

Electrolyte Disorders

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hyperkalemia

- ▶ Definition

- ▶ Classification

 - mild (5.5_6 meq/L)

 - moderate (6.1_6.9 meq/L)

 - severe(>7 meq/L)

Causes

- ▶ Spurious elevation
- ▶ Renal failure: Acute or chronic
- ▶ Acidosis: Diabetic ketoacidosis (DKA),
- ▶ Addison's disease,
- ▶ adrenal insufficiency
- ▶ type 4 renal tubular acidosis
- ▶ Cell death: Rhabdomyolysis, tumor lysis syndrome, massive hemolysis or transfusion, crush injury, burn
- ▶ Drugs: Beta blockers, acute digitalis overdose, succinylcholine, angiotensin converting enzyme inhibitors, angiotensin receptor blockers, nonsteroidal anti inflammatory drugs (NSAIDs), spironolactone, amiloride, potassium supplementation

Clinical features

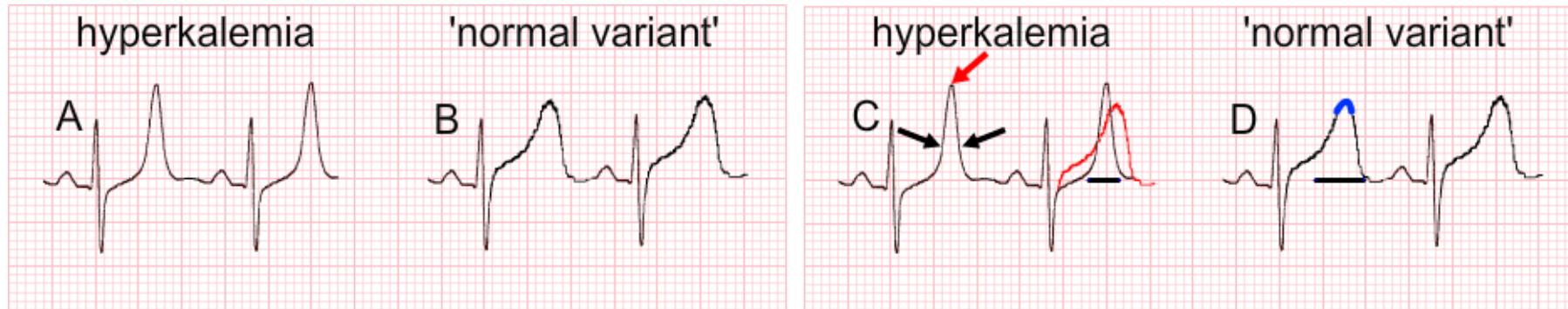
- ▶ **Gastrointestinal effects:** nausea, vomiting, diarrhea
- ▶ **Neuromuscular findings:** muscle cramp, generalized weakness, paresthesia, tetany, focal or global paralysis, decreased DTR
- ▶ **Dyspnea**
- ▶ **Cardiac arrhythmias:** heart blocks, brady dysrhythmias, pseudo infarction ST segment elevation, brugada pattern, sine wave pattern

Hyperkalemia

Diagnostic strategies

▶ ECG

Tall T



hyperkalemia



normal P waves



P waves flatten, prolonged PR



P waves disappear, bradycardia

hyperkalemia



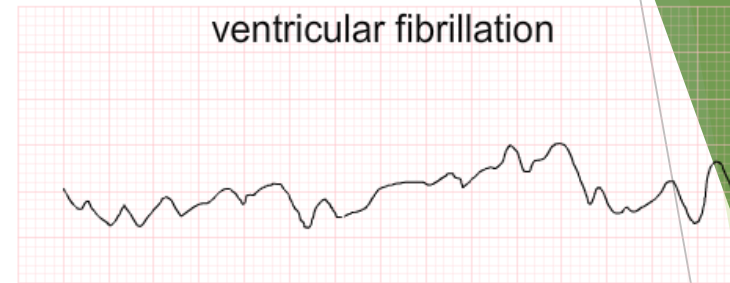
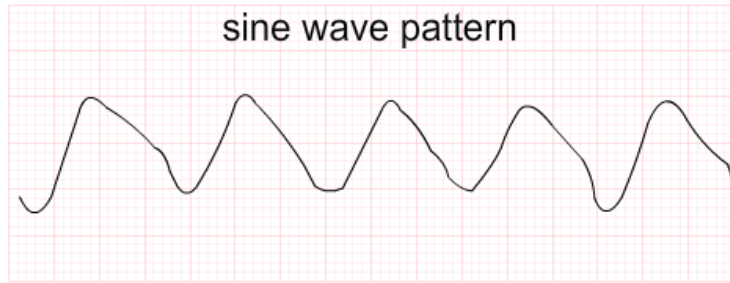
'sine wave pattern'



ventricular fibrillation



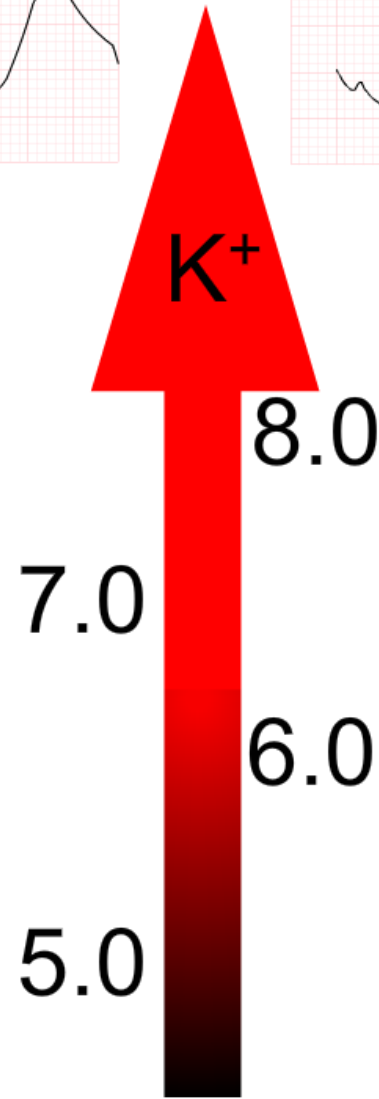
ECG/EKG changes in hyperkalemia



wide qrs



tented T waves



8.0

7.0

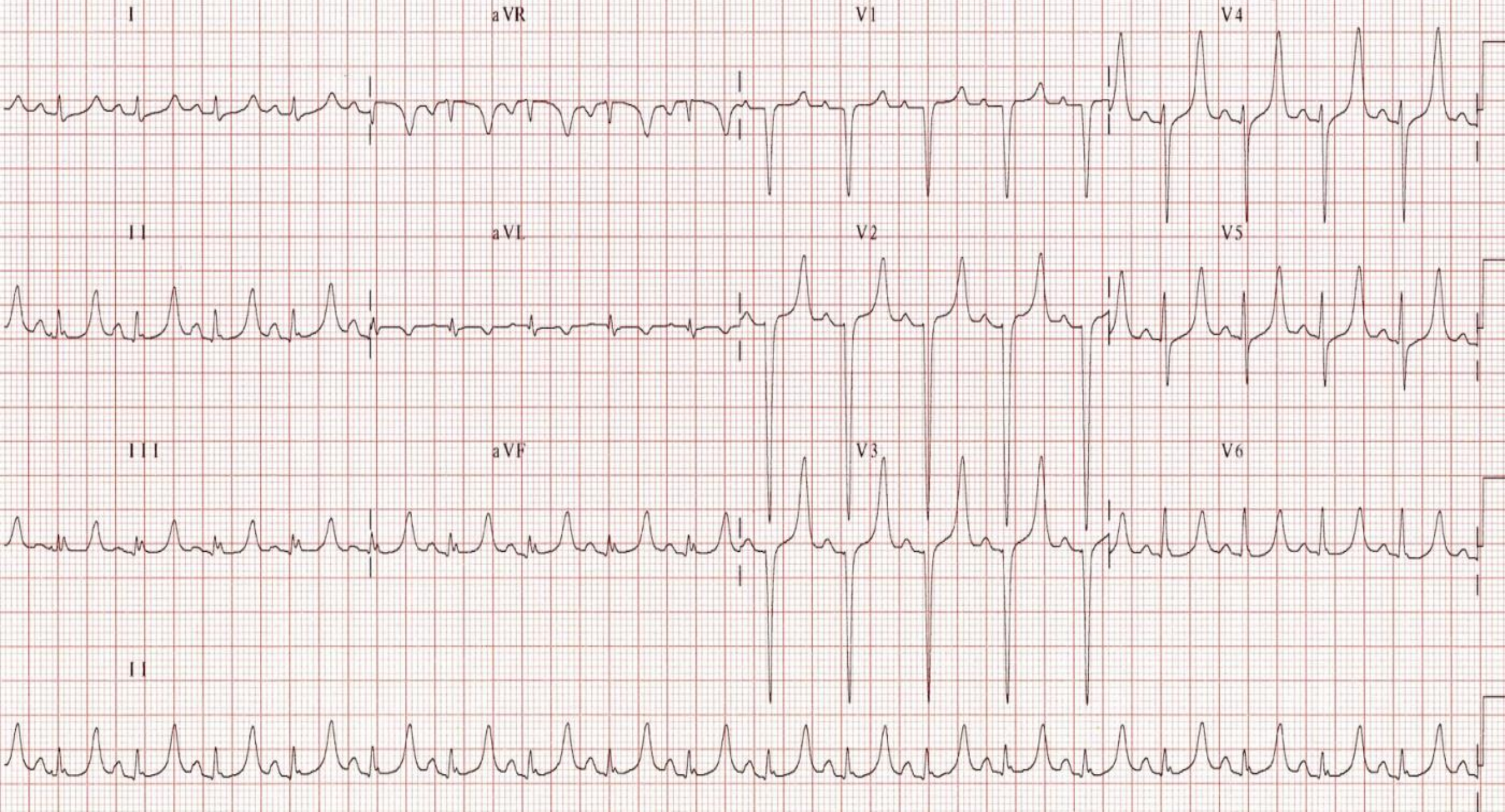
6.0

5.0

mmol/l



loss of P waves



Hyperkalemia treatment

- ▶ **Stabilize cardiac membrane**

- ▶ Calcium chloride
- ▶ Calcium gluconate

- ▶ **Shift potassium into cells**

- ▶ Insulin, combined with dextrose, IV push
- ▶ High-dose nebulized albuterol by face mask
- ▶ Bicarbonate
- ▶ Normal saline

- ▶ **Remove potassium from the body**

- ▶ Hemodialysis
- ▶ Normal saline and furosemide
- ▶ Ion exchange resin

HYPOKALEMIA

- ▶ Moderate hypokalemia
- ▶ severe hypokalemia

Causes

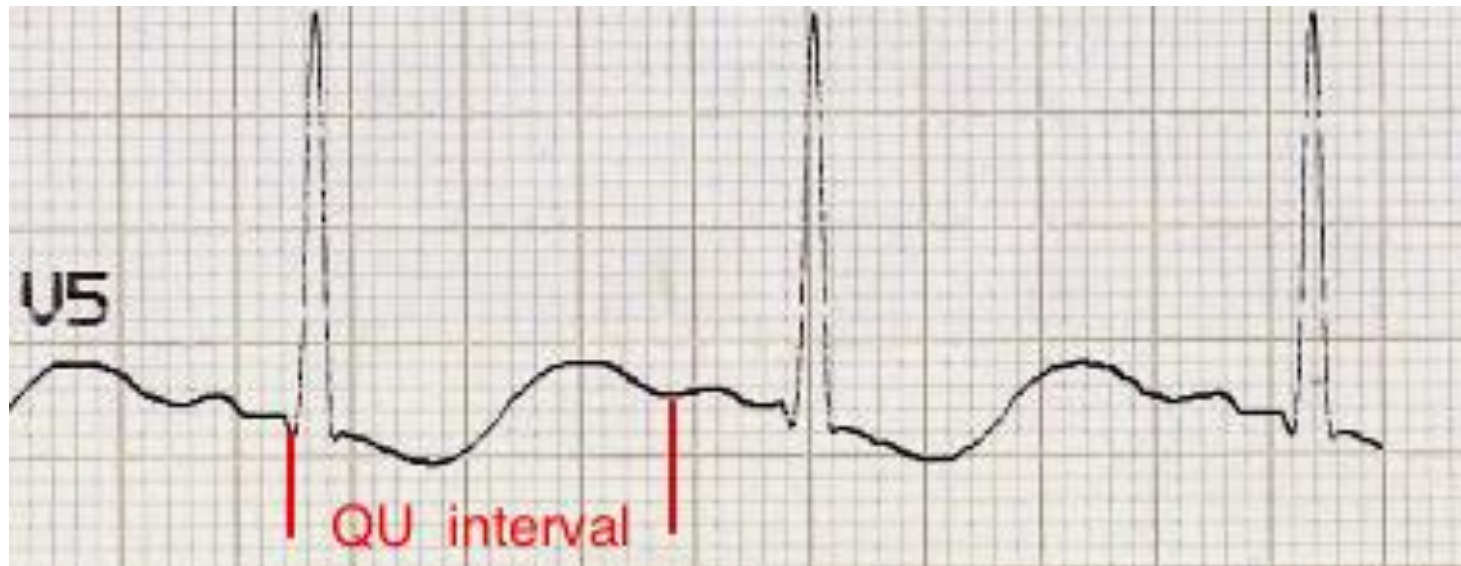
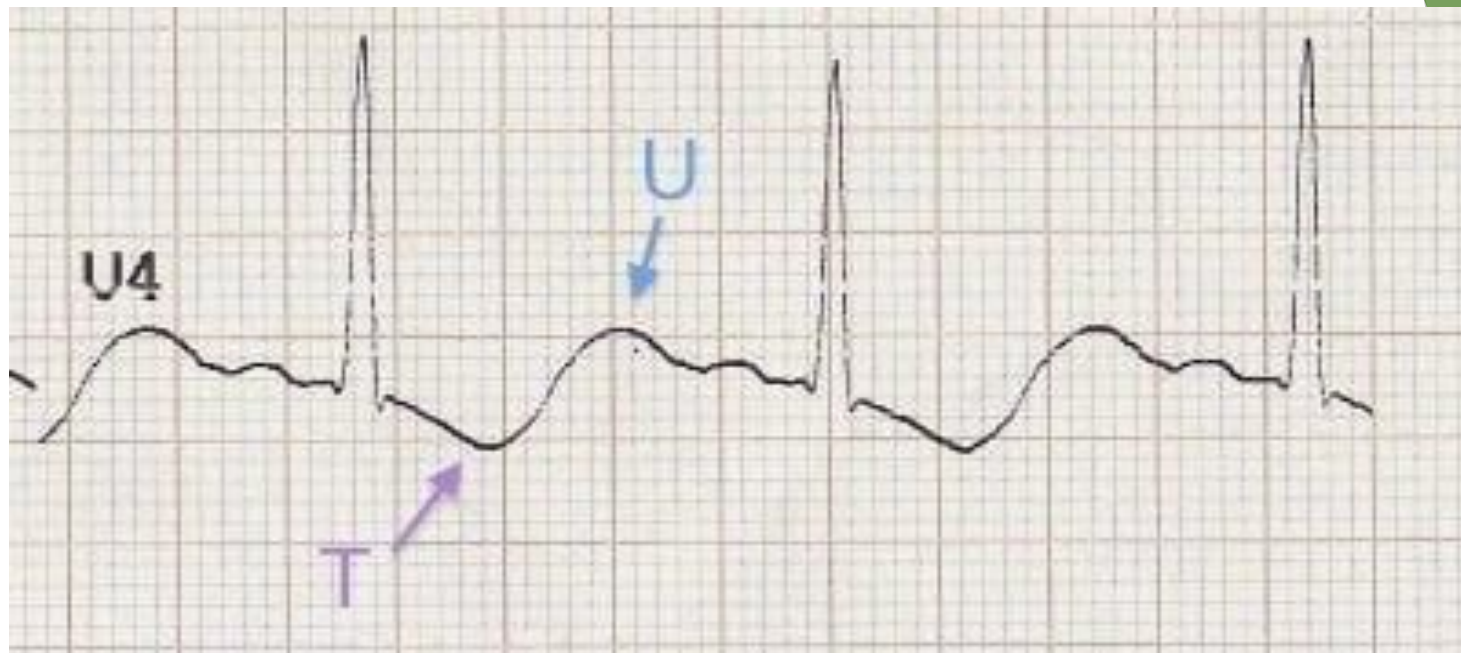
- ▶ Renal losses: Diuretic use, drugs, steroid use, metabolic acidosis, hyperaldosteronism, renal tubular acidosis, diabetic ketoacidosis (DKA), alcohol consumption
- ▶ Increased nonrenal losses: Sweating, diarrhea, vomiting, laxative use
- ▶ Decreased intake: Ethanol, malnutrition
- ▶ Intracellular shift: Hyperventilation, metabolic alkalosis, drugs
- ▶ Endocrine: Cushing's disease, Bartter's syndrome, insulin therapy

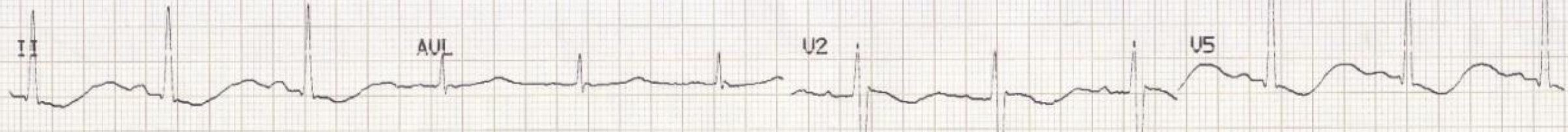
Clinical Features

The background of the slide is white with abstract green geometric shapes on the right side. These shapes include overlapping triangles and polygons in various shades of green, from light lime to dark forest green. A thin, light gray line runs diagonally across the white space, intersecting the green shapes.

Diagnostic Testing

▶ ECG





Management

- ▶ Oral replacement :Potassium chloride
- ▶ IV infusion: potassium chloride

Magnesium replacement should usually accompany potassium repletion

hypernatremia

- ▶ definition
- ▶ three physiologic pairings:
 - (1) hypernatremia with dehydration and low total body sodium
 - (2) hypernatremia with low total body water and normal total body sodium
 - (3) hypernatremia with increased total body sodium

Three Types of Hypernatremia

HYPERNATREMIA WITH DEHYDRATION AND LOW TOTAL BODY SODIUM

Heatstroke

Increased insensible losses: Burns, sweating

Gastrointestinal loss: Diarrhea, protracted vomiting, continuous gastrointestinal suction

Osmotic diuresis: Glucose, mannitol, enteral feeding

HYPERNATREMIA WITH LOW TOTAL BODY WATER AND NORMAL TOTAL BODY SODIUM

Diabetes insipidus

Neurogenic

Elderly with "reset" osmostat

Hypothalamic dysfunction

Suprasellar or infrasellar tumors

Renal disease

Drugs (amphotericin, phenytoin, lithium, aminoglycosides, methoxyflurane)

Sickle cell disease

HYPERNATREMIA WITH INCREASED TOTAL BODY SODIUM

Salt tablet ingestion

Salt water ingestion

Saline infusions

Saline enemas

IV sodium bicarbonate

Poorly diluted interval feedings

Primary hyperaldosteronism

Hemodialysis

Cushing's syndrome

Conn's syndrome

management

- ▶ 1. Correct underlying shock, hypo perfusion, hypovolemia(normal saline)
- ▶ 2. Treat underlying cause(fever, vomiting, diabetes insipidus)
- ▶ 3. Replace total body water

- ▶ $TBW \text{ deficit} = TBW \times \left\{ \frac{\text{serum Na}}{140} - 1 \right\}$
- ▶ $TBW \text{ deficit} = \text{Total body water} \times \left\{ \frac{\text{serum Na} - 140}{140} \right\}$

$$\text{Total H}_2\text{O deficit (L)} = \text{total body water} \times \left(1 - \frac{\text{desired Na}^+}{\text{serum Na}^+} \right)$$

Calculation of Body Water

POPULATION	TOTAL BODY WATER
Children and adult men	Body weight (kg) \times 0.6
Adult women	Body weight (kg) \times 0.5
Elderly men	Body weight (kg) \times 0.5
Elderly women	Body weight (kg) \times 0.45

HYPONATREMIA

- ▶ Definition

Clinical Features

- ▶ Anorexia
- ▶ Nausea, vomiting
- ▶ Generalized weakness
- ▶ Neurologic findings

Causes:

- ▶ Pseudohyponatremia

 - Dilutional

 - Hypovolemic Hyponatremia

 - Hypervolemic Hyponatremia

 - Euvolemic Hyponatremia

Causes of Hyponatremia

PSEUDOHYPONATREMIA

Hyperlipidemia

Hyperproteinemia (multiple myeloma, macroglobulinemia)

DILUTIONAL

Hyperglycemia*

HYPOVOLEMIC HYPONATREMIA: DECREASED TOTAL BODY WATER AND SODIUM, WITH A RELATIVELY GREATER DECREASE IN SODIUM

Body fluid losses: Sweating, vomiting, diarrhea, gastrointestinal suction

Third spacing: Bowel obstruction, burns, pancreatitis, rhabdomyolysis

Renal causes: Diuretics, mineralocorticoid deficiency, osmotic diuresis, renal tubular acidosis, salt-wasting nephropathies

HYPERVOLEMIC HYPONATREMIA: INCREASED TOTAL BODY SODIUM WITH A RELATIVELY GREATER INCREASE IN TOTAL BODY WATER

Heart failure

Chronic renal failure

Hepatic failure or cirrhosis

EUVOLEMIC HYPONATREMIA: INCREASED TOTAL BODY WATER WITH NEARLY NORMAL TOTAL BODY SODIUM

SIADH

Drugs causing SIADH (diuretics, barbiturates, carbamazepine, chlorpropamide, clofibrate, opioids, tolbutamide, vincristine)

Psychogenic polydipsia

Beer potomania

Hypothyroidism

Adrenal insufficiency

MDMA (ecstasy)

Accidental or intentional water intoxication

Three Most Common Causes of Syndrome of Inappropriate Secretion of Antidiuretic Hormone

LUNG MASSES

- Cancer (especially small cell)
- Pneumonia
- Tuberculosis
- Abscess

CENTRAL NERVOUS SYSTEM DISORDERS

- Infection (meningitis, brain abscess)
- Mass (subdural, postoperative, cerebrovascular accident)
- Psychosis (with psychogenic polydipsia)

DRUGS

- Thiazide diuretics
- Narcotics
- Oral hypoglycemic agents
- Barbiturates
- Antineoplastics

TABLE 117.3**Spot Urine Interpretation**

	HYPOVOLEMIC HYPONATREMIA	HYPOVOLEMIC HYPONATREMIA	EUVOLEMIC HYPONATREMIA	EUVOLEMIC HYPONATREMIA	HYPERVOLEMIC HYPONATREMIA	HYPERVOLEMIC HYPONATREMIA
Underlying etiologies	Non-renal causes	Renal causes	SIADH, endocrinopathies	Psychogenic polydipsia	Edematous disorders: eg, CHF, cirrhosis	Renal failure
Urinary sodium	<20 mEq/L	>20 mEq/L	>20 mEq/L	<20 mEq/L	<20 mEq/L	>20 mEq/L
Mechanism	Extrarenal solute loss	Renal solute loss	Volume expansion	Normal renal response to excess volume and sodium retention	Renal hypoperfusion	Renal solute loss

management

- ▶ Change in serum Na⁺ = (infused Na⁺ - serum Na⁺) / TBW + 1

Na⁺ requirement (mmol) = total body water x (desired Na⁺ - serum Na⁺)

$$\text{Rate of infusion (cc/hr)} = \frac{\text{Na}^+ \text{ requirement (mmol)} \times 1000}{\text{infusate Na}^+ \text{ (mmol/L)} \times \text{time (hours)}}$$

TABLE 117.4

Characteristics of Infusates

INFUSATE	INFUSATE SODIUM (mmol/L)	EXTRACELLULAR FLUID DISTRIBUTION (%)
3% Hypertonic saline	513	100
0.9% Normal saline solution	154	100
Lactated Ringer's solution	130	97
Half-normal saline solution	77	73
0.2% Sodium chloride + D ₅ W	34	55
D ₅ W	0	45