16 Metabolic

HYPOKALAEMIA

Causes

- Redistribution
  - ***Catecholamines*** eg ***caffeine, salbutamol***, pain
  - ***Insulin***
  - ***Aldosterone***: Cushing's, liquorice, Liddle's
  - ***Acidosis***: RTA, DKA, ***Diuretics***, Bartter's
  - Periodic paralysis
  - ***Vit B12***
  - ***Verapamil, Barium, Chloroquine***
- Poor intake
- ↑ losses: GIT, Renal (mostly acidosis)

Complications

- Worsens (not caused by) ***digoxin*** toxicity
- Weakness, ileus, rhabdomyolysis
- Nephrogenic diabetes insipidus of hypo K
- Arrhythmia: ***SVT, VT, VF, TdP***

ECG Δs

- P wave	peaked
- PR	prolonged
- ST	depression
- T wave	flattened
- ***U waves***	precordial, follows T, inverted

- Ventricular ectopics
- Arrhythmia: SVT, **VT**, VF, TdP

Management

- ***KCL*** 40mmol/hr (0.5mmol/kg/hr) ***20mmol ↑K⁺ 0.5 mmol/L***
  Main IV indication is arrythmia, paralysis, myopathy
- ***Chlorvescent*** (14mmol), ***Slow K*** (8mmol)

HYPERKALAEMIA

Causes

- Exogenous	- Supplements, Diet
	- Salt subs eg K salts in ***penicillin***
- Endogenous	- **Haemolysis, Tumour lysis**
	- **Rhabdo**
	- **Trauma: Burns, Crush**
	- Intense physical activity
- Redistribution	- **Alkalosis**
	- Insulin def
	- Drugs eg Sux, β-blockers, digoxin
	- Hyperkalaemic periodic paralysis
- ↓ Losses	- ↓GFR incl nephrotoxins ie ***AKI***
	- ↓ mineralocorticoids
- Pseudo	- in vitro haemolysis
	- thrombocytosis, leucocytosis
	- **prolonged tourniquet**

ECG Δs

5.5-6.5	Tall tented ***T*** waves, ***QT*** & ***PR*** shortening
6.5-7.5	Small/absent ***P*** waves
7-8	Wide ***QRS***
8-10	***Sine*** wave (fusion of QRS & T)
> 10	AV dissociation, VT, **VF**

Principles of Mx

- Defend heart	- Eliminate K from system
- Drive K into cells	- Underlying cause

Management

- 10ml 10% ***CaCl*** or 30ml 10% ***Ca Gluconate***
- 10u ***Insulin*** + 10% ***dextrose*** 250ml over 10min
- 10mg ***Salbutamol*** neb
- 1L 0.9%***NS***
- ***Ca resonium A*** 50g
- ***Frusemide*** 20-80mg
- Dialysis
- Underlying cause eg adrenal insufficiency
- Give ***Mg*** as well since Ca antagonises Mg

HYPONATRAEMIA

Severity

<115 Life threatening	<130 Moderate (GI Sx)
<125 Severe (neuropsych)	<135 Mild (ASx)

Management

- monitor electrolytes, crea, UO
- mild/mod: - fluid restrict 1L/day
- severe: - ***3%NS*** 3ml/kg (or 0.5-1.0 mg/kg ***mannitol***)
  - **correct < 10 mmol 1st 24hr, < 18 1st 48hr**
  - risk ***central pontine demyelination*** if more
- ***seizure: 3%NS*** 100ml over 10min x3 (100ml = 50mmol)

Rapid Replacement also indicated in

- Self-induced
- Acute onset < 24hrs
- Intracranial pathology eg ALOC

Osmotic Demyelination

- Symmetrical lesion midline pons (ie central pontine)
- Clinical: dysarthria, mutism, lethargy, emotion

Risk factors

- Chronic	- Concurrent	- ↓ K Elderly
- Severe	- Burns	- Malnourished
- Alcoholics	- Thiazides	

SIADH

- Most common cause of ↓ Na (50%)
- Corrects with fluid restriction

Criteria

- ***Euvolumic hypotonic hyponatraemia***
- Urine Na > 20 mmol/L
- Urine oSm > 100 mmol/kg > Plasma
- Normal heart, liver, kidney, thyroid, adrenal function
- No diuretics
- No extracellular volume depletion

Causes

- Neuro: tumour, trauma, infection, GBS, SLE, ICH
- Pulmonary: pneumonia, abscess, PPV
- Drugs: ***tramadol, amphetamines, haloperidol***
- Ca: bronchogenic, pancreatic, lymphoma

HYPERNATRAEMIA

Causes

- ↓ fluid intake most common eg too young/old/sick
- ↑ fluid loss
  - **Burns, sweat, GIT**
  - Renal: ***mannitol***, ↑ glc, ↑ urea
  - Trauma: ***diabetes insipidus (most common cause)***
- Iatrogenic: $NaHCO_3$, Salt ingestion
- ↓ Protein
- ↑ ***Aldosterone***: Conn's, CCF, cirrhosis

Management

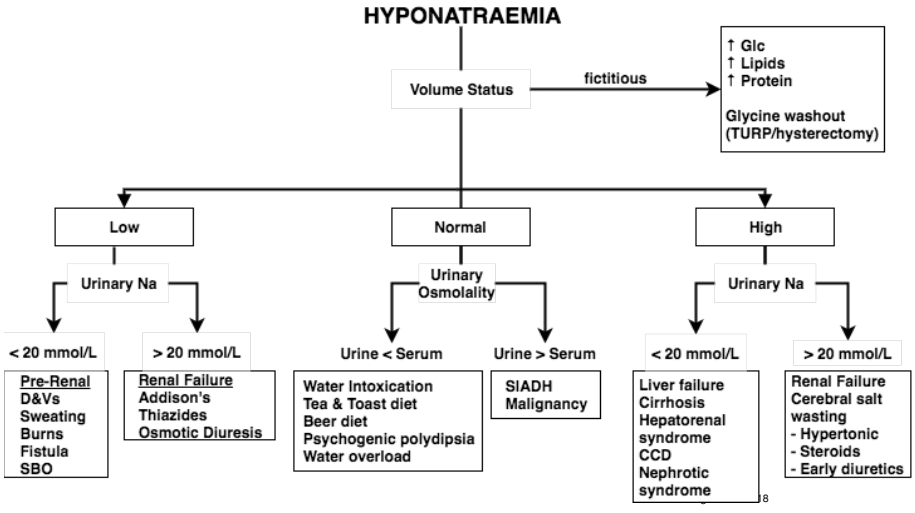
- 0.45%***NS*** or 5%***D*** ± ***Desmopressin, CBZP***

Diabetes Insipidus

- *Up to 20L urine/day*

Causes & Mx

- Central (no vasopressin made in hypothalamus)
  - Cause: any intracranial pathology
  - Mx: ***DDAVP***
- Nephrogenic (desensitised to vasopressin)
  - Polycystic kidneys, amyloidosis, Li tox, Ca++,
  - Mx: ***Thiazides, aspirin***
- Dipsogenic
  - Polydipsia; psychogenic or hypothalamic
  - Mx: ***DO NOT give DDAVP***
- Gestational
  - Placenta makes ***vasopressinase***
  - Mx: ***DDAVP***



HYPOCALCAEMIA

Laboratory Ca

- ½ Ca ***bound to albumin***, ½ ***Ionised*** form in serum
- Ionised is the physiologically important one
- iCa Homeostasis: ↓ iCa in ↑ pH, albumin

Range:	< 0.5	mmol/L	Critical: Tetany
	0.5-0.75	mmol/L	Transfuse
	1.1-1.35	***mmol/L***	***Normal***
	> 1.75	mmol/L	Coma

Causes

- ***Pseudo: ↓Albumin***	- Renal impairment
- Hyperventilating	- ↓ Mg
- Hypoparathyroid	- Conn's
- Malabsorption, Vit D def	

Signs

Ch for Chovstek & Cheek

- ***Chovstek's***: tap on parotid = facial spasm
- ***Trousseau's***: BP cuff = spasm
- Tetany → laryngospasm
- Seizures
- ***ecg ↑ QT = TdP***

Management

CaCl	10%, 10ml	2g, 27mmol
Ca Gluc	10% 10ml	2g, 4.5mmol

Routine: Ca gluconate 10% 100ml in 1L @ 50ml/hr

Other indications for Ca

- ↑ K & cardiotoxic (defend cardiac membrane)
- ***HFA*** burns (local application)
- SVT pre-treatment with ***verapamil***
- ***CCB***
- ***Digoxin*** OD (controversial) ?precipitate

HYPERCALCAEMIA

Causes

- Malignancy (80%)	- Hyperthyroidism
- 1ry adrenal insufficiency	- Rhabdo
- Milk alkali syndrome	- ***Thiazides***
- Sarcoidosis	- Vit D tox

Signs

- ***'Bones, moans & abdominal groans'***
- ECG: short QT, prolonged PR, QRS, ↑ ***K***

Management

- Dilute: 0.9%NS (Hartman's has Ca), ***frusemide***
- Bisphosphonate: ***Zoledronic acid*** 4mg IV over 15m
- Add ***Salcatonin*** 100 IU if ***life threatening***

Specific c Mx

- 1ry Hyperparathyroidism: surgery, Cinacalcet
- Malignancy: ***Zoledronic acid***
- Vit D Tox: ***Calcitriol ± pred***
- ***Sarcoidosis***: rehydration, ***pred*** 15-30mg daily

HYPOMAGNESAEMIA

Causes

- GIT: malnutrition, malabsorption
- Renal: ***alcohol, diuretics, gent,*** hyperaldosterone
- Recovery from AKI

Clinical Features

< 0.5	tetany, seizures, arrhythmias
0.5-0.7	neuromuscular irritability

↓ ***K*** (if due to ↑ aldosterone)

Cardiac Complications

- ↑ SA chronotropy	- Worse digoxin tox
- ↑ risk AF/SVT x3	- ecg ***↑ QT = TdP***

Indications for $MgSO_4$

- Life threats	- TdP or resistant tachyarrythmias	
	- Pre/eclampsia	
	- Refractory asthma	
- Other	- Dig toxicity	- Resistant ↓ K, Mg
	- Tetanus	- Box jellyfish bite

Management

- general: TdP, ***dig*** tox:	10mmol over 15min
- Pre-eclampsia:	40mmol over 15min

HYPERMAGNESAEMIA

Causes

- ***Antacids, enemas***
- Renal impairment

Clinical features

3	N&V, flushing skin
4	***↓ Tendon reflexes (before apnoea)***, drowsy, unsteady
5	ECG Δs: wide QRS, long PR
6	Stupor
10	Skeletal muscle paralysis no reflexes
15	3 HB

Management

- Remove exogenous	- ***Frusemide***
- ***Ca Gluconate*** 10% 10-20ml	- Dialysis

ELECTROLYTES PATTERNS

General Rules

The following groups usually change in the same direction:

Group 1: Ca, K, PO_4
Group 2: Na, Cl, Mg, Glc

Endocrine

↑ *Aldosterone*

- Causes: Cushing's, Conn's, excess exogenous
- ↑ Na, H_2O
- ↓ K, Mg, Ca

↓ *Aldosterone*

- Causes: Addison's, ***sepsis***, exogenous steroids
- ↑ K, Mg, Ca
- ↓ Na, H_2O

1ry Hyperparathyroidism

- ↑ Ca, ALP
- ↓ PO4

Diabetes Mellitus

- ↑ Glc → ↑ Na + ↓ K

Diabetes Insipidus

- ↑ Na (most common cause)

Hypothyroidism

- ↑ Total chol, LDL, TG, Mg, PO_4
- ↓ Ca, Na, K

Hyperventilation

- ↓ K, Ca, Na
- Resp alkalosis

FLUID COMPOSITION

	N	K	Cl	Glc	Notes
0.9%NS	150	0	150	0	isotonic
Hartmanns	131	5	111	0	30 Lactate
5%D				50	
10%D	30	30	0	100	10% = 1 mars bar
50%D				150	
Paed					
½NS+ 5%D	75	0	75	200	hypotonic
¼NS + 10%D + 10 KCL	37.5	10	36.5	400	< 1m old
Plasma-lyte + 5%D	140	5	98	0	Isotonic