



Electrolytes Summary

Nov 2014

Hyponatraemia

Mild >125	Mild GI Sx (anorexia, N+V)
Moderate 120-124	Lethargy, confusion, muscle weakness
Severe <120	Decr LOC, seizures; brainstem herniation, cerebral oedema, osmotic demyelination

1. Hypertonic: Osm >295

Glucose, mannitol

2. Isotonic: Osm 275-295

aka pseudohyponatraemia: incr lipids, incr protein (myeloma, Waldenstroms)

3. Hypotonic: Osm <275

Due to: solute depletion or solute dilution

a. Hypovolaemic (most common):

Loss of Na > H₂O

Renal (urine Na >20)

Diuretics, osmotic diuresis

Addisons

Na losing nephropathy (RTA, CRF)

Extrarenal (urine Na <20)

Upper GI: vomiting

Middle GI: pancreatitis, bowel obstruction

Lower GI: diarrhoea

Others: sweat, bleeding, burns

Management: give N saline; correct at <0.5mmol/hr or <12mmol/day; aim to get Na >125

b. Euvolaemic:

SIADH

Hypothyroid

Water intoxication: psychogenic, iatrogenic (TURP syndrome)

Drugs: SSRI/TCA/MAOI, ecstasy, oxytocin, carbamazepine, NSAIDs, omeprazole

Test urine osmolality: <100mosm/L = primary polydipsia; >100mosm/L = SIADH or endocrine

Management: fluid restrict to 500-1500ml/day; consider ADH antagonist if SIADH

c. Hypervolaemic:

Incr H₂O >> Na

ARF

CHF, cirrhosis, nephrotic syndrome

Management: fluid and salt restrict; diuresis (loop); dialysis

Hypertonic saline

Indications: coma, seizure, new onset profound decr LOC; not indicated if asymp

Give 25-100ml/hr (1-2ml/kg/hr) 3% saline via CVL

Can give more rapidly (500ml or 4-6ml/kg bolus over 10mins) if seizing

Endpoint: Sx resolved/Na incr by 8-20mmol/L/Na >125

Aim for correction of 1mmol/L/hr (max 10-14mmol/L/day)

SE: central pontine myelinosis (osmotic demyelination) if too rapid correction of chronic (>48hr)



SIADH

Hypotonic (<275) hyponatraemia (<130)
Inappropriately high urine osmolality (>100)
Elevated urine Na >20
Clinically euvolaemic
Normal cardiac, renal, adrenal, thyroid, liver function
Correctable with water restriction

Causes:

Malignancy (ectopic ADH) - lung (small cell, mesothelioma), GI, GU, lymphoma, sarcoma, thymoma
Pulmonary - pneumonia, COPD, lung abscess, TB
CNS - infection, abscess, AIDs, trauma, stroke
Drugs - cytotoxics, antidepressants, antipsychotics, desmopressin, oxytocin, vasopressin

Hypernatraemia (Na >150)

1. Iatrogenic, incapacitated
NaHCO₃, hypertonic saline
Formula (infants), neglect (elderly)
2. Pure water loss (H₂O $>$ Na) - hypovolaemic
Renal = osmotic diuresis (glucose), diuretics
Extra-renal = diarrhoea, blood loss, third spacing
Rx: Normal saline resus then 1/2 normal saline
Water deficit (L) = 1L per 3-5 incr Na = $(0.6 \times \text{kg}) \times ((\text{Na}-140)/140)$
Give deficit + maintenance (1500ml/day in adults), with 50% over 24hrs, 50% over next 48hrs
Correct for ongoing losses
Too rapid correction - cerebral oedema; correct at $<0.5\text{mmol/L/hr}$ or 10-15mmol/L/day
3. Aldosterone excess - hypervolaemic
Primary: Conns, Cushings
Secondary: CCF, cirrhosis, nephrotic syndrome, dehydration
Rx: frusemide + free water. Dialysis if renal failure
4. Diabetes insipidus - euvolaemic
Rx: same as euvolaemic without fluid bolus. ADH or DDAVP

Symptoms occur with Na >158

Osm 350 – 375	Restlessness, irritability, thirst, anorexia, N+V
Osm 375 – 400	Tremor, ataxia
Osm 400 – 430	Hyperreflexia, twitching, spasticity
Osm >430	Seizures, death; subcortical and SAH

Na 150 – suggests dehydration

Na 170-190 – suggests DI

Na >190 – suggests incr Na intake

Children: if mod: paedialyte no more than 15ml/kg/hr
use 0.45% saline + 2.5% dex and replace over 48hrs
if severe: use 0.45% saline + 2.5% dex and replace over 72-96hrs



Diabetes Insipidus

Inability to concentrate urine - large amounts of severely diluted urine

Failure of:

- production of ADH (central DI: neoplasm, pituitary surgery, trauma, idiopathic)
- response to ADH (nephrogenic DI: hypercalcaemia, hypokalaemia, renal disease, lithium, sickle)

serum osmolality > 290 mosmol/L

serum $[Na^+]$ > 145 mmol/L

urine osmolality < 150 mosmol/L

Fluid deprivation test - should make less, more concentrated urine - does not happen in DI

Desmopressin test - if central will concentrate urine (kidneys respond normally), if renal remains dilute

Hypokalaemia

1. Artefact/spurious (drip arm)

2. Decreased intake

3. Redistribution (Intracellular shift)

Alkalosis

Insulin

Beta agonists

4. Increased loss

GI (urine K < 20): D+V+NGT, malabsorption, fistula, villous adenoma

Renal (urine K > 20): RTA, diuretics

Hyperaldosteronism

Primary: Conns, Cushings, Bartters

Secondary: volume contraction (incr RAAS)

NB: acidaemia + low K^+ = doesn't fit - means profound whole body K^+ deficit - explained by RTA

ECG: long PR, T flattening/inversion, U waves (can mimic prolonged QTc), ST depression, VF/VT, atrial arrhythmias

Hyperkalaemia

1. Artefact/spurious (old specimen, WCC > 600 , haemolysed, iv arm, incr plt, clotted)

2. Incr intake

K supplements

GI bleeding

Transfusion

3. Redistribution (ie. extracellular shift)

Acidosis

Tissue damage - trauma, crush, burns, rhabdo, tumour lysis, post-op, hyperthermia

Haemolysis

Drugs - digoxin OD, sux, ACEi, b blockers, insulin deficiency

4. Decr renal excretion

Renal failure

Addisons

K^+ sparing diuretics, CA inhibitors, NSAIDs

RTA type 4



- 6-7: tall peaked T waves ($>5\text{mm}$)
- 7-8: QRS widening, small P waves
- 8-9: fusion of QRS complex with T wave - produces sine wave
- >9 : AV dissociation, VT, VT
- 10-12: VF, asystole, sinus arrest/brady, CHB

Management

Aims: membrane stabilisation, intracellular shift of K, removal of K from body
Ca Gluconate/chloride 10%: 10-20ml 10% Ca glu, 5ml CaCl 10% over 1-5mins
Beta-agonists, (Ca resonium), Insulin and dextrose, NaHCO_3
Frusemide, Dialysis

Hypocalcaemia

1. Spurious: Hypoalbuminaemia or Hyperventilation \rightarrow alkalosis \rightarrow \uparrow protein binding (exchanges for H^+)
2. Decr calcium absorption: Vit D deficiency/resistance, malabsorption, CRF
3. Incr calcium excretion: EtOH, diuretics, salt-wasting nephropathy
4. Endocrine: Hypoparathyroid, pseudohypoparathyroid (PTH resistance)
5. Shifts: alkalosis, rhabdo, pancreatitis (saponification)
6. Others: phosphate (enemas), citrate (transfusion, dialysis)

ECG: Prolonged QT (no U waves), heart block

Hypercalcaemia

- 3.0-3.5 mmol/L = mild symptoms: ECG CHANGES start
- 3.5-3.8 mmol/L = weak, lethargic, confused, polyuria, polydipsia
- >3.8 = stupor/coma
- >4.0 = cardiac arrest

1. Spurious: Hyperalbuminaemia, Sample after venous stasis (tourniquet)
2. Malignancy (50%): Paraneoplastic eg PTHrP, bone mets
3. Hyperparathyroidism (25%): primary and tertiary
4. Vitamin D excess: ingestion, lymphoma, sarcoidosis
5. Milk-Alkali syndrome
6. Thyrotoxicosis
7. Thiazides

ECG changes:

- ST depression, Short QT, Wide T wave
- Bradyarrhythmias, BBB - 2nd degree block - 3rd degree block
- Potentiates digoxin toxicity

Management

iv fluids (aim UO $\sim 100\text{ml/hr}$)
+/- frusemide (for fluid overload)
Bisphosphonates (interferes with osteoclast function, more potent than calcitonin, takes few days to work)
Calcitonin (incr Ca excretion, inhibit osteoclasts, works 4-6hrs, lowers Ca 0.25-0.5 mmol/L max)
Glucocorticoids (incr urinary excretion, decr calcium absorption)
Dialysis if oliguric



Hypomagnesaemia

1. GI: poor nutrition, malabsorption, diarrhoea, Crohns
2. GU: alcohol, diuretics, diabetes, nephrotoxic drugs, hypercalcaemia, Gittlemans and Bartters
3. Intracellular shift: adrenergics
4. Endocrine: hyperthyroidism, hyperparathyroidism
5. Pancreatitis

ECG: risk of AF and SVT after AMI, increases effects of digoxin toxicity, prolonged QT, risk torsades

Hypermagnesaemia

1. Decr excretion: renal failure
2. Incr intake: Rx pre-eclampsia, epsom salts, antacids, enemas
3. Release from cells: tumour lysis, rhabdo

- >3.0: N/V/flushing
- >4.0: decreased DTRs, drowsy, unsteady
- >5.0: ECG changes (QRS widening, PR prolongation)
- >6.0: stupor, hypotension, bradycardia
- >10: absent reflexes, muscle paralysis
- >15: heart block, apnoea

Management

Remove exogenous magnesium
Give calcium
iv fluids + frusemide
Consider dialysis if renal failure

Uses of magnesium

1. Torsades
2. Digoxin toxicity
3. Pre-eclampsia/Eclampsia
4. Asthma
5. AF
6. Irukandji Syndrome
7. Resistant hypokalaemia
8. Symptomatic hypomagnesaemia and $Mg^{2+} < 0.5 \text{ mmol/L}$

1g = 4mmol = 8meq

1 Ampoule = 10mmol = 2.47g

Dose: 10mmol over 10-15mins for emergency indications

Faster for life-threatening arrhythmias

Hyperchloraemia

NAGMA

Usually due to excess saline

Hypochloraemia

Due to associated hyponatraemia



Hypophosphataemia

1. Intracellular shift (resp alkalosis, CHO/insulin, catecholamines/beta agonist, leukaemia, hungry bone syndrome)
2. Incr urinary excretion (alcoholism, hyperpara, acute volume expansion, diuretics, malignancy)
3. Decreased intestinal absorption (alcoholism, malnutrition, malabsorption, phosphate-binding antacids)
4. Hypothyroidism
5. Severe sepsis, DKA, AKA, TPN

Hyperphosphataemia

1. Spurious (haemolysis, myeloma)
2. Incr intake: exogenous (enema), tumour lysis, rhabdo
3. Decr excretion: CRF, Vit D intoxication