

Electric Lytes

Jeffrey P Schaefer, MSc, MD, FRCPC

Objectives

- Hypo... Hyper...
 - Sodium
 - Potassium
 - Calcium
 - Magnesium
 - Phosphate

Sodium





Case

- 81 yr old female presents to ER
 - recent viral illness
 - vomiting and diarrhea
 - Na = 110
 - What to do?

Clinical Features – hypoNa⁺

- mild anorexia
 - headache
 - muscle cramps
 - irritability
 - delirium
 - coma
 - seizure
-
- Rate of Reduction affects clinical severity

DDx – HypoNa+

- With Edema
 - HF, nephrosis, cirrhosis
- Volume Depleted
 - diuretics (esp thiazide), vomiting, diarrhea
- Salt loss
 - adrenal insufficiency, hypoT₄, cerebral salt wasting
- Excess Water
 - SIADH, polydipsia, iatrogenesis
- Shift
 - hyperglycemia

Major Causes of Hyponatremia

Disorders in which ADH levels are elevated

- Effective circulating volume depletion
 - True volume depletion
 - Heart failure
 - Cirrhosis
 - Thiazide diuretics
- Syndrome of inappropriate ADH secretion, including reset osmostat pattern
- Hormonal changes
 - Adrenal insufficiency
 - Hypothyroidism
 - Pregnancy

Disorders in which ADH levels may be appropriately suppressed

- Advanced renal failure
- Primary polydipsia, including ecstasy
- Beer drinker's potomania

Hyponatremia with normal or elevated plasma osmolality

- High plasma osmolality
 - Hyperglycemia
 - Mannitol
- Normal plasma osmolality
 - Pseudohyponatremia
 - Hyperlipidemia
 - Hyperproteinemia
 - Glycine solutions
- Renal failure, in which the patient has true hyponatremia since the effective plasma osmolality is low since urea is an ineffective osmole

Case

- 81 yr old female presents to ER
 - recent viral illness
 - vomiting and diarrhea

- Na = 110 mMol

Case

- 82 year old female in ER
 - HTN on thiazide
 - presents with seizure and delirium
 - Na = 103 mMol

Sodium Deficit

- Calculated sodium deficit

$0.6 \times (\text{weight in kg}) \times (\text{desired sodium} - \text{actual sodium})$

0.5 for females

desired range= 120 - 125 meq/L

hypertonic saline has 513 mMol / l of Na

Complication of Treatment

- Hyponatremia
 - water goes into brain cells
 - causes cerebral edema
- Correction
 - water comes out of brain
 - risks central pontine myelinolysis

Case

- 30 year old female presents to ER
 - was hiking in the mountains
 - drank 10 liters of water per day on the advice of a well meaning friend
 - delirium with paranoia

 - Na = 110 mMol

Case

- 78 year old female on general surgery
 - Post-op day 3 hemicolectomy for Duke B ca
 - Overnight developed delirium
 - Na = 120 mMol

Case

- 19 year old man presents to ER
 - progressive weakness
 - anorexia and weight loss
 - nauseated

- Na = 128 mMol, K = 6.5 mMol

Case

- 82 year old female in clinic
 - HTN on thiazide
 - feels well

 - Na = 125 mMol

Case

- 65 year old man on neurosurgery
 - post-op day 2 brain aneurysm clip
 - Na = 129 mMol

Case

- 59 year old female
 - presents with pneumonia
 - day 4 feels strange
 - can eat and drink, likes tea

- Na = 120 mMol



Case

- 81 year old female on stroke unit
 - doing poorly over last few days
 - now unconscious

 - Na = 176 mMol (normal 135-145 mMol)

 - What's your approach?

Clinical Findings

- Hyponatremia
 - lethargy
 - weakness
 - irritability
 - twitching
 - delirium
 - reduced level of consciousness
 - coma
 - seizures

DDx – HyperNa⁺

- Not enough water!
 - no thirst
 - can't act on thirst
 - can't retain water
- except for Normal Saline, not usually a salt issue

Major Causes of Hypernatremia

Unreplaced water loss (which requires an impairment in thirst or access to water)

- Insensible and sweat losses
- Gastrointestinal losses
- Central or nephrogenic diabetes insipidus
- Osmotic diuresis
- Hypothalamic lesions impairing thirst or osmoreceptor function
 - Primary hypodipsia
 - Reset osmostat in mineralocorticoid excess

Water loss into cells

- Severe exercise or seizures

Sodium overload

- Intake or administration of hypertonic sodium solutions

Case

- 81 year old female on stroke unit
 - doing poorly over last few days
 - now unconscious

 - Na = 176 mMol (normal 135-145 mMol)

 - What's your approach?

Calculate Free Water Deficit

- Water Deficit

$$0.6 \times \text{wt (kg)} \times (\text{measured Na} - \text{desired Na}) / \text{desired Na}$$

use 0.5 for females

desired = 145 mMol

Infusion Rate

Correct no faster than 0.5 – 1 mmol / hr

Risk of cerebral edema

1. determine water deficit
2. determine duration of correction
3. rate = deficit / duration (index to hour)
4. consider ongoing losses
5. decide on re-assessment

Case

- 81 year old female on stroke unit
 - doing poorly over last few days
 - now unconscious

 - Na = 176 mMol (normal 135-145 mMol)

 - What's your approach?

Case

- 55 year old female
 - pituitary resection
 - post-op dilute polyuria
 - Na = 165 mMol

DDAVP

- IV / sq → 1-2 ug q12 h
- nasal → 10 – 40 ug / day (divide bid / tid)
- oral → 0.1 – 1.2 mg / day (divide bid / tid)
- give hypotonic IV while getting control
- usually this is a planned event



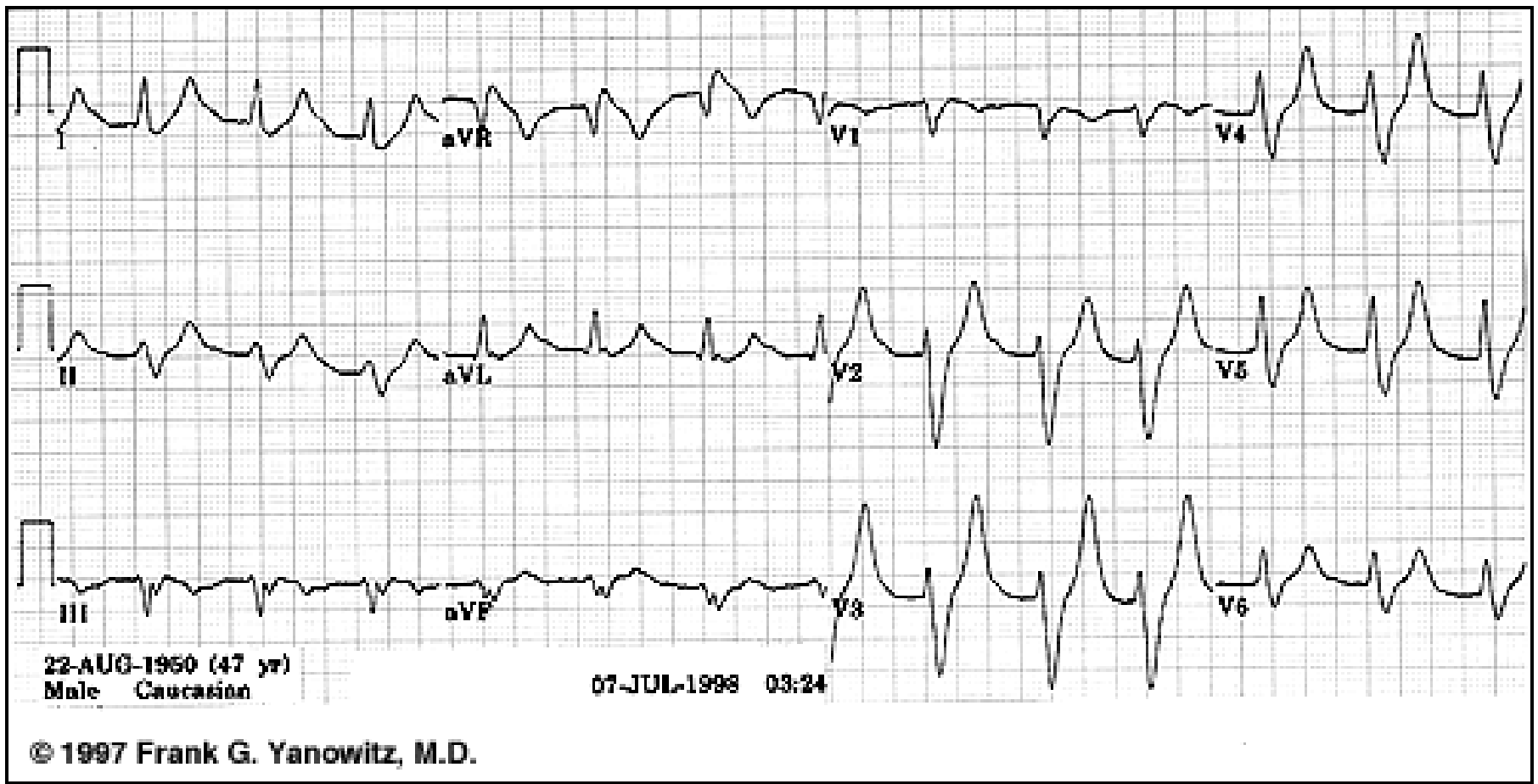


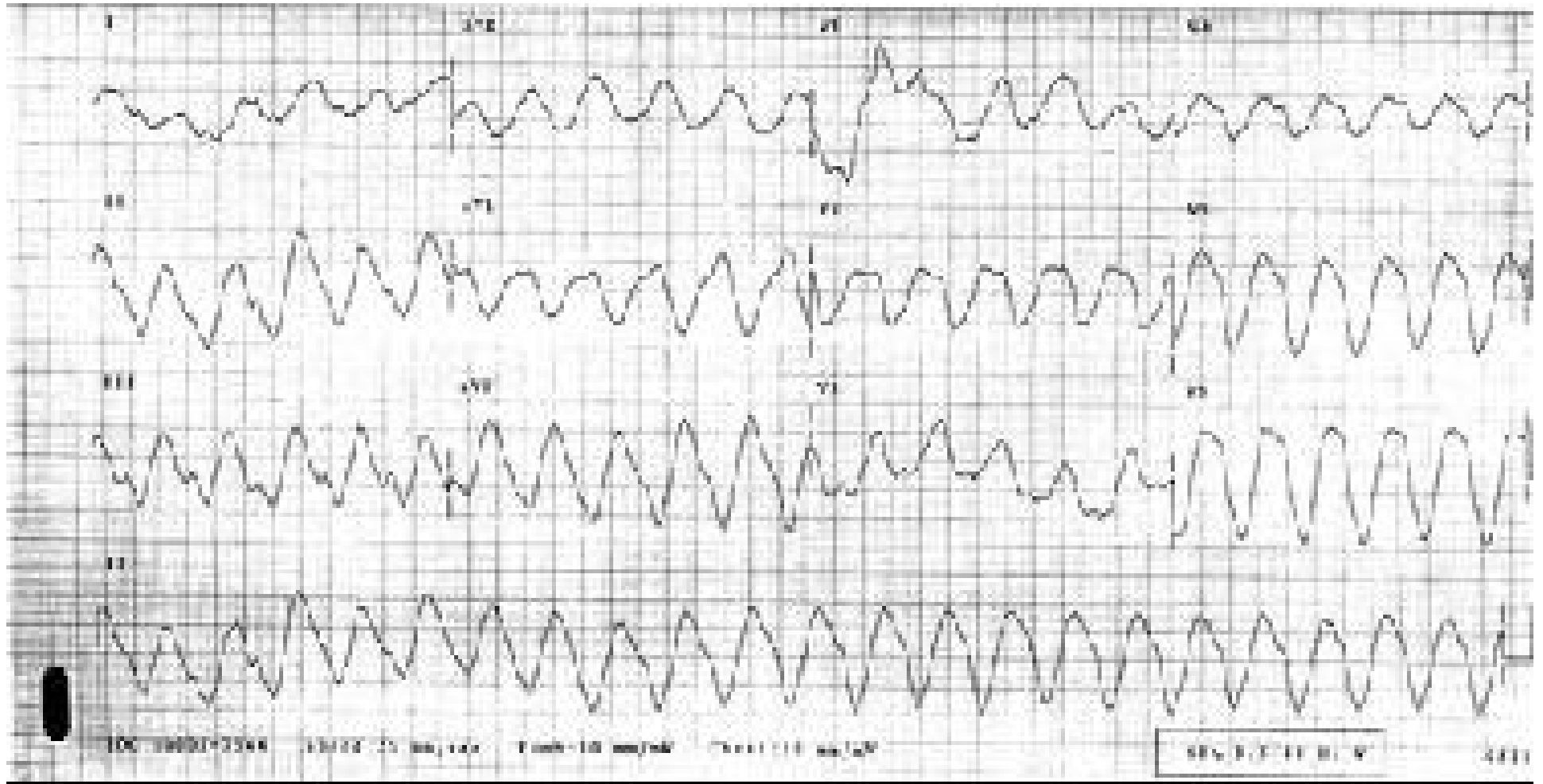
Case

- 78 year old presents with SOB
 - recent gout
 - indomethacin
 - creatinine 790
 - $K = 7.0$ mMol

Clinical Features

- none





Potassium

- Hyperkalemia:
 - acute renal failure
 - pre-renal
 - renal: especially *drugs and toxins (acute!)
 - post-renal
 - too much K
 - ACE-I, ARBs, spironolactone, NSAIDs
- Pseudohyperkalemia
 - check CBC and phlebotomy

Major Causes of Hyperkalemia

Increased potassium release from cells

- Pseudohyperkalemia
- Metabolic acidosis
- Insulin deficiency, hyperglycemia, and hyperosmolality
- Increased tissue catabolism
- β -adrenergic blockade
- Exercise
- Other
 - Digitalis overdose
 - Hyperkalemic periodic paralysis
 - Succinylcholine
 - Arginine hydrochloride

Reduced urinary potassium excretion

- Hypoaldosteronism
- Renal failure
- Effective circulating volume depletion
- Hyperkalemic type 1 renal tubular acidosis
- Selective impairment of potassium excretion
- Ureterojejunostomy

Case

- 78 year old presents with SOB
 - recent gout
 - indomethacin
 - creatinine 790
 - $K = 7.0 \text{ mMol}$

Case

- Restore renal function
 - D5-normal-bicarb (3 amps bicarb into 850 ml of D5W)
 - kaliuresis → loop diuretic
 - remove obstruction
- Remove K from body
 - K binder → Resonium or Kayexalate
 - laxative
- Shift K into cells
 - create alkalosis, insulin, glucose, salbutamol

Case

- 78 year old man with CLL
 - routine blood work
 - WBC = $75,000 \times 10^9/l$
 - K = 6.4
 - ECG normal



Case

- 65 year old man
 - post-op day 4 cholecystectomy
 - NS at 125 ml/hr
 - $K = 2.8$

Clinical Features

- hypokalemia
 - muscle twitch / spasm
 - dysrhythmia

Major Causes of Hypokalemia

Decreased potassium intake

Increased entry into cells

- An elevation in extracellular pH
- Increased availability of insulin
- Elevated β -adrenergic activity – stress or administration of beta agonists
- Hypokalemic periodic paralysis
- Marked increase in blood cell production
- Hypothermia
- Chloroquine intoxication

Increased gastrointestinal losses

- Vomiting
- Diarrhea
- Tube drainage
- Laxative abuse

Increased urinary losses

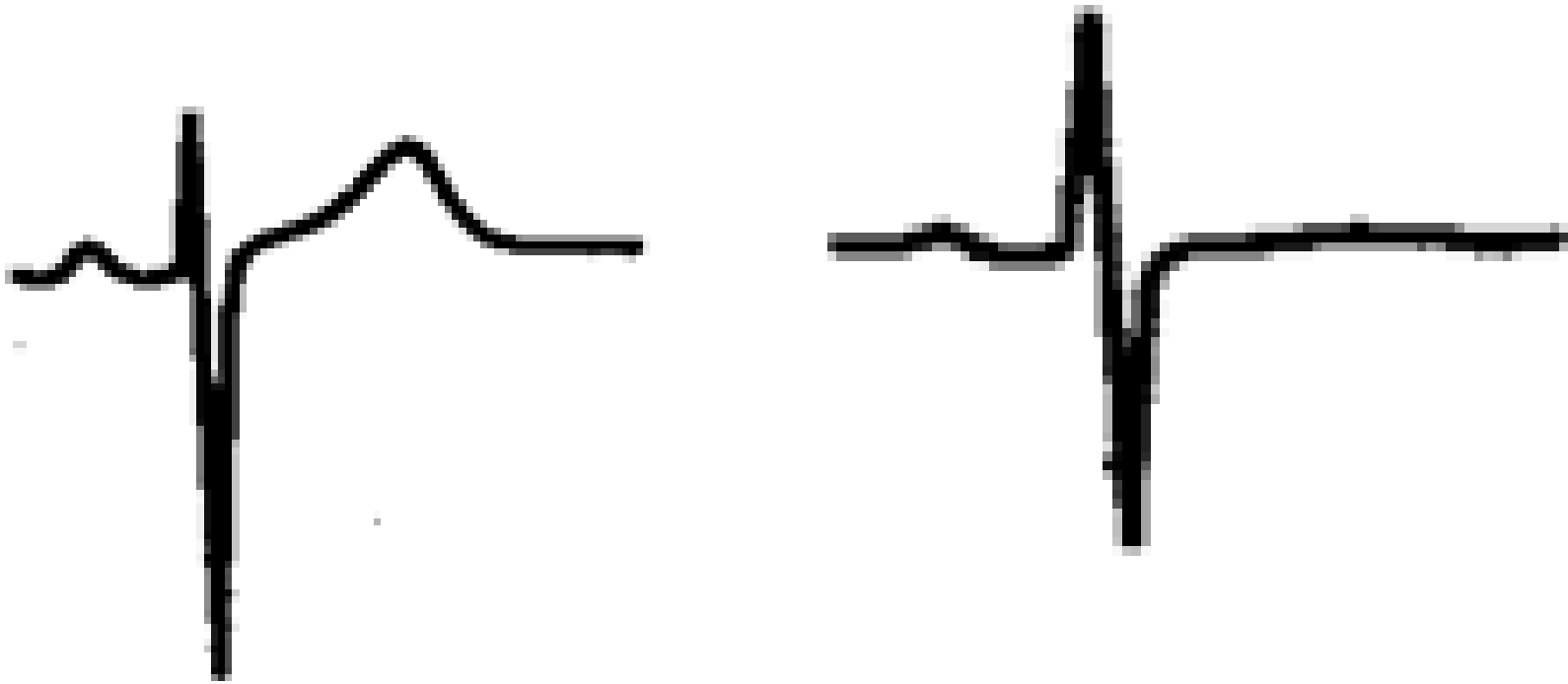
- Diuretics
- Primary mineralocorticoid excess
- Loss of gastric secretions
- Nonreabsorbable anions
- Metabolic acidosis
- Hypomagnesemia
- Amphotericin B
- Salt-wasting nephropathies – including Bartter's or Gitelman's syndrome
- Polyuria

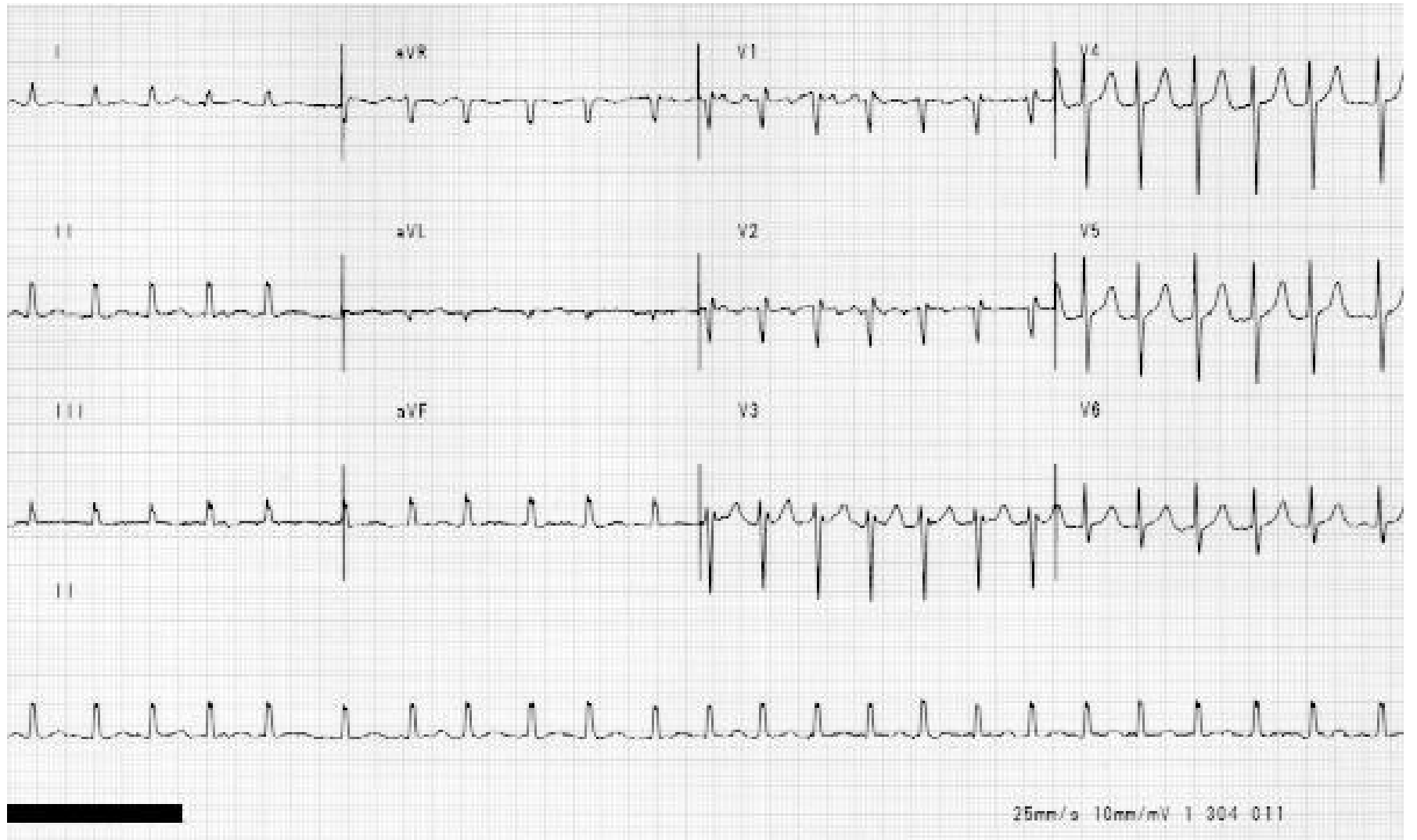
Increased sweat losses

Dialysis

Plasmapheresis

Normal and Flat ST





Potassium Replacement

- Oral whenever possible
 - KCl tablet 8 mEq (slow-K, micro-K)
 - KCl tablet 20 mEq (K-Dur)
 - KCl tablet 25 mEq (K-lyte effervescent)
 - KCl solution 10%
- IV if needed
 - 20 – 40 mMol / l added to IV
 - 10 mMol / hour max

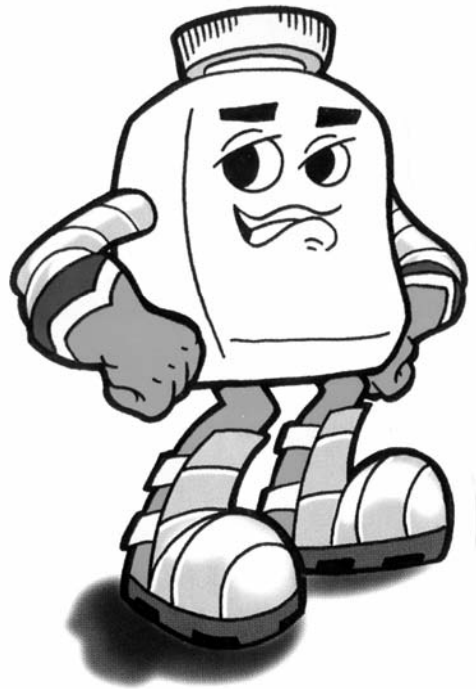
Potassium

- Avoid Kaliuresis
 - can you add / use potassium sparing diuretic?

Case

- 24 year old female presents to ER
 - nausea, vomiting
 - Na = 132
 - K = 6.8
 - Cl = 100
 - HCO₃ = 5
 - glucose = 28

***Captain
Calcium***



Case

- 58 year old female
 - post-op hour 6 neck surgery
 - twitchy and trouble breathing
 - Calcium = 1.7 mMol (2.15 – 2.30 mMol)

DDx - hypocalcemia

- In hospital
 - injured parathyroid glands
 - acute pancreatitis

 - uncorrected calcium for albumin

Albumin Correction

- Corrected Ca =

$$\text{measured Ca} + [(40 - \text{alb}) \times 0.02]$$

e.g.

albumin is 20 g/l

measured Ca = 1.90 mmol

correction is $\rightarrow 20 \times 0.02 = 0.4$

$1.9 + 0.4 = 2.30 \text{ mMol}$

Major Causes of Hypocalcemia*

Loss of calcium from the circulation

- Hyperphosphatemia
- Acute pancreatitis
- Osteoblastic metastases
- Intravascular complexing with citrate, lactate, foscarnet, EDTA
- Acute respiratory alkalosis

Hypoparathyroidism

- After parathyroid, thyroid, or radical neck surgery
- Idiopathic – may be associated with chronic mucocutaneous candidiasis and primary adrenal insufficiency (HAM syndrome)
- Infiltration of the parathyroid gland
- HIV infection
- Pseudohypoparathyroidism

Disorders of magnesium metabolism

Vitamin D deficiency

- Multiple causes

Other

- Sepsis
- Autosomal dominant hypocalcemia
- Fluoride intoxication

*Excluding hypocalcemia due to hypoalbuminemia

Case

- 58 year old female
 - post-op hour 6 neck surgery
 - twitchy and trouble breathing
 - Calcium = 1.7 mMol (2.15 – 2.30 mMol)

Calcium Replacement

- Oral Preferred
 - Calcium carbonate (500 mg elemental)
 - dose according to situation
 - vit D3 → 0.25 to 0.5 ug od
- IV if emergency
 - 10% ca-gluconate 90 mg / 10 ml x 1 to 2 ampules each over 3 – 5 minutes or longer
 - 10% ca-chloride 270 mg / 10 ml (AVOID)

IV Calcium for EMERGENCY

- 10% Ca-gluconate x 6 amps into 500 ml of D5W = $540 \text{ mg} / 560 \text{ ml} = \sim 1 \text{ mg/ml}$
- 0.25 – 0.50 mg / kg / hour infusion
- BE CAREFUL – GOOD IV NEEDED
- MONITOR FREQUENTLY
- CO-ADMINISTER ORAL AND VIT D so as to GET OFF IV ASAP

Case

- 59 year old female with breast cancer
 - obtunded
 - Ca = 4.5 mMol

Calcium

- Hypercalcemia
 - constipation
 - abdominal pain
 - general achiness
 - depressed mood
 - decreased LOC
 - coma

DDx Hypercalcemia

- Malignancy
- Hyperparathyroidism
- Excess Calcium / Vit D
- Fracture
- Bed rest

Major Causes of True Hypercalcemia

Increased bone resorption

- Primary and secondary hyperparathyroidism
- Malignancy
- Hyperthyroidism
- Other – Paget's disease, estrogens or antiestrogens in metastatic breast cancer, hypervitaminosis A, retinoic acid

Increased intestinal calcium absorption

- Increased calcium intake
 - Renal failure (often with vitamin D supplementation)
 - Milk-alkali syndrome
- Hypervitaminosis D
 - Enhanced intake of vitamin D or metabolites
 - Chronic granulomatous diseases (eg, sarcoidosis)
 - Malignant lymphoma
 - Acromegaly

Miscellaneous

- Chronic lithium intake
- Thiazide diuretics
- Pheochromocytoma
- Adrenal insufficiency
- Rhabdomyolysis and acute renal failure
- Theophylline toxicity
- Familial hypocalciuric hypercalcemia
- Immobilization
- Total parenteral nutrition

Case

- 59 year old female with breast cancer
 - obtunded
 - Ca = 4.5 mMol

Calcium Case

- Calciuresis
 - Saline load
 - Furosemide
- Bisphosphonate
 - Zoledronic acid (Zometa)
 - Pamidronate, Clodronate



Case

- 34 year old homeless man presents
 - Feels poorly
 - Day 2 PO₄ = 0.20 mMol (0.8 – 1.5 mMol)

Ddx – Hypo PO4

Major Causes of Hypophosphatemia

Internal redistribution

- Increased insulin secretion, particularly during refeeding
- Acute respiratory alkalosis
- Hungry bone syndrome

Decreased intestinal absorption

- Inadequate intake
- Antacids containing aluminum or magnesium
- Steatorrhea and chronic diarrhea
- Vitamin D deficiency or resistance

Increased urinary excretion

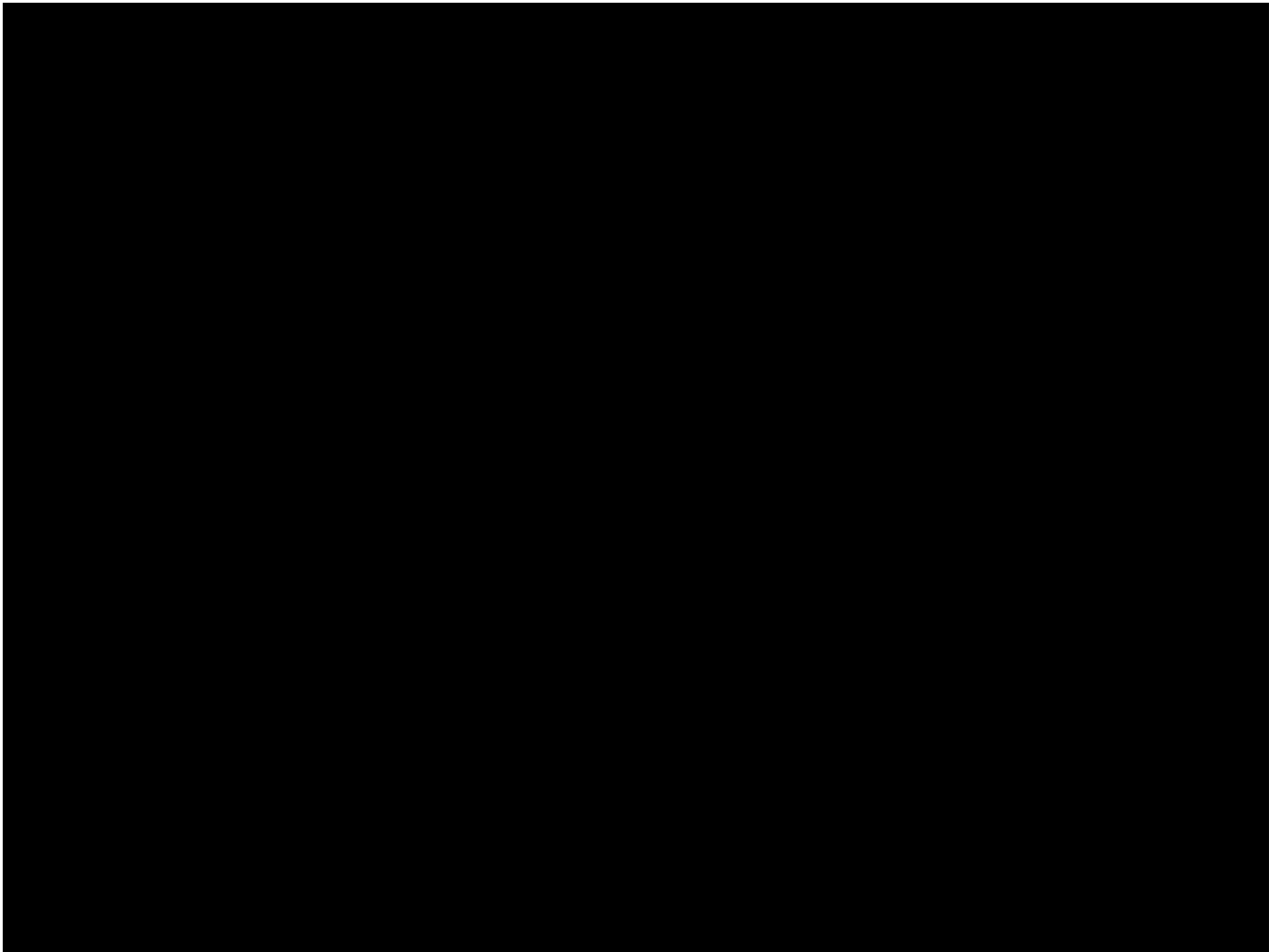
- Primary and secondary hyperparathyroidism
- Vitamin D deficiency or resistance
- Hereditary hypophosphatemic rickets
- Oncogenic osteomalacia
- Fanconi syndrome
- Other – osmotic diuresis, acetazolamide, acute volume expansion

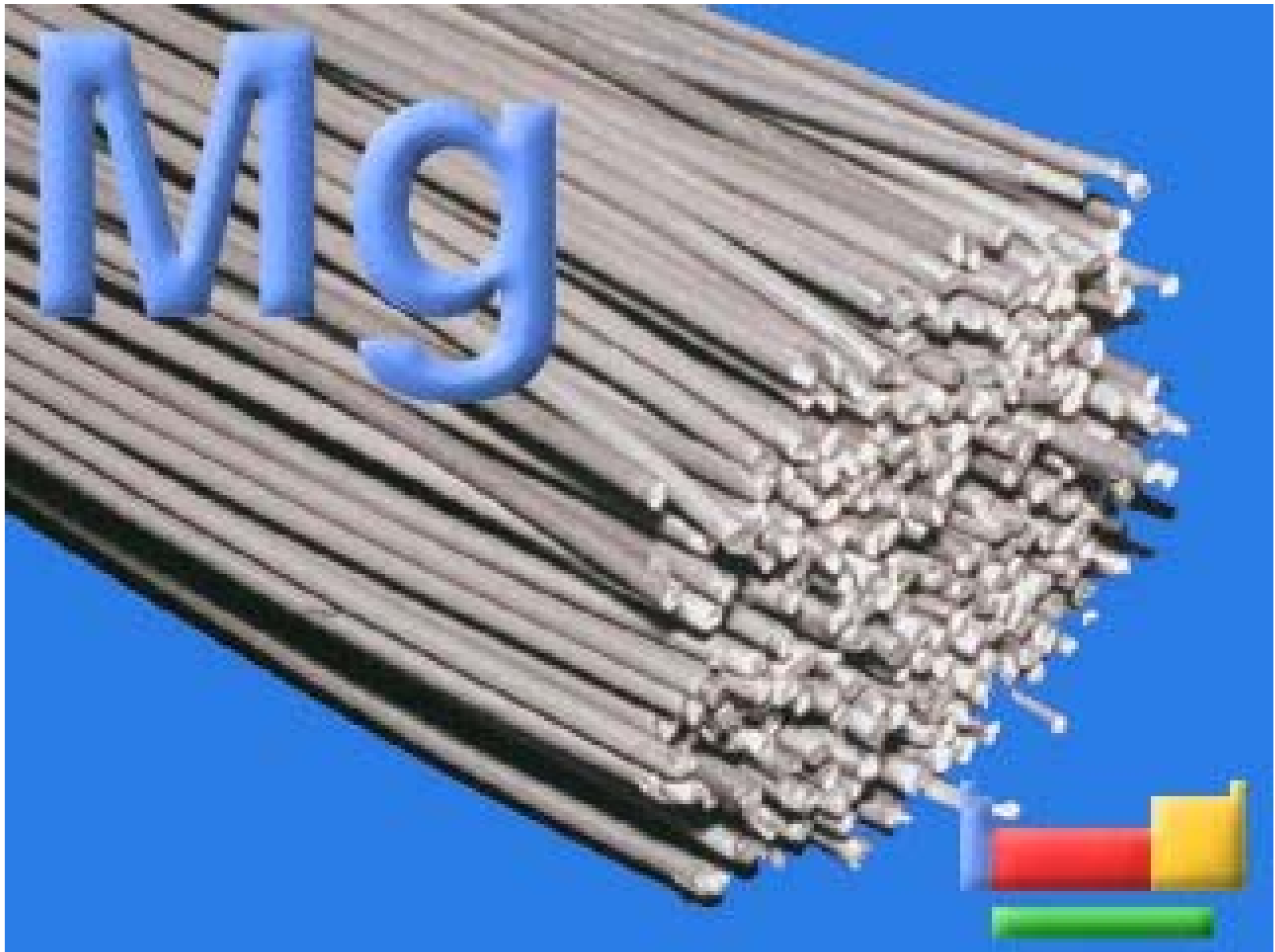
Case

- 34 year old homeless man presents
 - Feels poorly
 - Day 2 PO₄ = 0.20 mMol (0.8 – 1.5 mMol)

Phosphate

- Sandoz Phosphate
- Milk and Food





Case

- 55 yr old alcoholic
 - blood tests done
 - Mg = 0.8 mMol (1.2 – 2.2 mMol)

