# FLUIDS AFTER-HOURS

Prepared by Arunima Jain

# Outline

- Approach to fluid balance
- Basic physiology
- Cases and questions!

# Fluid balance

**Input**

- Oral and IV fluid
- Food
- Metabolism (approx 500ml)

**'Circulation'**

- *MAP = Cardiac output (SV X HR) x TPR*
  - *Cardiac function, valvular heart disease, sepsis (infective vs non infective)*
- *Starling's equation and oncotic pressure*
  - *Noting nutritional status / albumin*

**Output**

- Drive to reduce excretion (RAAS/ADH)
- Urine output
- Insensible and GI losses + drains/etc

# Assessing fluid status

- History
  - Intake / output
  - Orthopnoea, paroxysmal nocturnal dyspnoea
  - Dizziness/light-headedness/postural symptoms
- Physical examination
  - Physical appearance
  - Skin turgor, mucous membranes
  - Peripheries, pulse, capillary refil
  - Central capillary refil
  - JVP
  - Cardio/respiratory examination
  - Peripheral oedema
- End organ effects
  - Mental state
  - Urine output

# Objective measures

- Bedside
  - HR, BP
  - Weight
  - Postural blood pressure
  - Fluid balance chart
- Bloods
  - Lactate
  - UEC
- Urine
  - Urine Na < 20 (hypovolemia or low effective volume in certain cases)
  - Urine output

# What is normal…

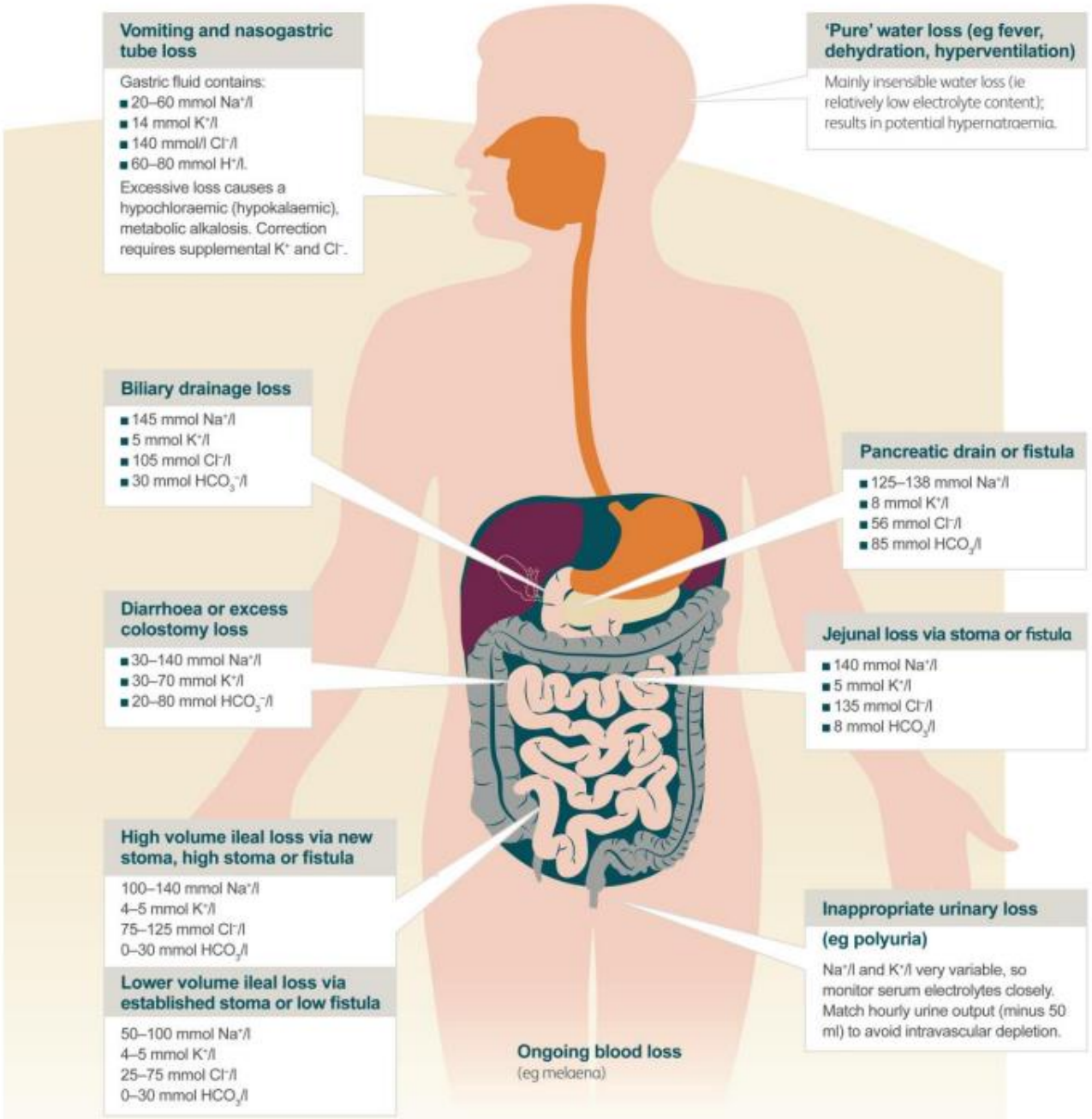
- Sodium intake?
  - 1-2 mmol/kg/day
- Potassium?
  - 1 mmol/kg/day
- Chloride?
  - 1 mmol/kg/day
- Water intake?

# How do I account for losses?

- Examples: vomiting, diarrhoea, stoma, biliary drain loss…

# Losses to consider…

- Vomiting
  - 20-40mmol $Na^+$ /L, 14 mmol $K^+$ /L, 60-80 mmol $H^+$/L
  - 140 mmol $Cl^-$ /L
  - Can cause metabolic alkalosis!
- Diarrhoea:
  - 30-140mmol $Na^+$ /L, 30-70 mmol $K^+$ / L,
  - 20-80 mmol $HCO_3^-$
  - Can cause normal anion gap metabolic acidosis!
- Stoma
  - 100-140 mmol $Na^+$/L, 4-5 mmol $K^+$/L, 75-125 mmol/L $Cl^-$
- Biliary loss
  - 145 mmol $Na^+$ /L, 5 mmol $K^+$/L, 105 mmol $Cl^-$/L, 30 mmol $HCO_3^-$/L




NICE Guidelines, UK

# Cases

- 33 year old female, presents with nausea and vomiting…

# Cases:

| | |
|---|---|
| Sodium Level | * L 131 mmol/L |
| Potassium Level | * L 2.6 mmol/L |
| Chloride Level | * L 75 mmol/L |
| Bicarbonate Level | * C 41 mmol/L |
| Urea Level | * 4.2 mmol/L |
| Creatinine | * 46 umol/L |
| eGFR CKD-EPI | * >90 mL/min/1. |
| Bilirubin Total | |
| Protein Total Level | |
| Albumin Level | 39 g/L |
| ALP | |
| GGT | |
| ALT | |
| AST | |
| Calcium Level | 2.53 mmol/L |
| Corrected Calcium Level | 2.48 mmol/L |
| Magnesium Level | L 0.66 mmol/L |
| Phosphate Level | 1.37 mmol/L |

# What would your approach be?

- Fluid status
  - History
  - Documented losses
- Current intake / output
  - Urine output!
- Comorbidities
- Medications

# What choices do you have?

| | $Na^+$ | $Cl^-$ | $K^+$ | ($HCO_3^-$) | (glucose) |
|---|---|---|---|---|---|
| **NORMAL PLASMA** | **135-145** | **100-110** | **3.5-5.0** | **22-26** | **3.5-7.8** |
| **Sodium chloride 0.9%** | 154 | 154 | - | - | - |
| **Hartmann's solution** | 131 | 111 | 5 | 29 | - |
| **5% Dextrose** | - | - | - | - | 50g (170 calories) |
| **Dextrose-saline 4%/0.18%** | 30 | 30 | - | - | 40g |

*Consider albumin and blood products if appropriate

*Oral supplementation with Slow K (600mg = 8 mmol) or Chlorvescent (1 tab = 14mmol)

- Approximately 60kg
- Estimating: 120 mmol Na, 60 mmol K, 60 mmol Cl required assuming NO INPUT

- Vomiting related losses – 2L
  - Approx 80 mmol sodium
  - 80 mmol potassium, 200mmol chloride

Reference: Oscestop.com

# A well 33 year old…

# A 33 year old with a history of…

- ESKD on HD
  - On 1L FR
  - Factor in fluid restriction / urine output, potassium!
- Cardiomyopathy awaiting heart transplantation
- Child Pugh C cirrhosis
  - Cautious with administration of sodium load
- A 5 day fast

# Questions?

# Case 2:

- 75M with CKD, HTN and T2DM presents with chest pain and shortness of breath. Asked to review for tachypnoea
  - Examination consistent with fluid retention
  - Plan for imminent angiogram
  - Creatinine rise from 240 → 350 with eGFR now 15

- Medications:
  - Telmisartan/HCT 40mg/12.5mg
  - Furosemide 40mg
  - Jardiamet 1000/12.5mg
  - Insulin
  - Allopurinol
  - PRN ibuprofen

# What would you do?

- A) WH all diuretics and nephrotoxins pending team review in the morning
- B) Give IV furosemide
- C) Pre hydrate with 1L normal saline, then give IV furosemide and post hydrate in preparation for angiogram
- D) Give fluids and bicarbonate infusion, then diurese
- E) Call Renal

# General management of hypervolemia

- Non pharmacological
  - Low sodium diet (<2g)
  - Fluid restriction
- Pharmacological
  - Diuresis
  - Dialysis
  - Manage precipitant causes

# Factors to consider with diuretics

- Dose-response curve
  - Secreted into tubular lumen and act on luminal membrane
  - If 40mg does not work → 80mg, etc.
- Nephrotic syndrome
  - Diuretics are highly protein bound, and confined to the vascular space
  - In hypoalbuminaemic patients, Vd is increased and slows rate of delivery to the kidney
- CHF
  - Decreased renal perfusion impacting diuretic delivery to kidney
  - Delayed intestinal absorption → role for bumetanide

# Questions?

# Case 3

- 47M presents with seizure…
- BG: Asthma
- History of heavy drinking over the past few weeks, but hadn't drunk for 24 hours
- Given 5mg IM midazolam, 1L normal saline, 20mg PO diazepam, 500mg IV thiamine

# Case 3

| Blood Chemistries | 19/03/2022 01:36 |
|---|---|
| Sodium Level | * C 117 mmol/L |
| Potassium Level | * C 2.2 mmol/L |
| Chloride Level | * L 78 mmol/L |
| Bicarbonate Level | * L 12 mmol/L |
| Urea Level | * L 1.4 mmol/L |
| Creatinine | * L 50 umol/L |
| eGFR CKD-EPI | * >90 mL/min/1.7 |
| Bilirubin Total | |
| Protein Total Level | |
| Albumin Level | |
| ALP | |
| GGT | |
| ALT | |
| AST | |
| Troponin T | * H 698 ng/L |
| Calcium Level | |
| Corrected Calcium Level | |
| Iron Level | |
| Transferrin saturation | |
| Transferrin | |
| Ferritin | |
| Glucose Level | * H 8.2 mmol/L |
| Osmolality Random | * L 246 mmol/kg |
| Osmolality Calculated | * L 244 mmol/kg |
| Osmolality Gap | * 2 mmol/kg |
| Magnesium Level | |
| Phosphate Level | |
| Vitamin B12 Level. | |
| Folate Level. | |

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What is the patient's fluid status?

What's in the URINE?

- Urine osmolality: 309
- Urine Na: 77

What are his undiagnosed comorbidities:

- HF
- Cirrhosis

# Hyponatremia

- Serum Na
  - Severe hyponatremia: Na < 120 mmol/L
  - Moderate hyponatremia: Na 120 – 129 mmol/L
  - Mild hyponatremia: Na 130 – 134 mmol/L
- Exclude pseudohyponatremia
  - Pseudohyponatremia occurs when seemingly low sodium levels are actually normal.
  - Causes include hyperglycemia, hyperproteinemia, mannitol use, or laboratory errors.

# Symptoms of hyponatremia

- Nausea, vomiting
- Headache, neuropsychiatric symptoms, weakness
- Lethargy
- Seizures
- Coma

# Investigations

- Serum osmolality
  - If clinically dehydrated – would suspect high osmolality
  - Low in states of fluid retention, SIADH, etc
- Urine osmolality
  - Urine Osmolality < 100 mmol/L → DILUTE urine
    - Primary polydipsia, beer potomania, malnourished
  - High urine osmolality + low urine Na
    - Often indicates patient is intravascularly dry

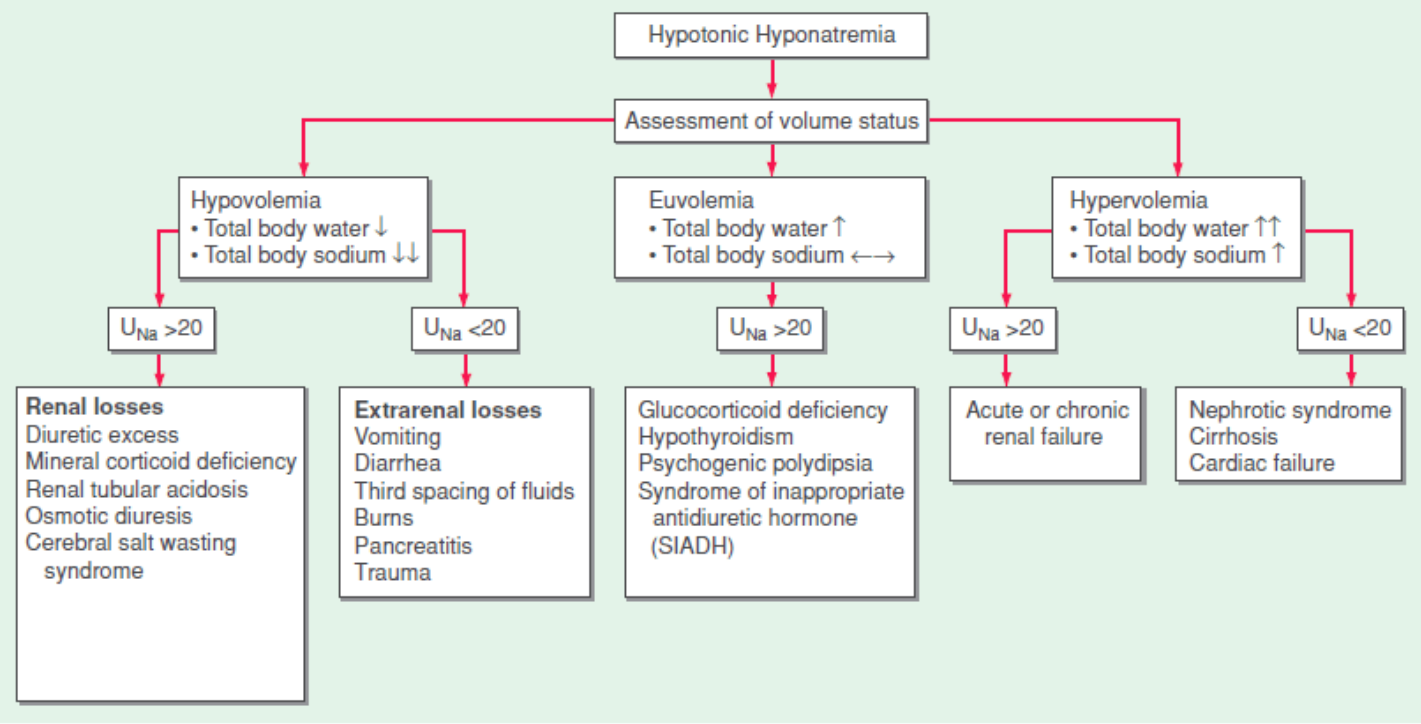
# Osmolalities continued

- Interplay between osmolality / ADH and RAS system
- One way to approach…
  - Serum osmolality should be around 280-295 mmol/L
  - Urine adapts, as low 50 mmol/L and as high as 1200mmol/L
  - Eg: if a 60kg patient ingests 10mmol/kg (usual)
    - 600mmol intake – at 50mmol/L urine output = 12L urine
    - 600mmol intake – 1200mmol/L = 0.5L urine
  - Eg: if only 100mmol ingested
    - 100 mmol intake and 50mmol/L urine output = 2L
    - If patient drinks 3L (water/alcohol) – sodium will fall
      - Not enough solute to make urine and excrete free water

Reference: Curbsiders.com

# Causes

- Classified based on fluid status




(From Kumar S, Berl T. Diseases of water metabolism. In: Schrier RW, ed. *Atlas of Diseases of the Kidney*. Philadelphia, PA: Current Medicine, Inc.; 1999; with permission.)

# SIADH

- MADCHOP?
  - Major surgery: abdominal, thoracic, intracranial
  - ADH production: adenocarcinoma, bronchogenic carcinoma
  - Drugs: antidepressants, psychotrpics, chemotherapy, others
  - CNS disorders: trauma, brain tumour, meningitis, SAH, SLE
  - Hormone deficiencies: hypothyroidism, adrenal insufficiency
  - Others: HIV, GCA, etc.
  - Pulmonary: pneumonia, TB, abscess

Reference: LIFTL

# Management

- Important to establish:
  - Symptomatic vs asympmtomatic
  - Acute versus chronic?
  - Risk of osmotic demyelination syndrome?
    - Less of an issue in acute hyponatremia
    - Sodium at presentation <125, specifically <105 in chronic hyponatremic patients
    - Alcoholism, liver disease, malnutrition

# AJKD Core Curriculum

**Table 1.** Suggested Treatment Strategies for Management of Hyponatremia According to Chronicity, Symptom Severity, and Risk for ODS

| Presentation | Risk for ODS | Goal Increase in $[Na^+]$ | Limit to Increase in $[Na^+]$ | Treatment Strategy |
|---|---|---|---|---|
| **Acute Hypotonic Hyponatremia (duration verified to be <48 h)** | | | | |
| Severe symptoms | Negligible | Rapid increase by 4-6 mEq/L, then gradual increase to normalization | Normalization | Rapidly increase $[Na^+]$ by 4-6 mEq/L with up to three 100-mL boluses of hypertonic saline solution given over 10 min at a time, followed by hypertonic saline solution at 1 mL/kg/h until substantial normalization. If rapid spontaneous correction occurs, it need not be constrained. |
| Mild or moderate symptoms | Negligible | Normalization | Normalization | Fluid restriction alone if cause rapidly reversible. Otherwise, hypertonic saline solution at 1 mL/kg/h until substantial normalization. |
| **Chronic Hypotonic Hyponatremia (duration known to be >48 h or uncertain)** | | | | |
| Severe, moderate, or mild symptoms | High[a] | 4-6 mEq/L in 24 h | 8 mEq/L in any 24-h period | Treatment according to cause (volume repletion for hypovolemic hyponatremia, water restriction with SIADH or hypervolemic hyponatremia, etc) and severity of symptoms. Hypertonic saline solution for severely symptomatic hyponatremia with risk for seizures or herniation or a vaptan or urea for mild to moderate refractory euvolemic or hypervolemic hypematremia. During early phase, closely monitor $[Na^+]$ every 2-4 h and urine output. Re-lower $[Na^+]$ with IV D5W or enteral water ± desmopressin, 1-2 μg, every 6 h if correction over rapid. |
| Severe, moderate, or mild symptoms | Intermediate | 4-8 mEq/L in 24 h | 10-12 mEq/L in any 24-h period and no more than 18 mEq/L in any 48-h period | Same strategy as high-risk ODS patients, except with less strict $[Na^+]$ correction limits. |
| Moderate or mild symptoms | Low (initial $[Na^+]$ > 125 mEq/L) | Normalization | Normalization | Treatment according to cause. Consider vaptan or urea for refractory euvolemic or hypervolemic hypernatremia. |

*Note:* In patients with substantial risk for ODS (especially those with starting $[Na^+]$ < 120 mEq/L) who experience an increase in $[Na^+]$ exceeding the recommended limit, consider re-lowering $[Na^+]$ to a value below target by administration of electrolyte-free water. Urine output and/or osmolality should also be followed to detect onset of a spontaneous water diuresis (especially with volume depletion or thiazide-associated hyponatremia) that can lead to over rapid correction. Desmopressin may be useful in this setting to limit ongoing urinary water loss.

Abbreviations: D5W, 5% dextrose in water; IV, intravenous; $[Na^+]$, serum sodium concentration; ODS, osmotic demyelination syndrome; SIADH, syndrome of inappropriate antidiuretic hormone secretion.

Based on recommendations from Verbalis et al (Diagnosis, evaluation, and treatment of hyponatremia: expert panel recommendations. *Am J Med.* 2013;126(10)(suppl 1):S1-S42).

[a]$[Na^+]$ ≤ 105 mEq/L, hypokalemia, alcoholism, malnutrition, and advanced liver disease.

# Back to our case

- Management considerations:
  - How would you replace sodium / potassium / phosphate / magnesium?
  - Where should this be done and how often would you repeat blood tests?

- Other factors:
  - Fluid overload / diuresis
  - Risk of refeeding
  - Alcohol withdrawal

# Thank you!

Email: arunima.jain@health.nsw.gov.au