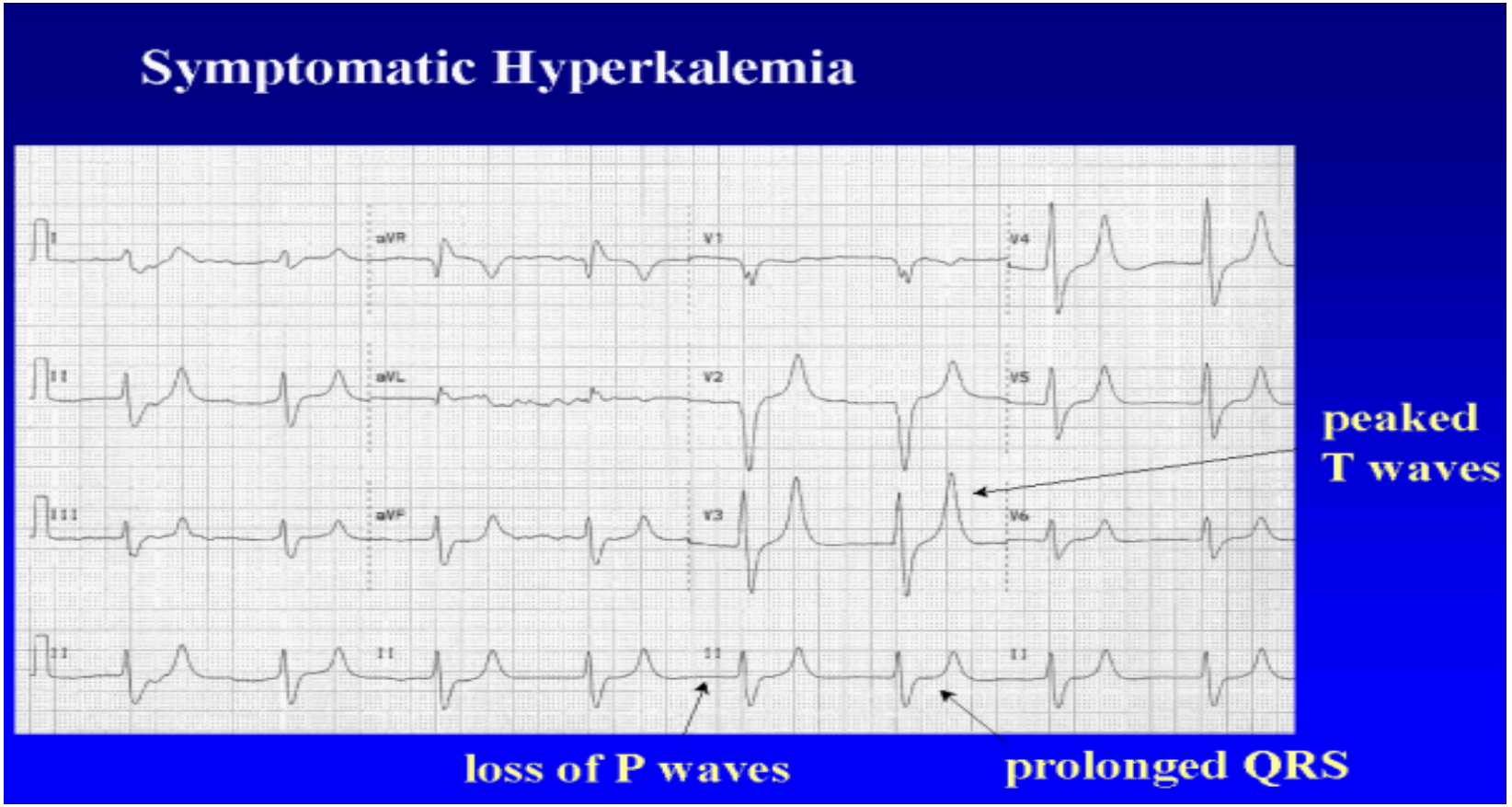
Intraventricular blocks,BBB,

Progressive widening of QRS complex

Sine wave pattern ventricular fibrillation,asystole

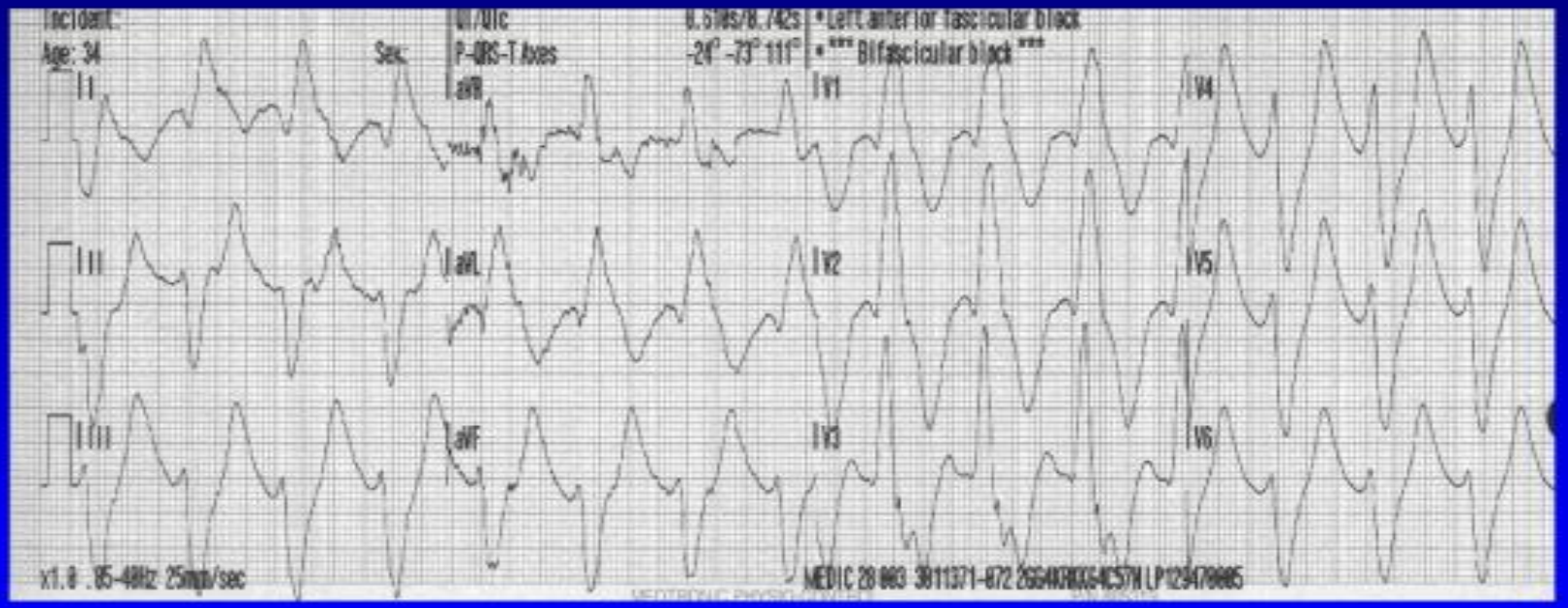

II
III
V3
V4

EKG Changes
Peaked T Waves



EKG Changes
Widening of QRS Complex

Severe Hyperkalemia



Treatment

1- Stabilize myocardial membrane •

2- Drive extracellular potassium into the cells •

3- Removal of Potassium from the body •

TREATMENT OF HYPERKALAEMIA •

1-Stabilise cell membrane potential •

Intravenous calcium gluconate (10 ml of 10% • solution

2-Shift K into cells (•

Inhaled βagonist, e.g. salbutamol •

Intravenous glucose (50 ml of 50% solution) and (insulin (5 U Actrapid

Intravenous sodium bicarbonate 100ml of 8.4%solution

3-Remove K from body •

Intravenous furosemide and normal saline •

4-Ion-exchange resin (e.g. Resonium) orally or rectally

5-Dialysis

- One commonly used regimen for administering insulin and glucose is 10 units of **regular insulin** in 500 mL of 10 percent dextrose, given over 60 minutes.
- Another regimen consists of a bolus injection of 10 units of regular insulin, followed immediately by 50 mL of 50 percent dextrose (25 g of glucose).

Hypokalemia

Concept:( )

Serum potassium<3.5mmol/L

Causes:

a. Inadequate intake: Inability to eat;
Fast and anorexia;
Administration of K^+ -free parenteral solutions

b. Excessive losses:

Gastrointestinal losses – Vomiting; Diarrhea; suction; Fistula.

Renal losses – Polyurine phase of acute renal failure,Diuretic therapy (except triamterene and spironolactone).

Increased mineralocorticoid levels – primary and second aldosteronism

Cushing's syndrome

Treatment with glucocorticoid hormones

c. Intracellular shift:

Alkalosis

Insulin treatment

Familial hypokalemic periodic paralysis

Barium poisoning

ECG changes with potassium imbalance:

Hypokalemia

Shallow T-wave /Prominent U-wave (2.5-3.5)

ST depression/

Tall “P” waves

(1.5-2.5)

Ventricular Tachycardia (<1.5)

Hyperkalemia

Tall, peaked T-wave(5.5-6.5)

Wide flat P-wave/Prolonged PR interval/Widened QRS complex /Deep S-wave (6.5-8.0)

Ventricular fibrillation. Sine-wav: proceed to asystole (absence of heartbeat)(>8.0)

Manifestations of hypokalemia

- **Neuromuscular manifestations**
  - **Muscle flabbiness, weakness and fatigue**
  - **Muscle cramps and tenderness**
  - **Paresthesia and paralysis**
- **Impaired kidney's ability to concentrate the urine**
  - **polyuria, urine with low osmolality, polydipsia (ECF osmolality↑)**
- **Gastrointestinal manifestations**
  - **Anorexia, nausea, vomitting,**
  - **Constipation, abdominal distension, paralytic ileus**
- **Cardiovascular manifestations**
  - **Arrhythmias, increased sensitivity to digitalis toxicity**
- **Metabolic alkalosis**

(4) Principle of treatment

a. In mild hypokalemia:

replenishment of KCl by the oral route is preferable because it is safer than I.V. administration.

b. In severe hypokalemia:

adding KCl to glucose water intravenously at a final concentration of 40 mmol/L, and infusing KCl at a rate of 10-20 mmol/h, since KCl is an irritating substance. Usually the repair of hypokalemia needs several days. Never give KCl solution by direct intravenous injection to patients.