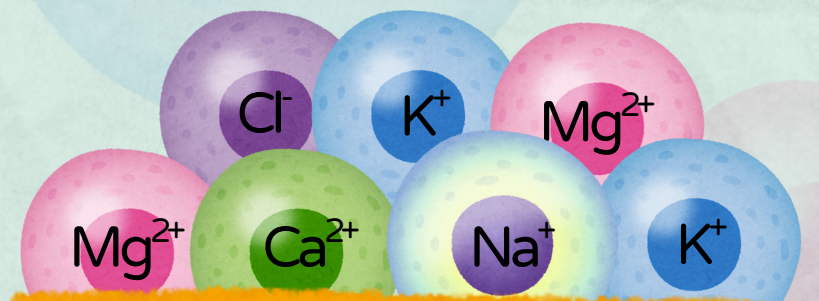
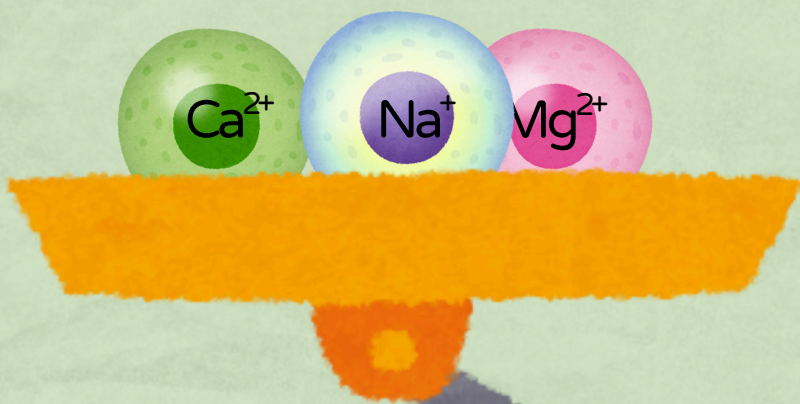


ELECTROLYTE IMBALANCE



SODIUM DISORDERS

Normal range: 135 mmol/L - 145 mmol/L

Clinical Manifestations

↓ Na⁺ Hyponatremia

 Nausea

Headache

Lethargy 

Irritability

Weakness 

Vomiting

Confusion 

Seizures

Coma

Hypernatremia Na⁺ ↑

Thirst 

Dry mucosa

Lethargy

Irritability 

Weakness

Hyperreflexia 

Confusion

Seizures

Coma 

Mild

Moderate

Severe

APPROACH TO HYPONATREMIA



Hyponatremia

Na <135 mmol/L

Serum osmolarity

<280 mOsm/L

Hyponatremia

Urine osmolarity

<100 mOsm/L

Normal Water Excretion (ADH Independent)

- Psychogenic polydipsia

≥100 mOsm/L

Impaired Water Excretion (ADH Dependent)

Volume status

Hypovolemia

Urine sodium

<20 mmol/L

Extrarenal

- Vomiting
- Diarrhea
- Hemorrhage
- Burns
- Pancreatitis
- Cystic fibrosis

≥20 mmol/L

Renal

- Diuretic
- Adrenal insufficiency

Euvolemia

- Syndrome of inappropriate ADH secretion (SIADH)
- Severe hypothyroidism

≥280 mOsm/L

Pseudohyponatremia

Pseudohyponatremia

- Hyperlipidemia
- Hyperproteinemia

Redistributive

- Mannitol
- Hyperglycemia

Hypervolemia

Urine sodium

<20 mmol/L

Extrarenal

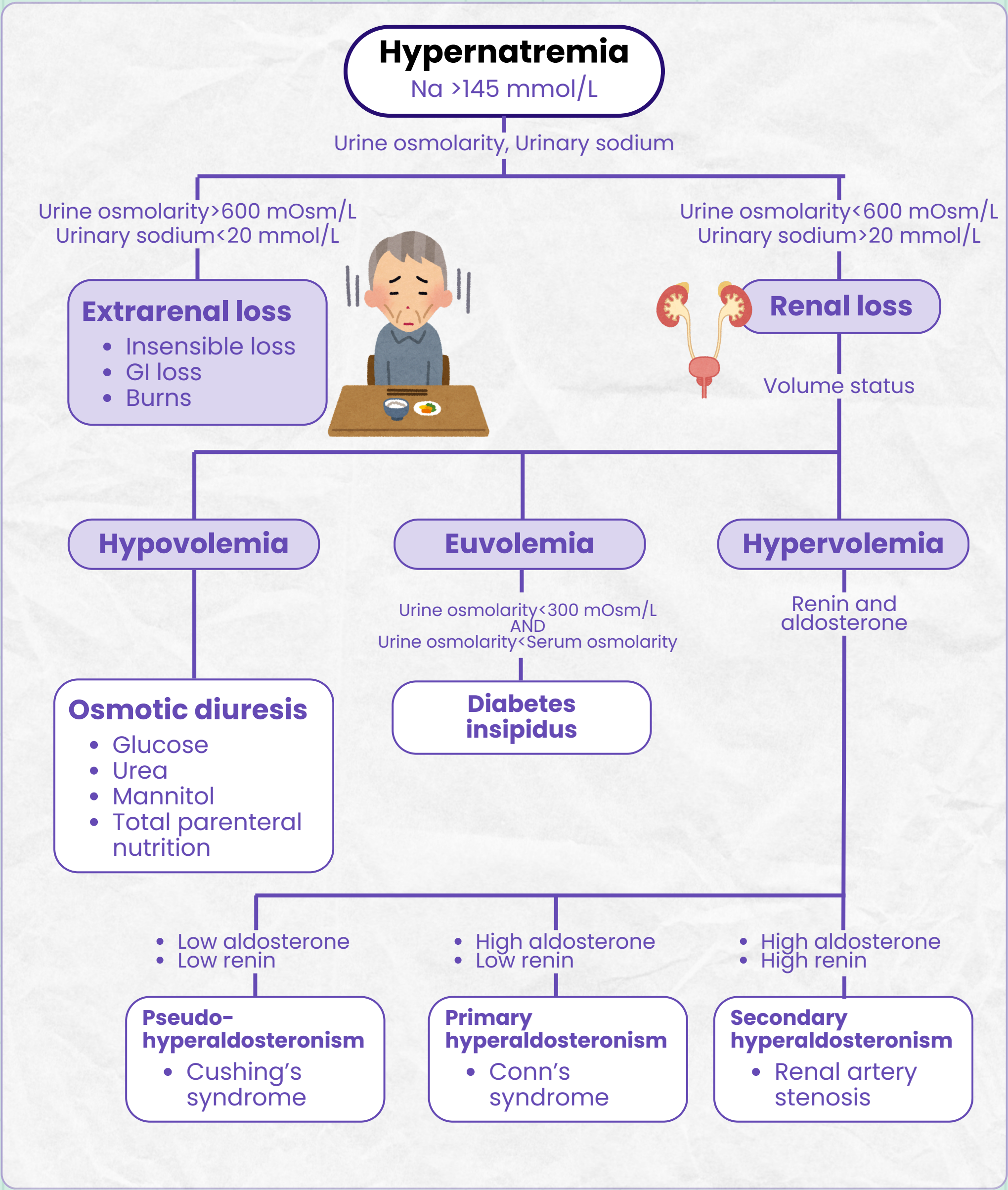
- Heart failure
- Liver failure
- Nephrotic syndrome

≥20 mmol/L

Renal

- Renal failure

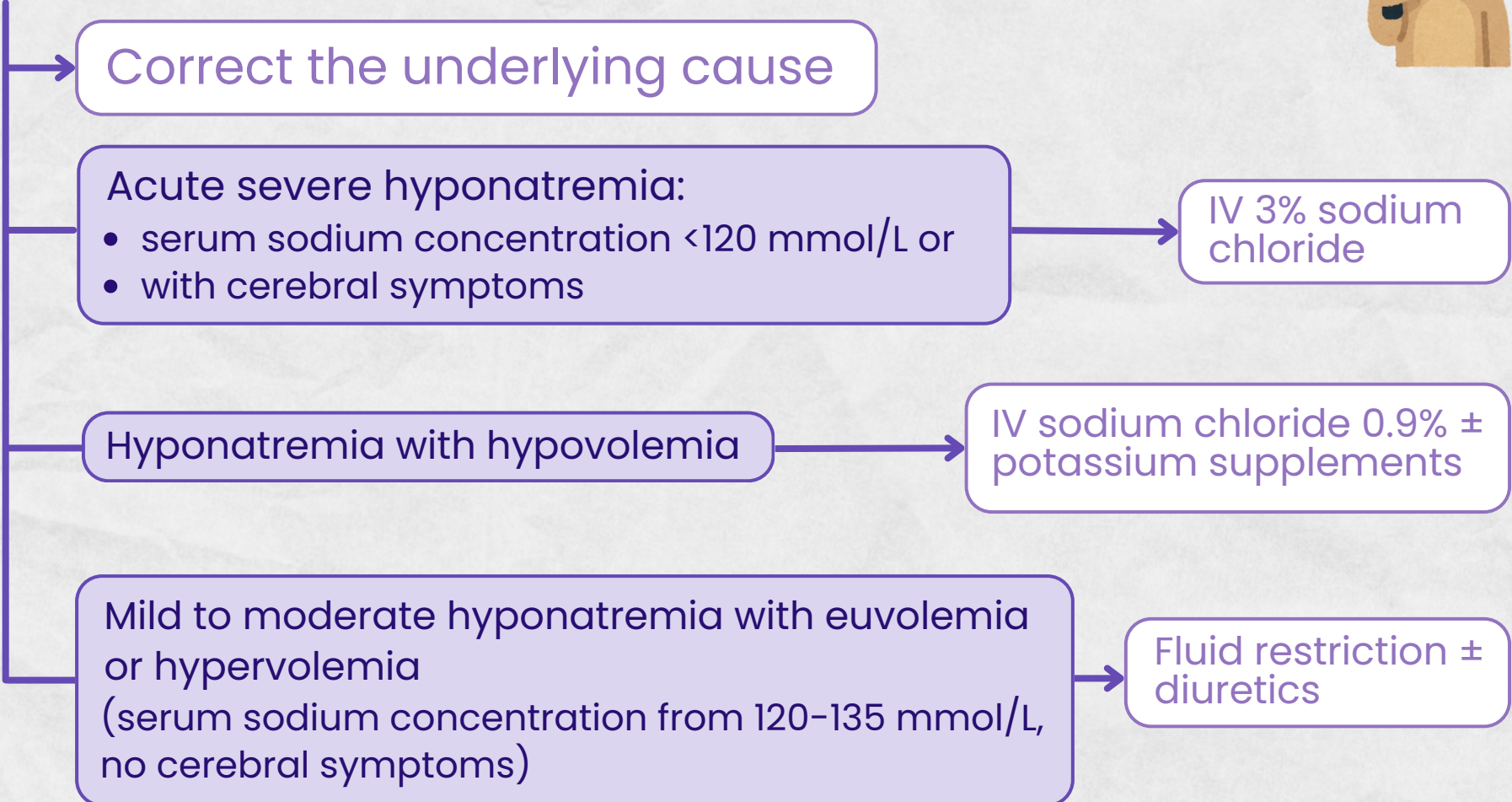
APPROACH TO HYPERNATREMIA



MANAGEMENT

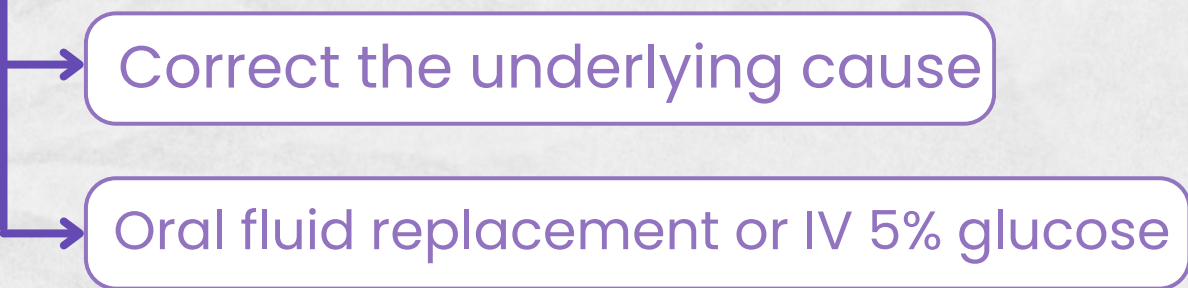


Hyponatremia



**Avoid rapid correction of chronic hyponatremia → Risk of osmotic demyelination syndrome*

Hypernatremia



**Avoid rapid correction of chronic hypernatremia → Risk of cerebral oedema*

POTASSIUM DISORDERS

Normal range: 3.5 mmol/L - 5.0 mmol/L

Clinical Manifestations

↓ K^+ Hypokalemia

Mild
3.0 - 3.4 mmol/L

Asymptomatic

Moderate
2.5 - 3.0 mmol/L

- Muscle weakness
- Muscle cramps
- Palpitations
- Tetany

Severe
<2.5 mmol/L

- Paralysis
- Arrhythmias

Hyperkalemia K^+ ↑

Mild
5.5 - 6.0 mmol/L

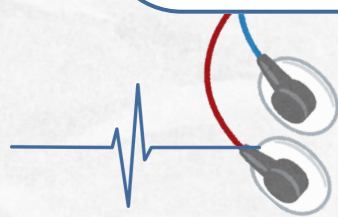
Asymptomatic

Moderate
6.1 - 7.0 mmol/L

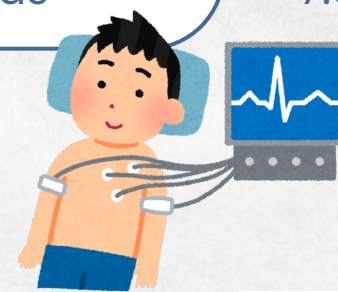
- Muscle weakness
- Nausea
- Paraesthesia
- ECG changes

Severe
>7.0 mmol/L

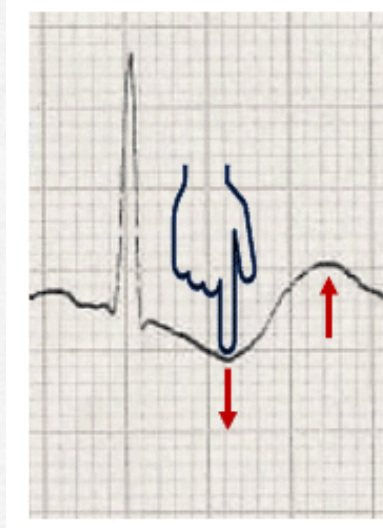
- Paralysis
- Arrhythmias



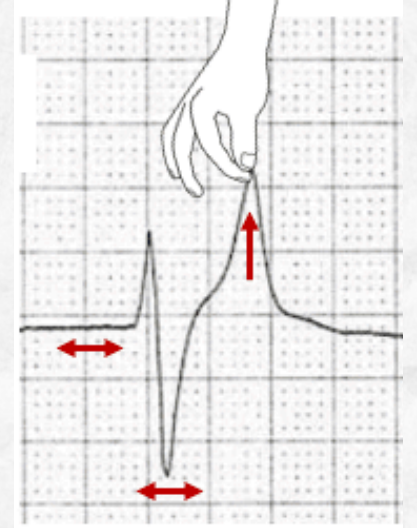
ECG Changes



- Prominent U waves
- Prolongation of PR interval
- Widespread ST depression with T wave flattening or inversion



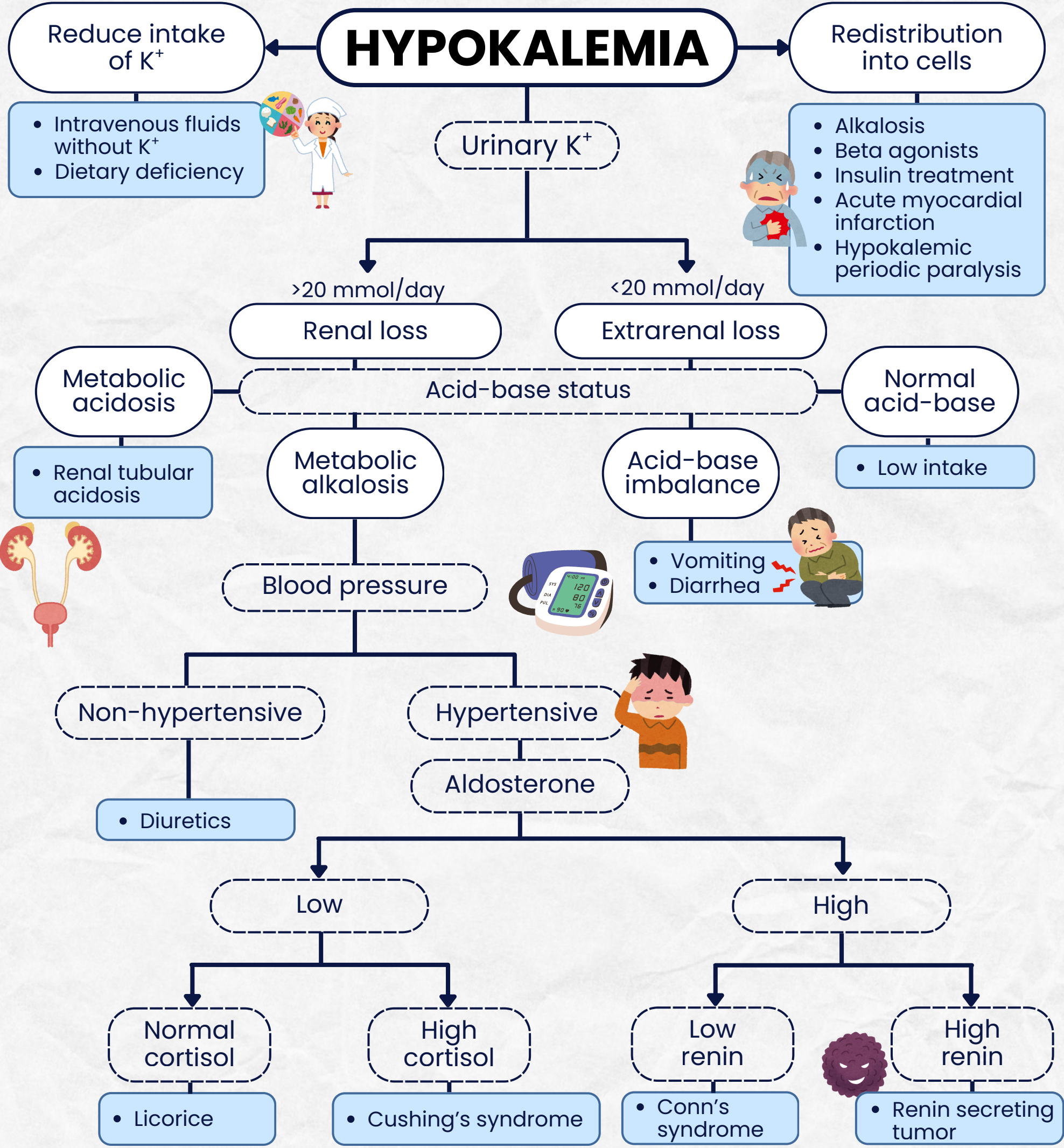
- Peaked T waves
- P wave widening or flattening
- PR prolongation
- Wide QRS complex
- Bradyarrhythmia





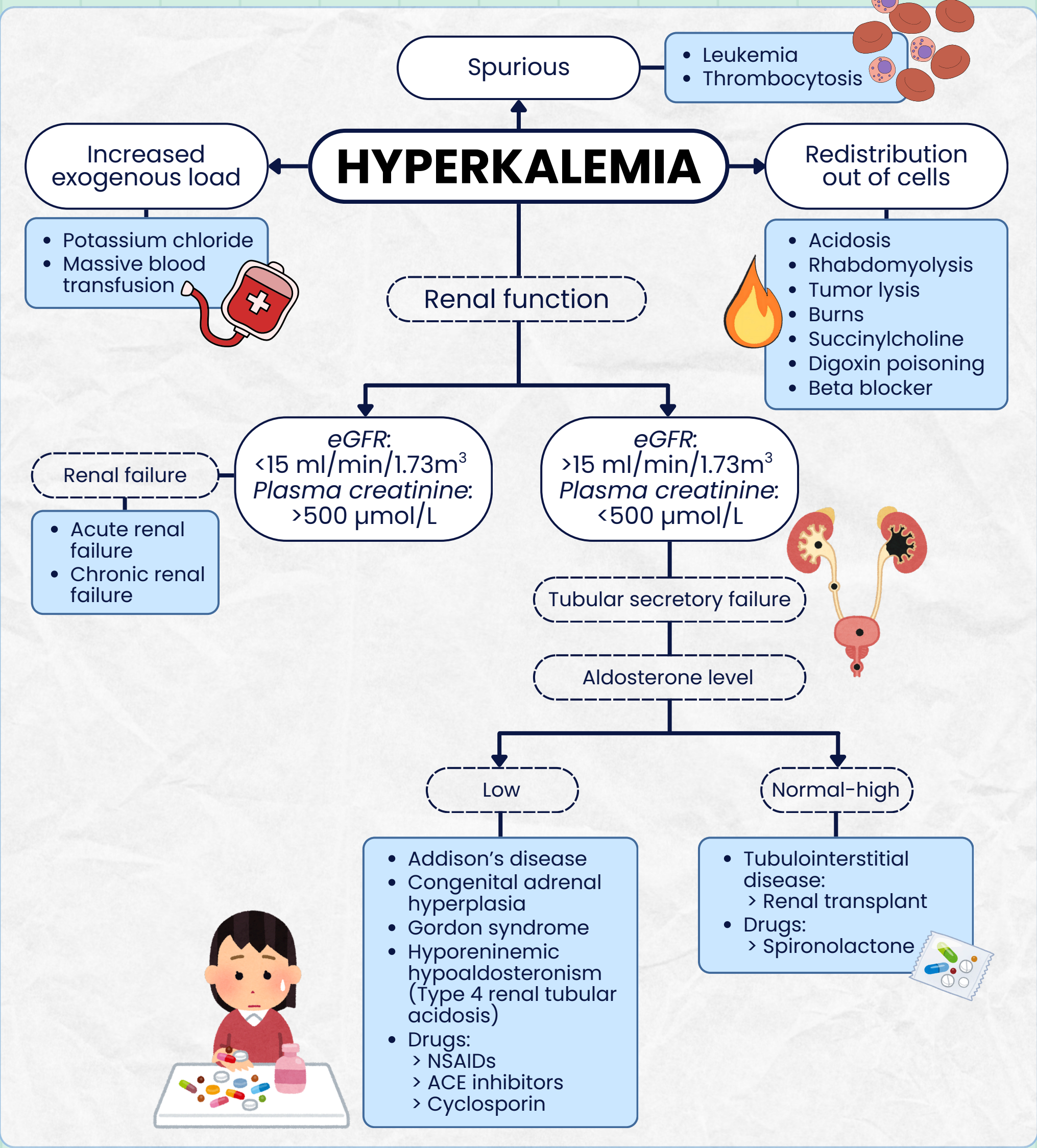
APPROACH TO HYPOKALEMIA

HYPOKALEMIA





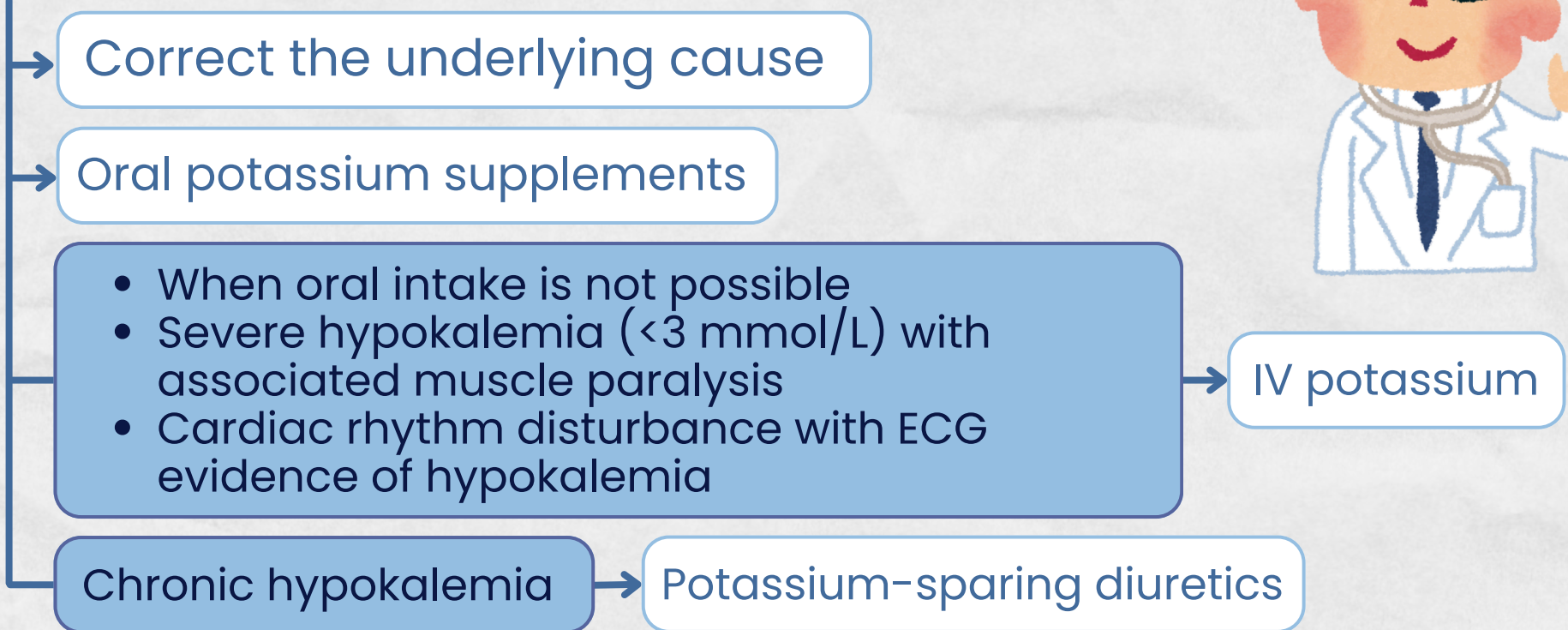
APPROACH TO HYPERKALEMIA



MANAGEMENT



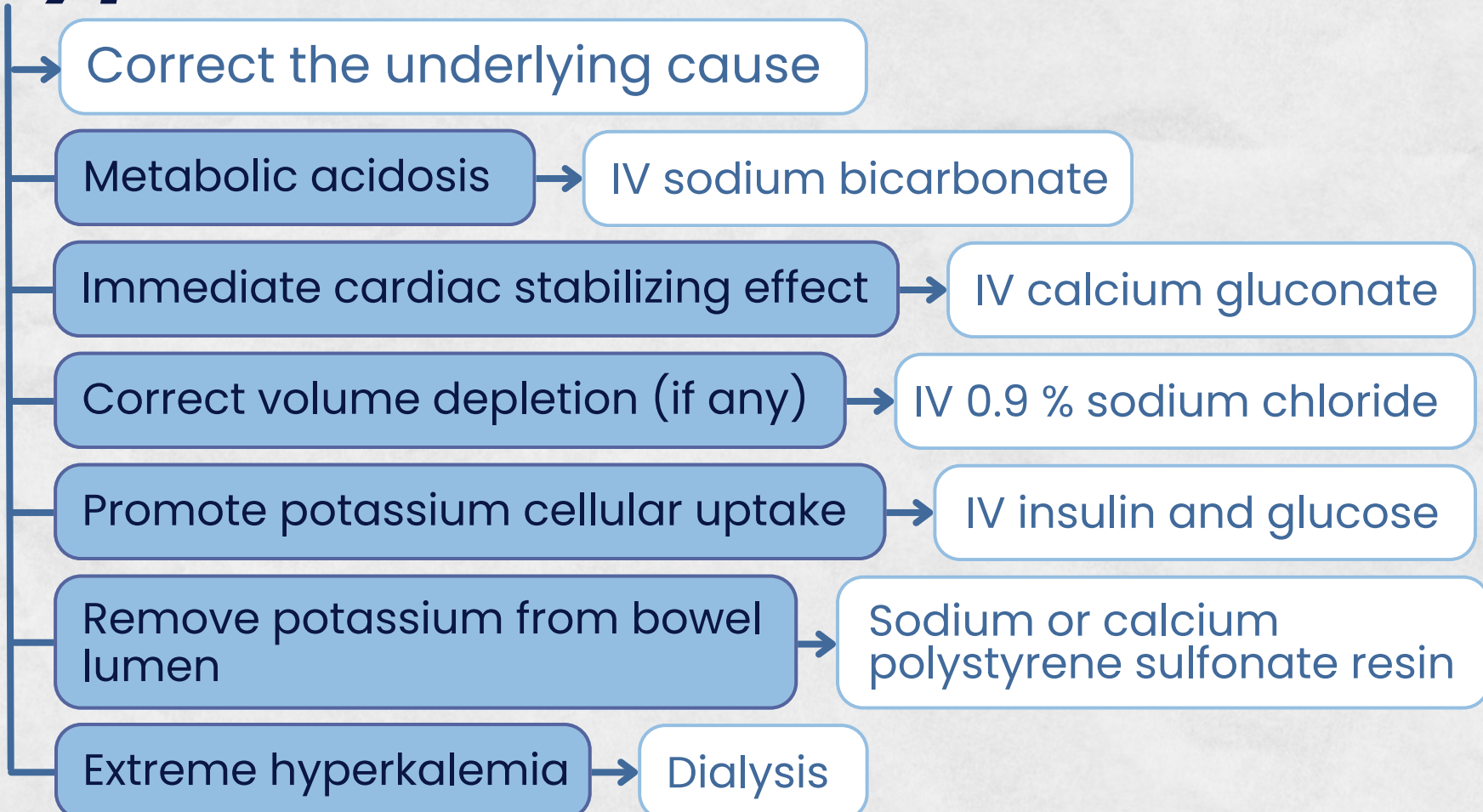
Hypokalemia



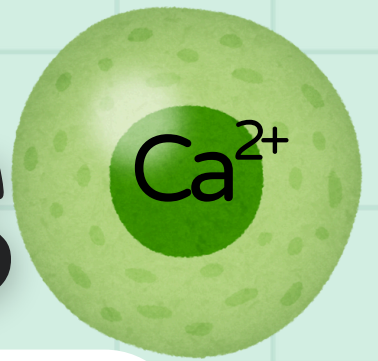
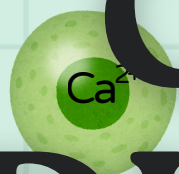
**Avoid rapid infusion of potassium unless special circumstances apply (eg emergency management of diabetic ketoacidosis)
→ Risk of fatal hyperkalemia*



Hyperkalemia



CALCIUM DISORDERS





Normal range: 2.10 mmol/L - 2.60 mmol/L

Clinical Manifestations

↓ Hypocalcemia (SPASMODIC)

- Spasms (carpopedal spasm = Trousseau's sign)
- Perioral paraesthesia
- Anxious, irritable, irrational
- Seizures
- Muscle tone increased in smooth muscle (colic, wheeze, dysphagia)
- Orientation impaired and confusion
- Dermatitis
- Impetigo herpetiformis
- Chvostek's sign, choreoathetosis, cataract, cardiomyopathy

Hypercalcemia ↑

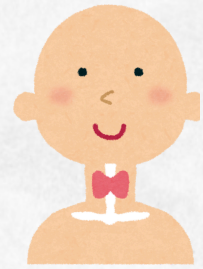
- Bone → Bone pain
 - Stones → Renal stones
 - Abdominal pain
 - Vomiting
 - Constipation
 - Anorexia
 - Weight loss
 - Depression
 - Lethargy
 - Weakness
- Groans 
- Psychiatric moans 

ECG Changes

Long QT interval

Short QT interval

APPROACH TO HYPOCALCEMIA



HYPOCALCEMIA

Parathyroid hormone level

Serum magnesium level

25-OH Vitamin D level

High

Low/
Normal

Low

Normal

Low

Normal

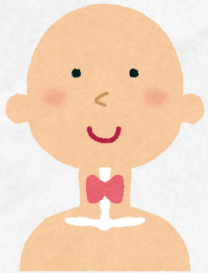
- Vitamin D deficiency
- Chronic kidney disease

- Gastrointestinal loss
- Alcoholism
- Malnutrition
- Drugs

- Gastrointestinal loss
- Low dietary intake
- Low sunlight exposure

- Hypoparathyroidism
 - > Surgical
 - > Autoimmune
 - > Storage disorder
- Dysregulation of parathyroid hormone secretion
 - > DiGeorge's syndrome

APPROACH TO HYPERCALCEMIA



HYPERCALCEMIA

Parathyroid hormone (PTH) level

Low

Parathyroid hormone-related peptide (PTHrP), calcitriol, calcidiol, vitamin D levels

High PTHrP

- Malignancy

High calcidiol

- Vitamin D intoxication

High calcitriol

- Granulomatous disease

All normal

- Bone metastasis

Normal or high

Phosphate

Low

High

- Tertiary hyperparathyroidism

24 hour urinary calcium excretion

Low

- Familial hypocalciuric hypercalcemia

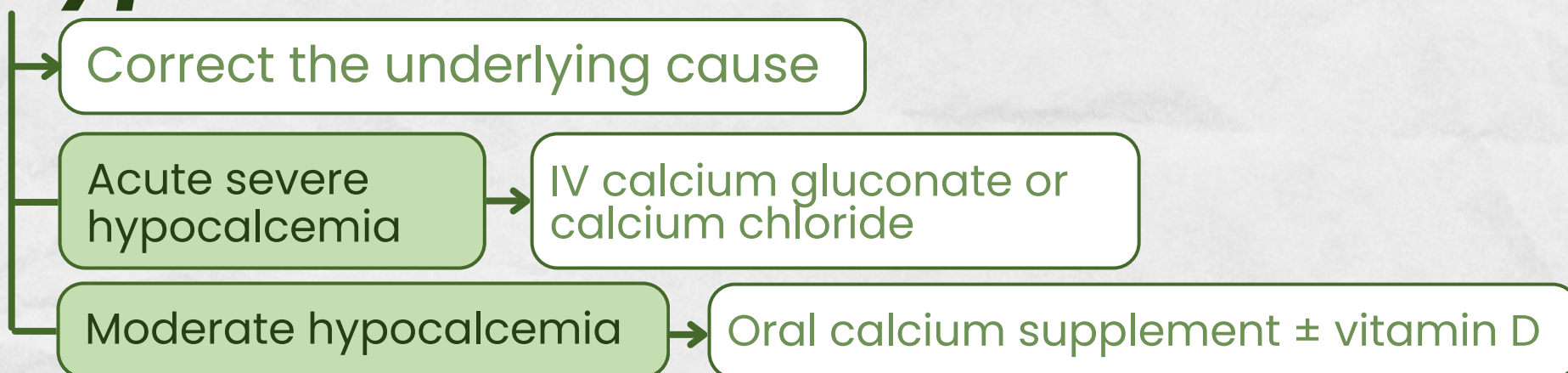
Normal or high

- Primary hyperparathyroidism (adenoma)
- Lithium-induced hyperparathyroidism



MANAGEMENT

Hypocalcemia

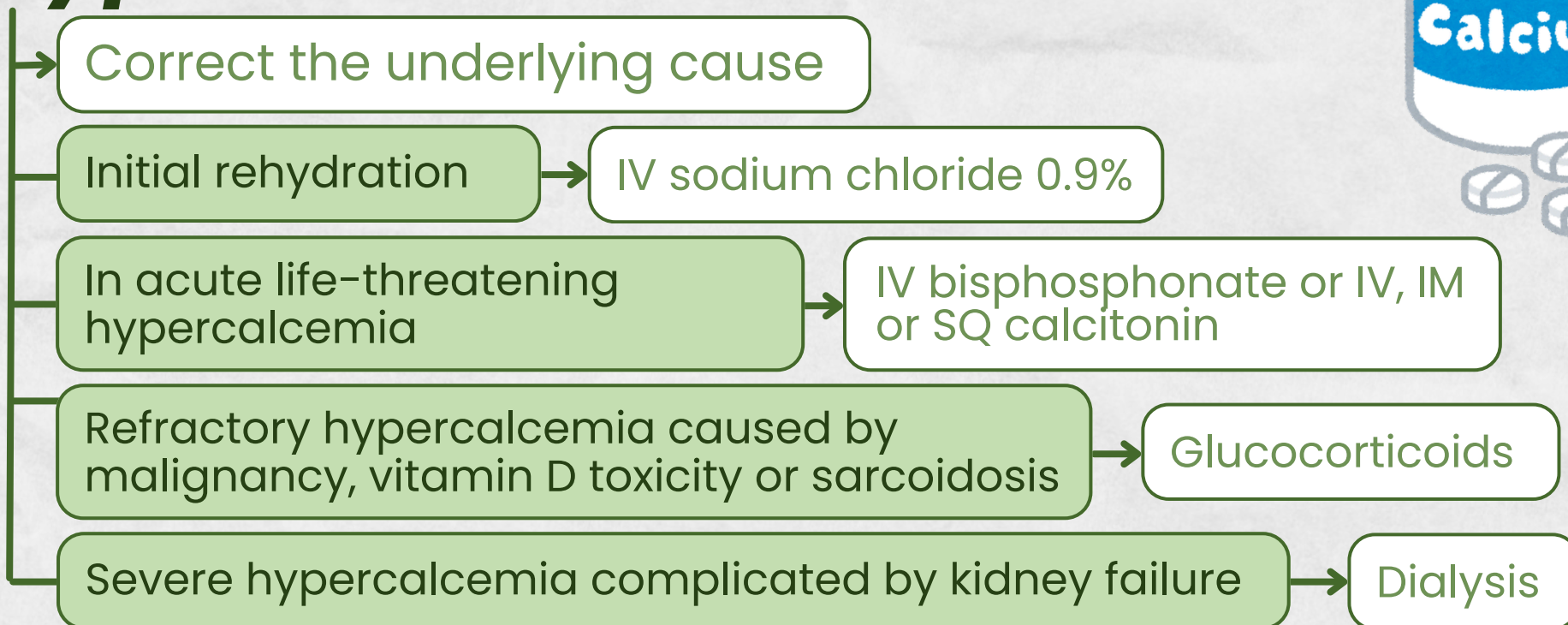


Safety notes:

- Calcium should never be given by intramuscular or subcutaneous injection
- Ensure intravenous access is secure, extravasation of intravenous calcium can cause severe tissue damage



Hypercalcemia



REFERENCES

1. Kumar & Clark's Clinical Medicine (8th edition)
2. Oxford Handbook of Clinical Medicine (11th edition)
3. LITFL
4. GrepMed
5. Davidsons Principles and Practice of Medicine (26th edition)
6. Gram Project
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8. Ninja Nerd

