

Electric Lytes

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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



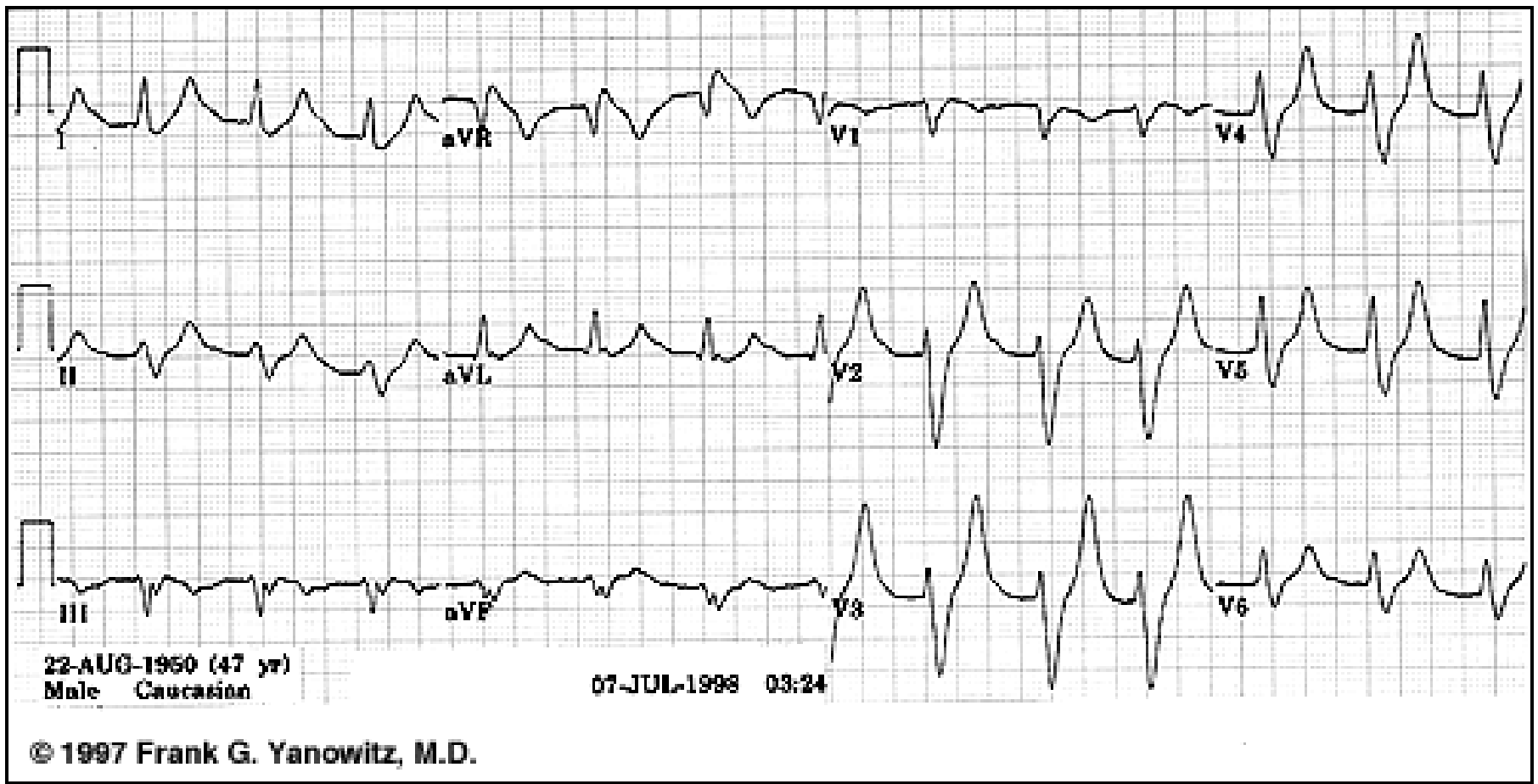


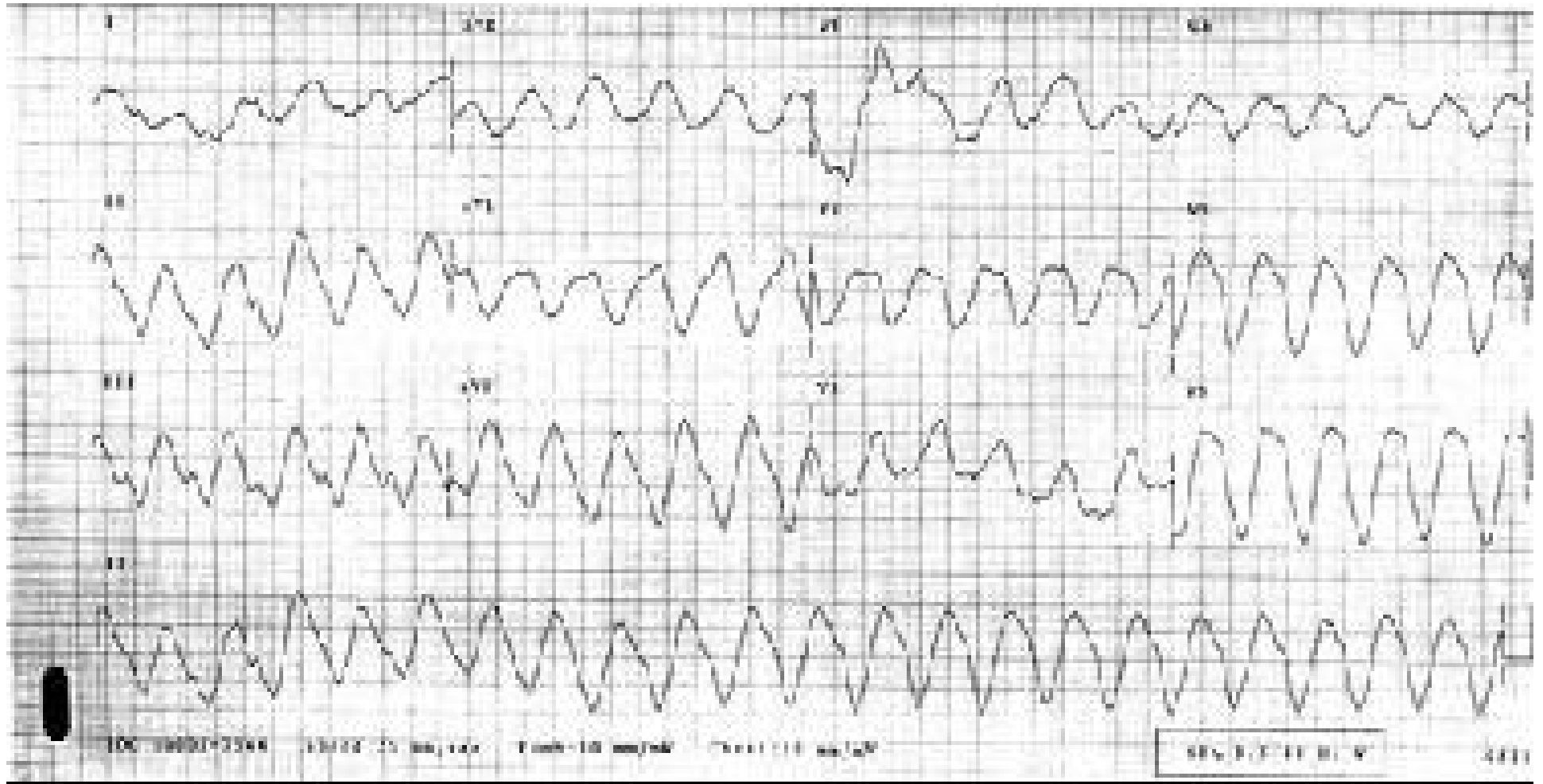
Case

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

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 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

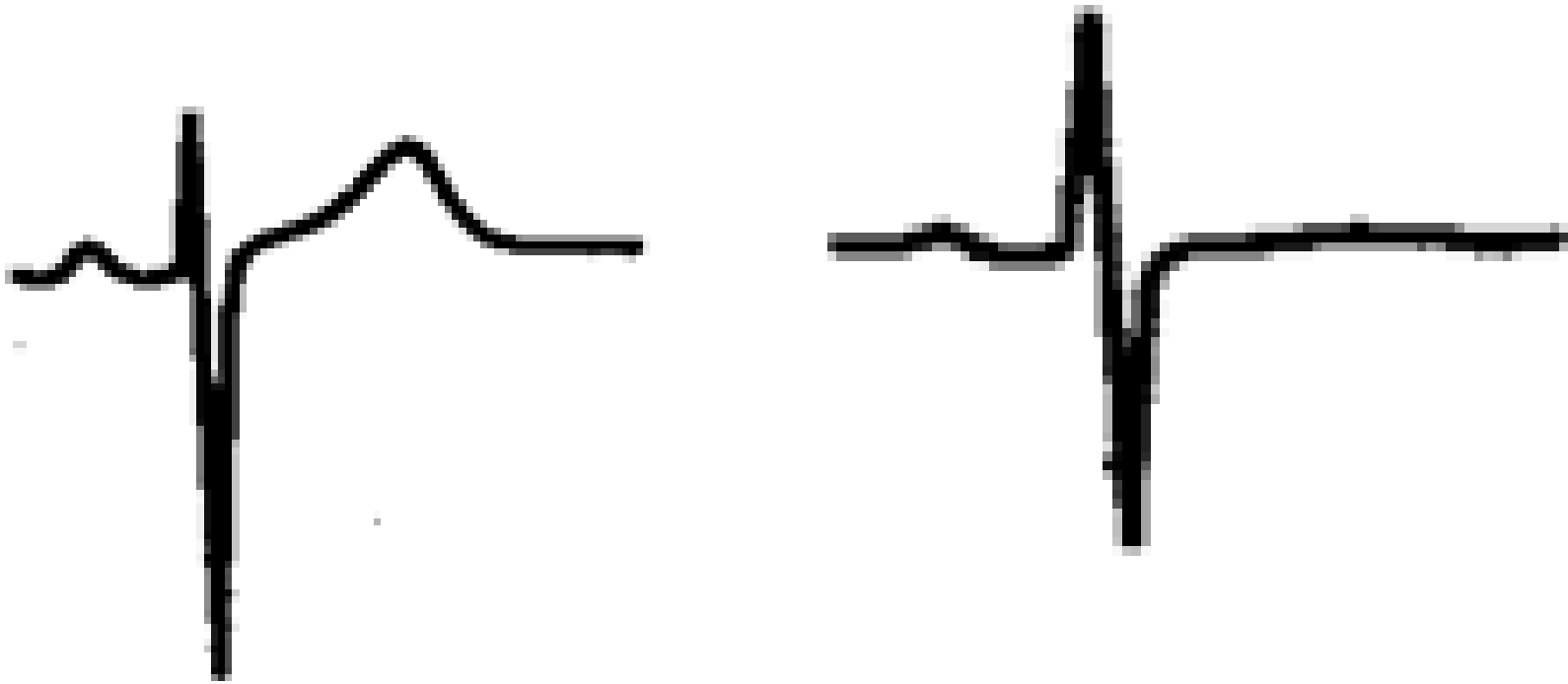
- Diuretics
- Primary mineralocorticoid excess
- Loss of gastric secretions
- Nonreabsorbable anions
- Metabolic acidosis
- Hypomagnesemia
- Amphotericin B
- Salt-wasting nephropathies – including Bartter's or Gitelman's syndrome
- Polyuria

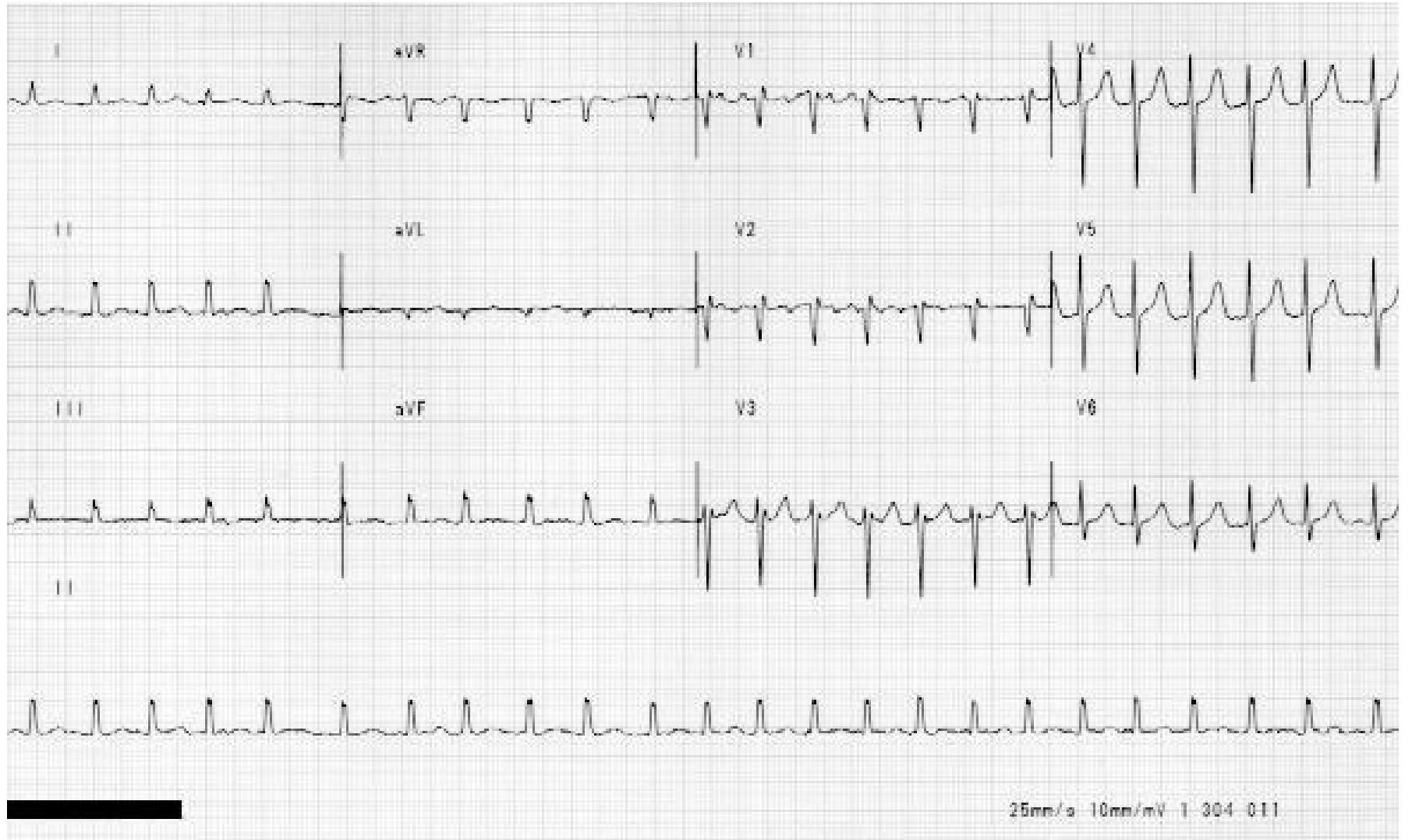
Increased sweat losses

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

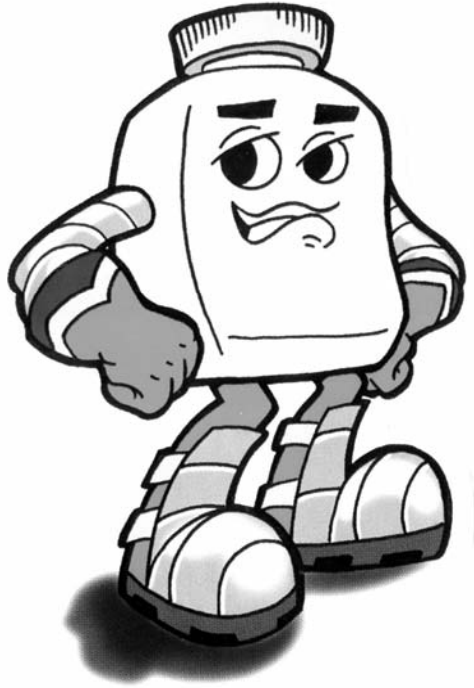
Potassium

- 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

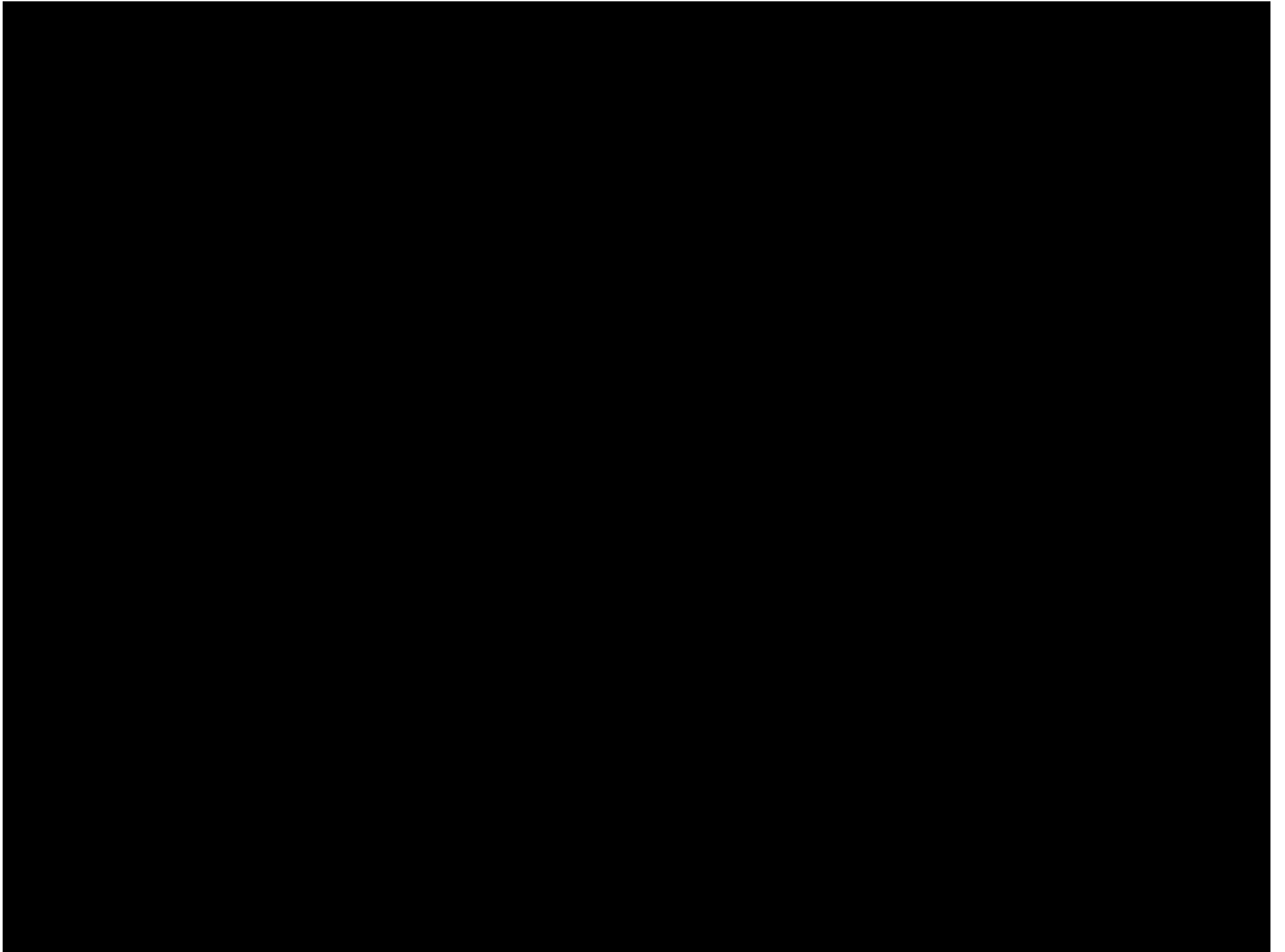
Other – osmotic diuresis, acetazolamide, acute volume expansion

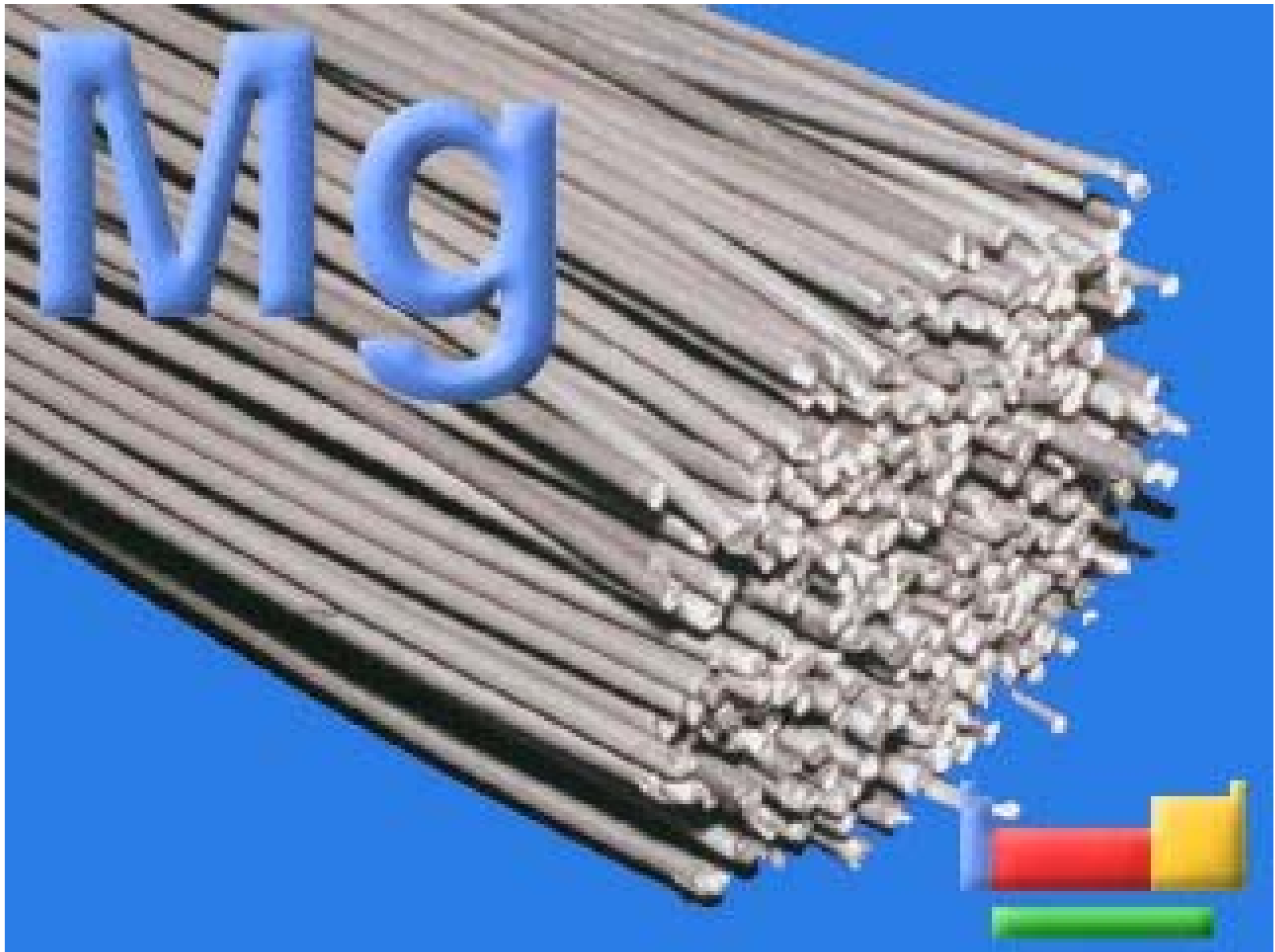
Case

- 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)

