EVALUATING AND MANAGING ELECTROLYTE DISBALANCES IN THE OUTPATIENT SETTING

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DISCLOSURE

- There are no conflicts of interest

TO BE DISCUSSED

Homeostasis

- Potassium
- Water

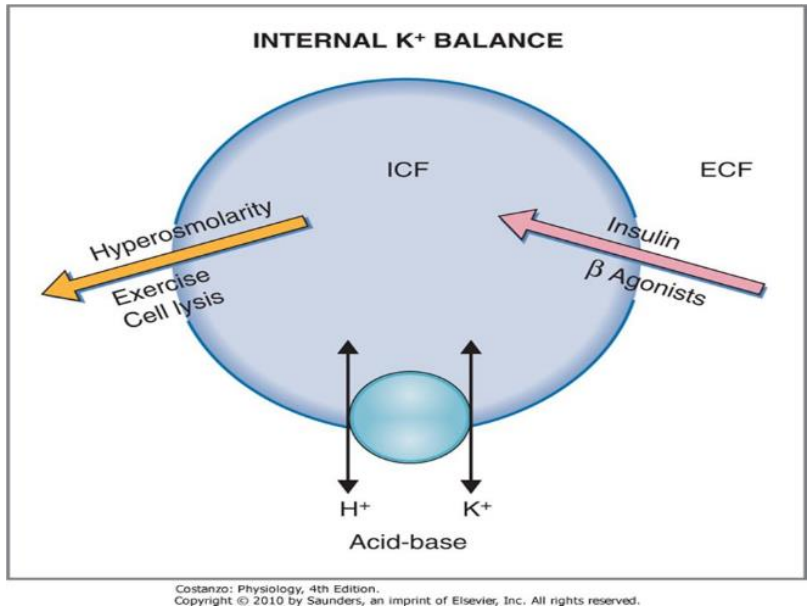
Evaluation and Management of Electrolyte Disbalances

- Hyperkalemia
- Hypokalemia
- Hypernatremia
- Hyponatremia

Summary

DISORDERS OF POTASSIUM BALANCE: HYPERKALEMIA AND HYPOKALEMIA

POTASSIUM HOMEOSTASIS



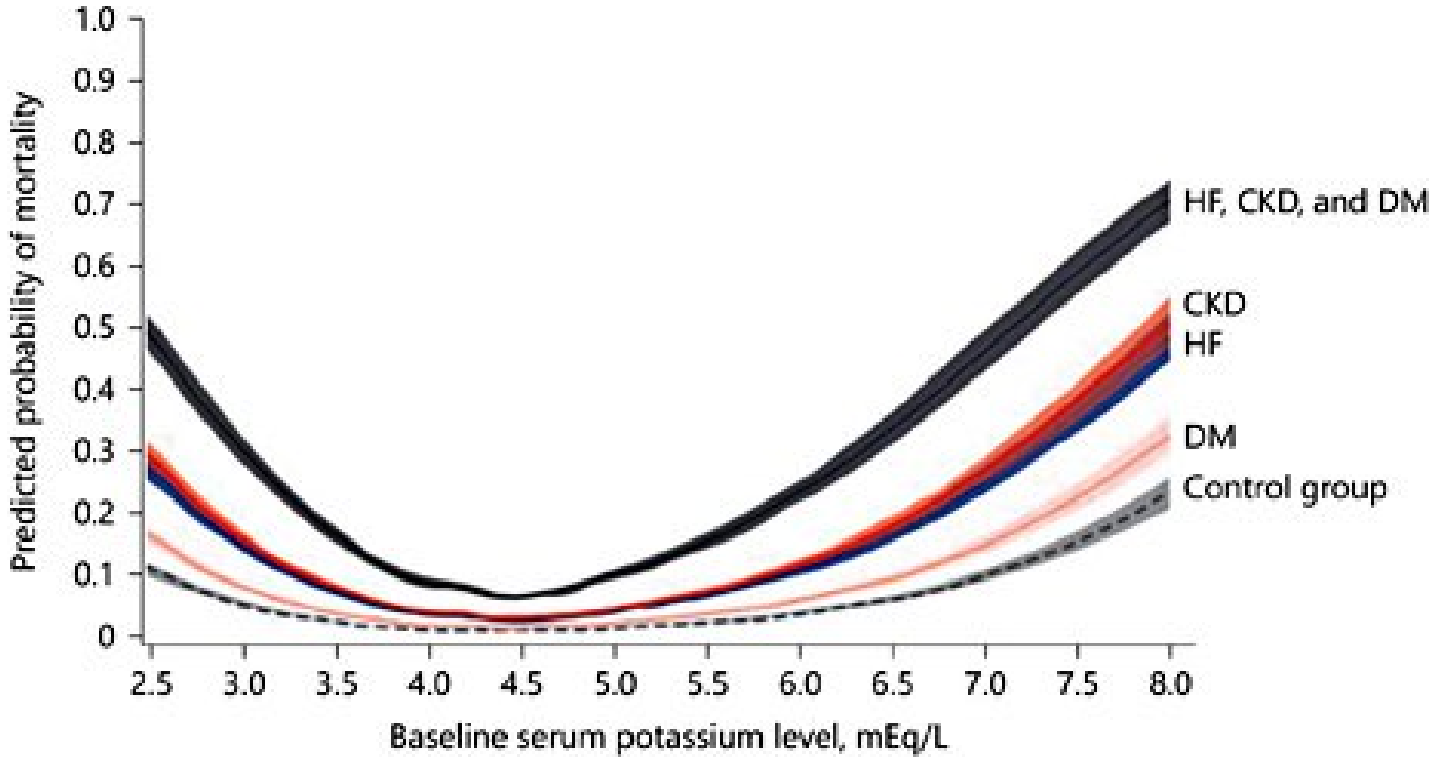
Increase Renal K^+ Excretion

- Aldosterone
- High Na^+ delivery to distal tubule (diuretics)
- High urine flow (osmotic diuresis)
- High serum K^+ level
- Delivery bicarbonate to distal tubule

Decrease Renal K+ Excretion

- Absence, or very low aldosterone
- Low Na^+ delivery to the distal tubule
- Low urine flow
- Low serum K^+ level
- Kidney Injury

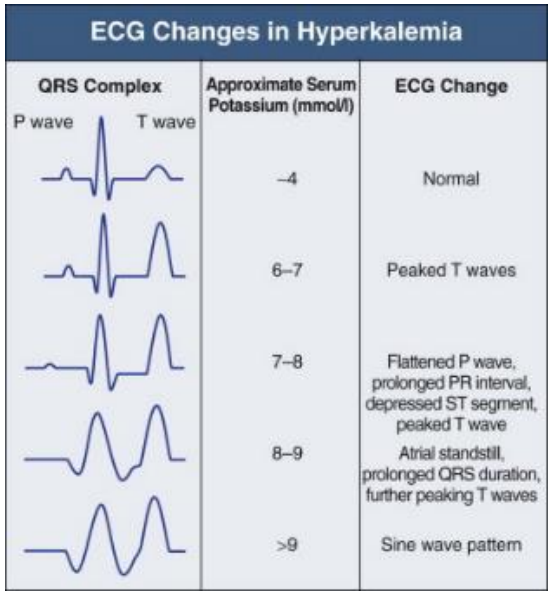
MORTALITY IN DYSKALEMIA



Collins et al Am J Nephrol 2017;46:213-

HYPERKALEMIA

MY PATIENT HAS HYPERKALEMIA, WHAT SHOULD I DO?



ECG Changes in Hyperkalemia

QRS Complex (P wave, T wave)	Approximate Serum Potassium (mmol/l)	ECG Change
	~4	Normal
	6–7	Peaked T waves
	7–8	Flattened P wave, prolonged PR interval, depressed ST segment, peaked T wave
	8–9	Atrial standstill, prolonged QRS duration, further peaking T waves
	>9	Sine wave pattern

EKG and BMP

- Changes? Treat

H&P and medication review

- Symptoms? Treat

- Send home

Pseudohyperkalemia

Check other causes

- Metabolic acidosis
- Obstruction
- Hyperosmolarity
- K^+ increasing meds
- CKD

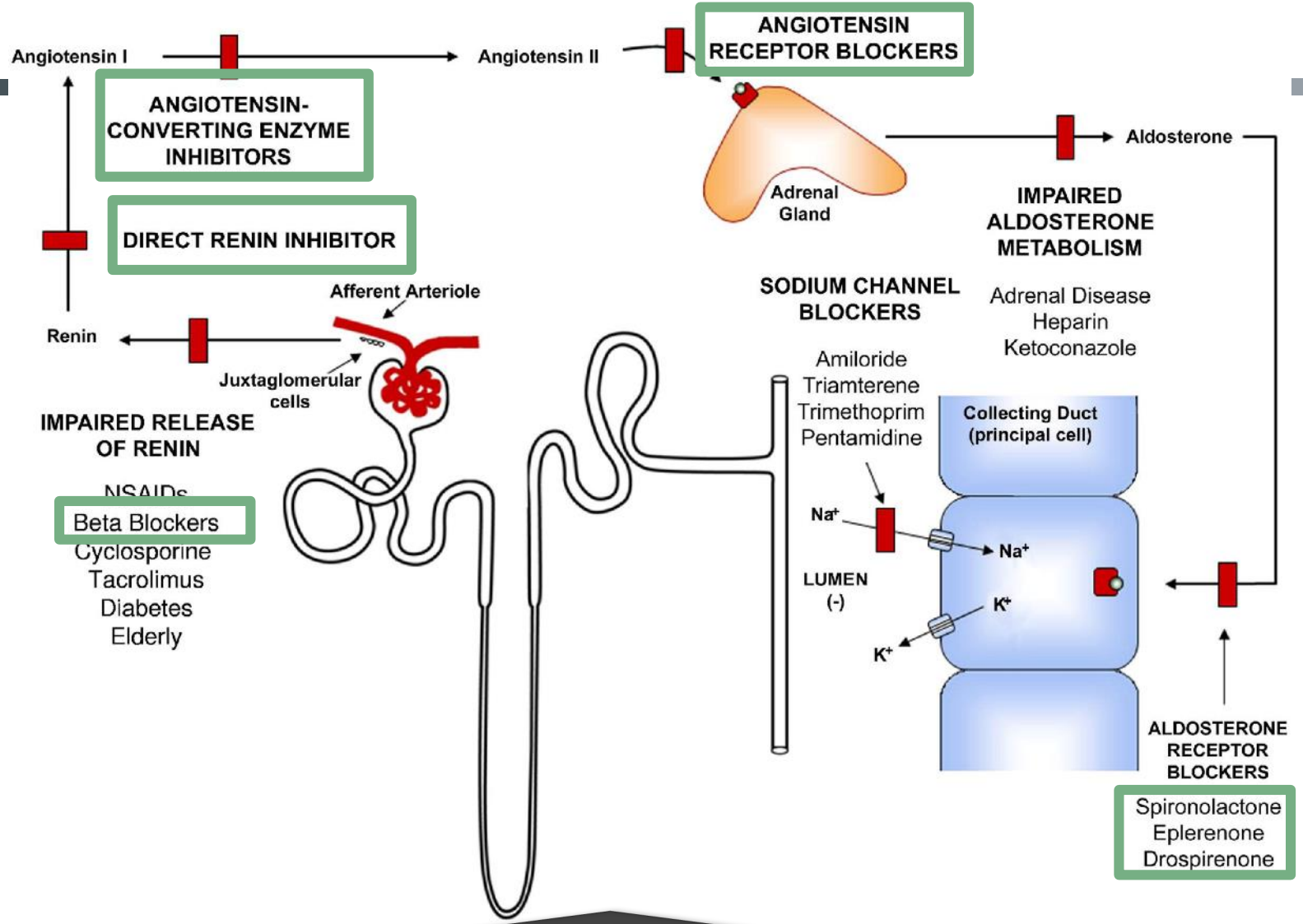
CAUSES OF HYPERKALEMIA

Increased potassium release from cells

- Pseudohyperkalemia
  - Fist clenching
  - Tourniquet use
- Metabolic acidosis
- Insulin deficiency, hyperglycemia, and hyperosmolality
- Increased tissue catabolism
- Drugs
- Hyperkalemic Periodic Palasysis

Reduced urinary potassium excretion

- Acute and chronic kidney disease
- Reduced aldosterone secretion or response to aldosterone
- Reduced distal sodium and water delivery
- Drugs



Biff Palmer A Physiologic-Based Approach to the Evaluation of a Patient with Hyperkalemia *2010 AJKD*

Medications That Cause HK

MANAGEMENT OF ACUTE HYPERKALEMIA

Medication	Onset	Duration	MoA	Comments
Calcium Gluconate 1g/3min	1-2 min	30-60 min	Protect cardiomyocytes	Does not decrease K^+ May have to repeat
RegInsulin 10u IV + Dextrose 50% 50ml (if CBG <250mg/dl)	10-30 min	4-6 hrs	Shifts K^+ into cells	Check CBG q30min for 4 hrs, especially if CKD
Inhaled Albuterol, 10-20mg	30 min	2-4 hrs	Shifts K^+ into cells	Usual albuterol dose is 1.25mg or 2.5mg
Furosemide	>30 min	2-6 hrs	Kaliuresis	2x Cr rule, use with 0.9%NSS
Hemodialysis	Minutes	Permanent	Removal	May be delayed
Exchangers?	1 hour to days	Permanent?	Remove via GI tract	None approved for acute management

MANAGEMENT OF HYPERKALEMIA IN THE OUTPATIENT SETTING

Diuretics

- Loops (Furosemide, bumetadine, torsemide)
  - For patients with CKD, CHF
- Thiazides (Chlorthalidone (preferred), indapamide, hydrochlorothiazide)

Ion-exchange polymers

Sodium Polystyrene Sulfonate (Kayexalate®)?

Patiromer (Veltassa®)

Sodium Zirconium Cyclosilicate (Lokelma®)

Others

Bicarbonate

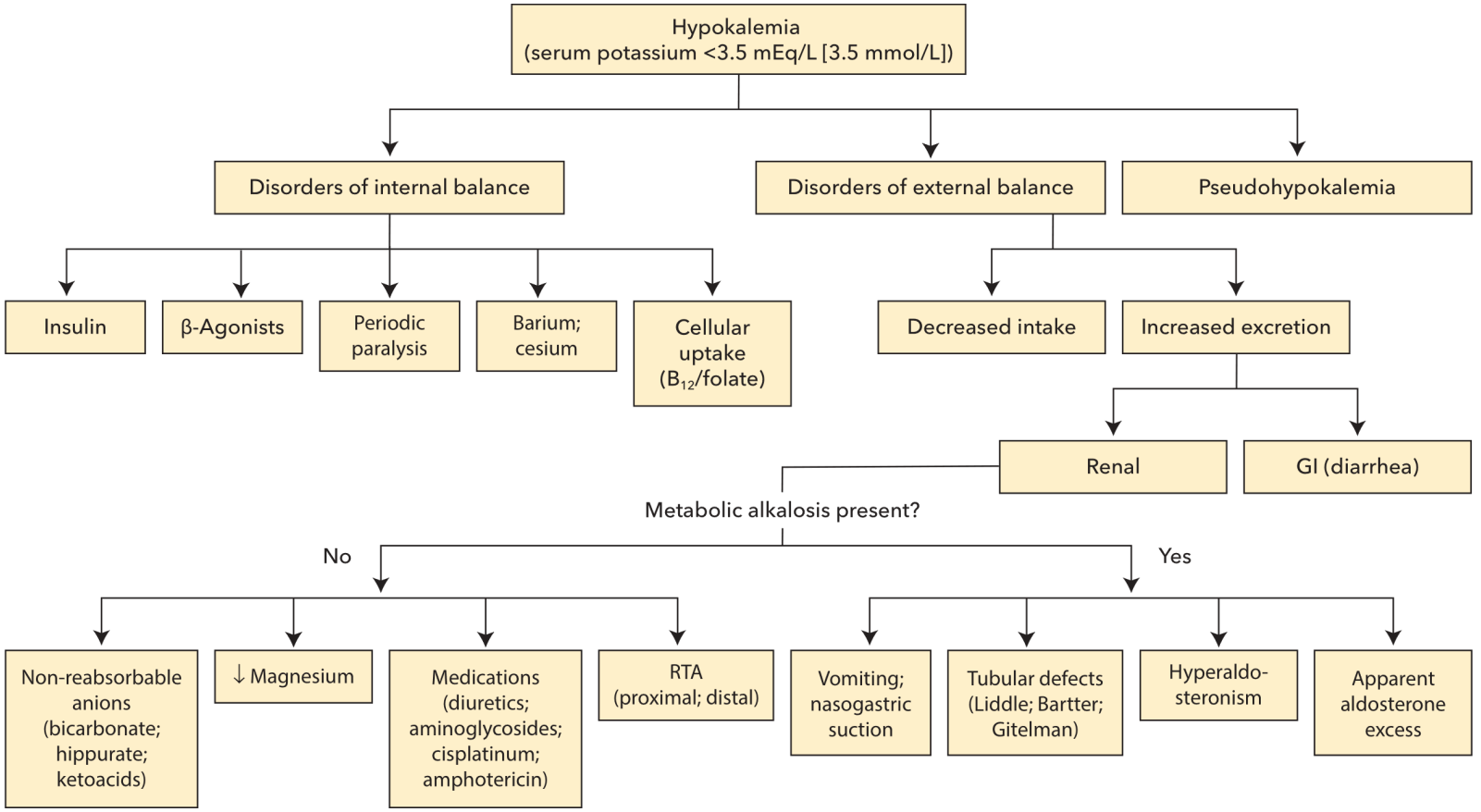
Fludrocortisone

Limiting potassium intake?

Discontinue medications?

	Kayexalate® sodium polystyrene sulfonate, USP	Veltassa® (patiromer) for oral suspension	LOKELMA™ (sodium zirconium cyclosilicate) 10 g for oral suspension
FDA Approval	1958	2015	2018
MoA: Exchange	Na^+ for K^+	Ca^{2+} for K^+	Na^+/H^+ for K^+
Na^+ Content	1,500mg per 15g	N/A	800mg per 10g
Onset	Hours to days	7 hours	1 – 2.2 hours
Dosing	15-60g 1-4x QD	8.4g QD (max TID)	10g TID (for 48 hrs) then 10g QD
Side Effects	GI (nausea, vomiting, constipation) Severe: GI necrosis, obstruction, perforation	GI (constipation) Hypomagnesemia Hypercalcemia?	GI (diarrhea) Edema
Administration	Liquid or Powder Separate other meds by 3 hours	Mix powder with 90ml of water Separate other meds by 3 – 6 hours	Mix powder with 45ml of water Separate other meds by 2 hours
Cost	$	$$$	$$$
Storage	Room temperature	Refrigerator (2-8 °C)	Room Temperature
Advantages	Cost and availability	No sodium	Less GI issues, Onset
Disadvantages or concerns	Lack of randomized trials Severe GI AEs High sodium content	Hypomagnesemia Potential for DDIs Must be refrigerated	Availability High sodium content
FDA	No	No	No

HYPOKALEMIA



MY PATIENT HAS HYPOKALEMIA, WHAT SHOULD I DO?

History and Physical, medication review

- GI/skin loss, meds, workplace

CBC, BMP

- Leukocytosis, acid-base, magnesium

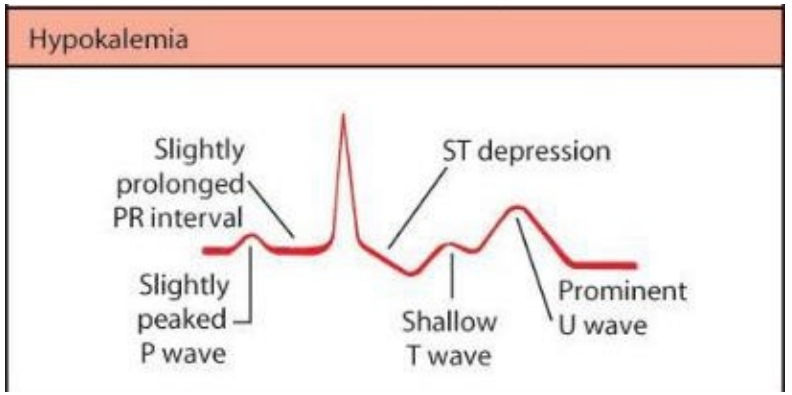
Urinary K^+

- >20mmol/24h – meds, RTA, others
- <20mmol/24h – Poor intake, GI loss

Blood Pressures

- Elevated – plasma aldosterone, renin activity and cortisol
- Low – Bartter, Gitelman, diuretics

MANAGEMENT OF HYPOKALEMIA



- Weakness or paralysis, decreased GI motility

If symptoms or EKG changes, send to ER

Hypomagnesemia

- Treat

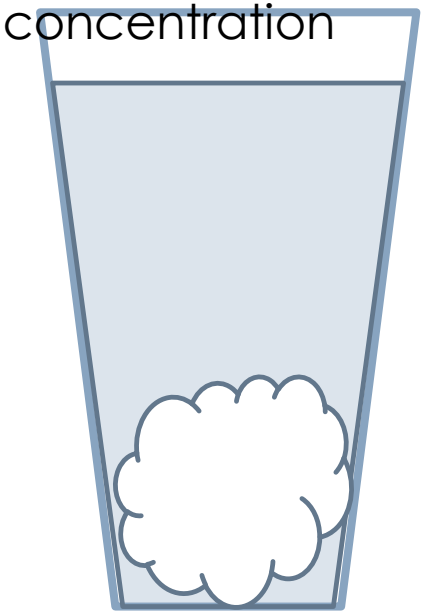
- Discontinue offending meds
- Replenish

If >2.5mEq/L

>2.5mEq/L

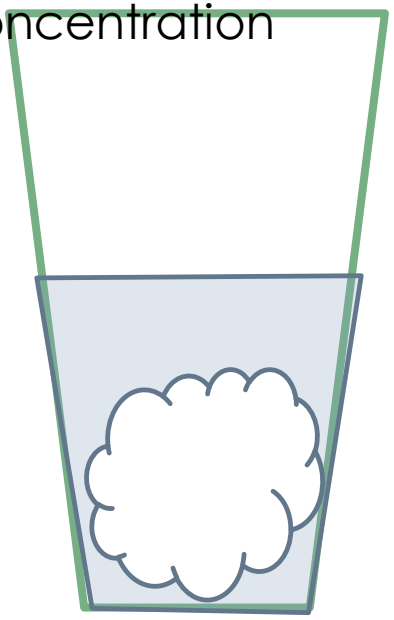
Oral route preferred	KCL 40mEq Liquid	Tablet – risk of pill esophagitis	Potassium citrate if metabolic acidosis	Meds that increase serum K^+

Low salt concentration



DISORDERS OF WATER BALANCE: HYPERNATREMIA AND HYPONATREMIA

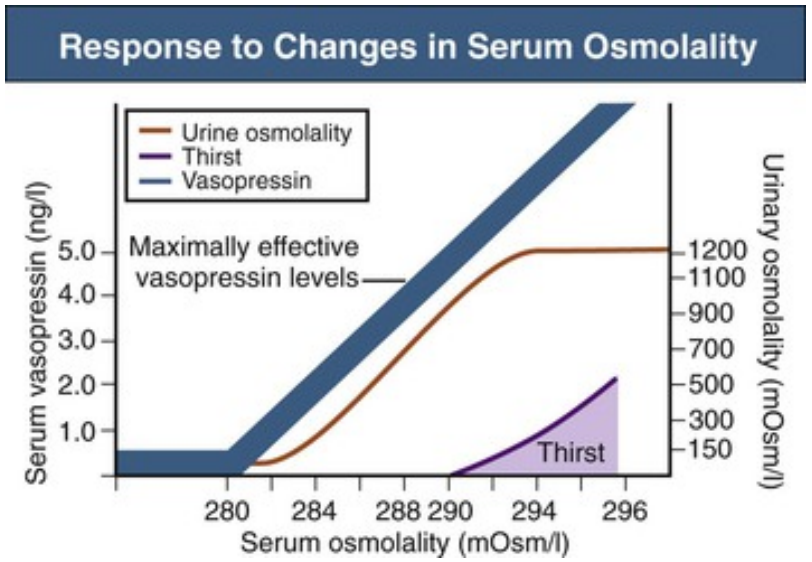
High salt concentration

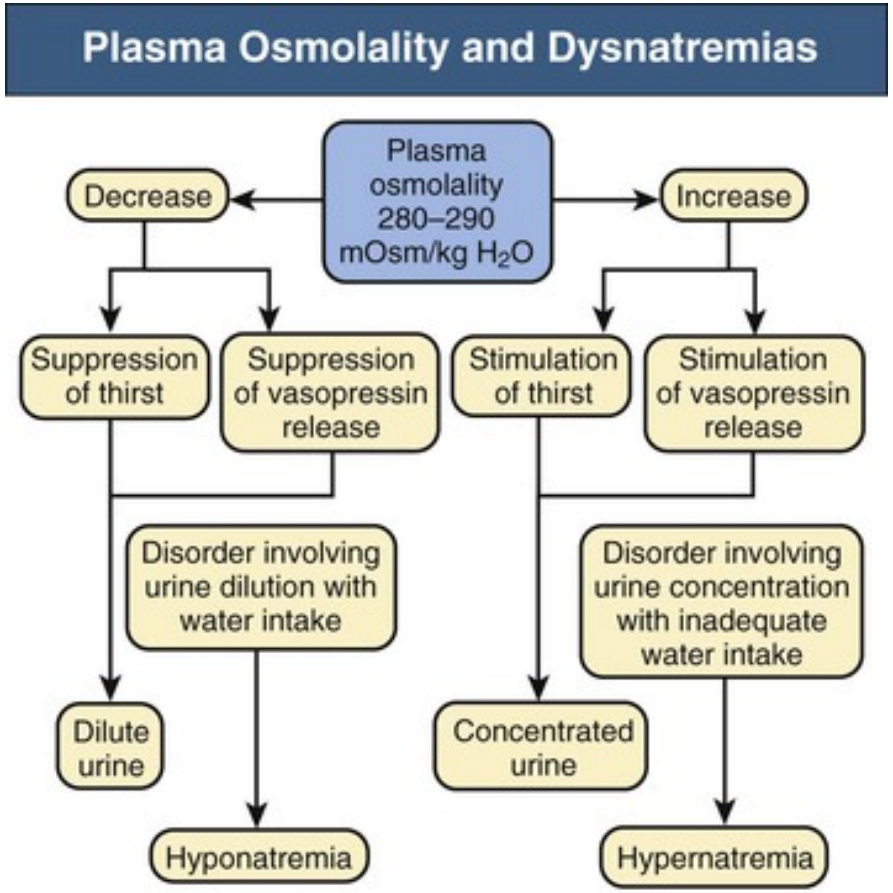


WATER HOMEOSTASIS

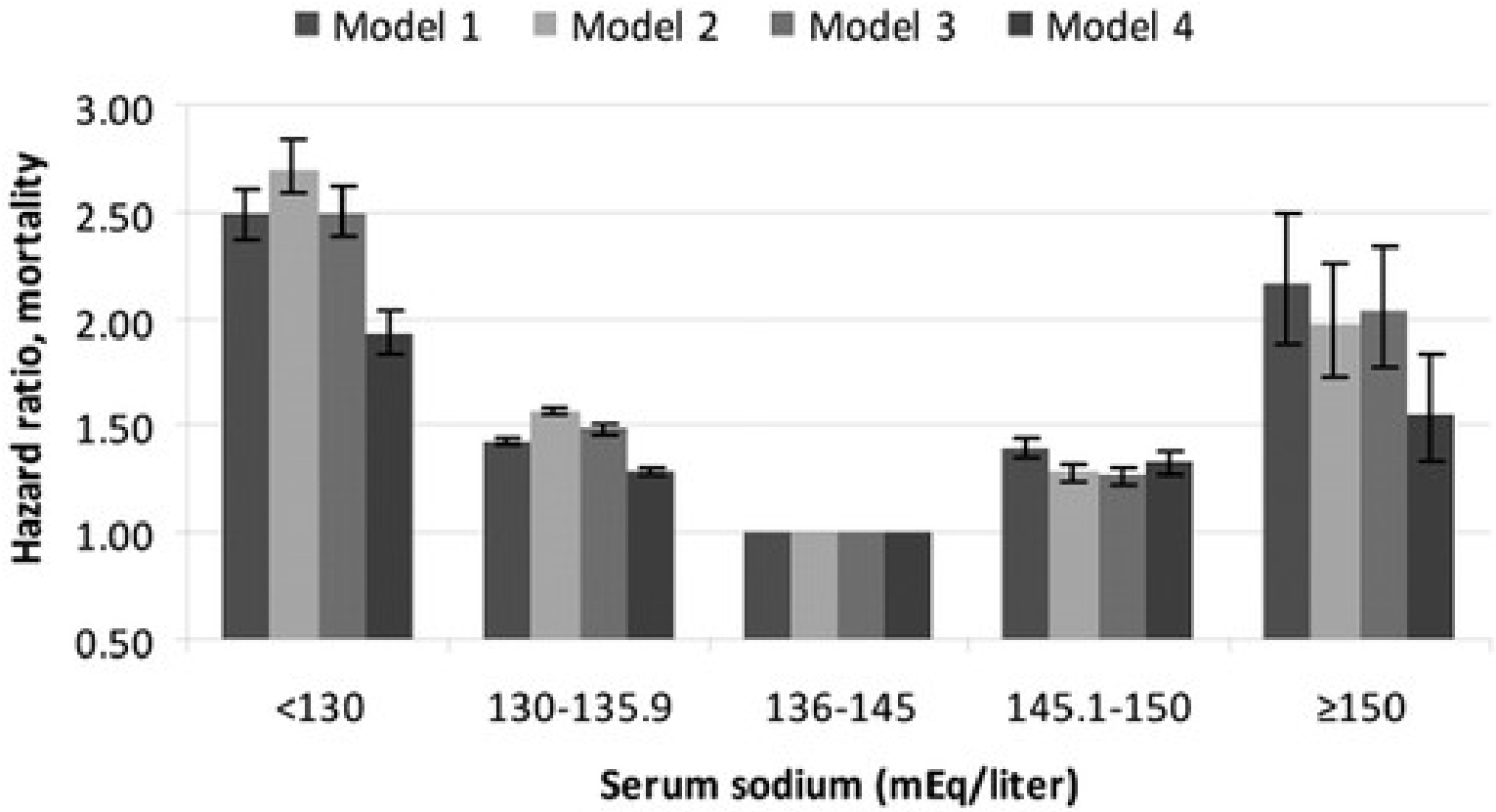
Vasopressin (ADH) controls water excretion in collecting system

Osmoreceptors in hypothalamus control vasopressin secretion in response to changes in tonicity

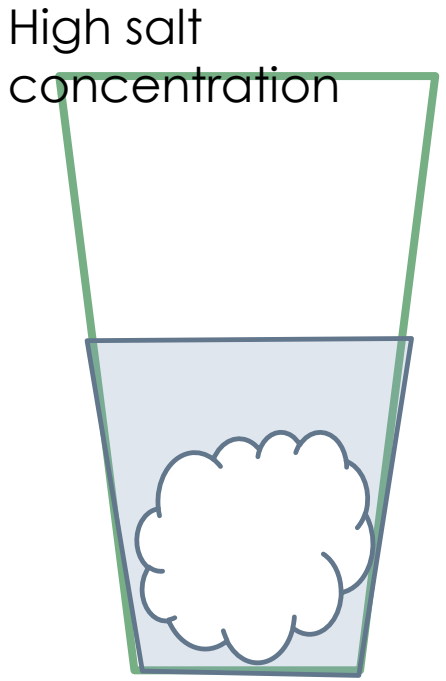




MORTALITY IN DYSNATREMIAS



HYPERNATREMIA



History and physical examination, medication review

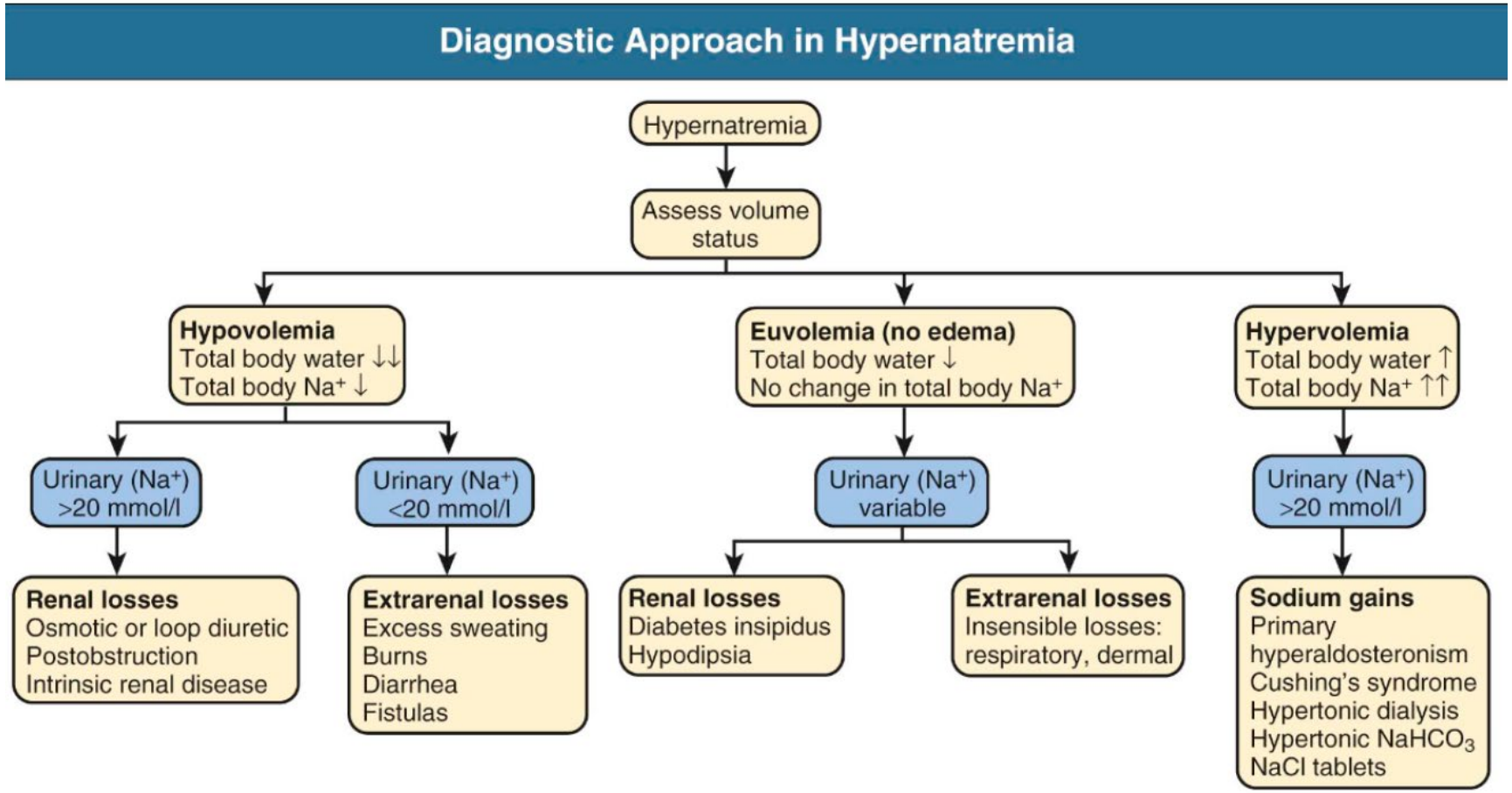
Volume Status

Vitals

Spot urine electrolytes and osmolality

Water deprivation test

MY PATIENT HAS HYPERNATREMIA , NOW WHAT?



HYPERNATREMIA

The Journal of Emergency Medicine, Vol. 45, No. 2, pp. 228–231, 2013

0736-4679/$ - see front matter

http://dx.doi.org/10.1016/j.jemermed.2012.11.109

ELSEVIER

Selected Topics: Critical Care

SURVIVAL OF ACUTE HYPERNATREMIA DUE TO MASSIVE SOY SAUCE INGESTION

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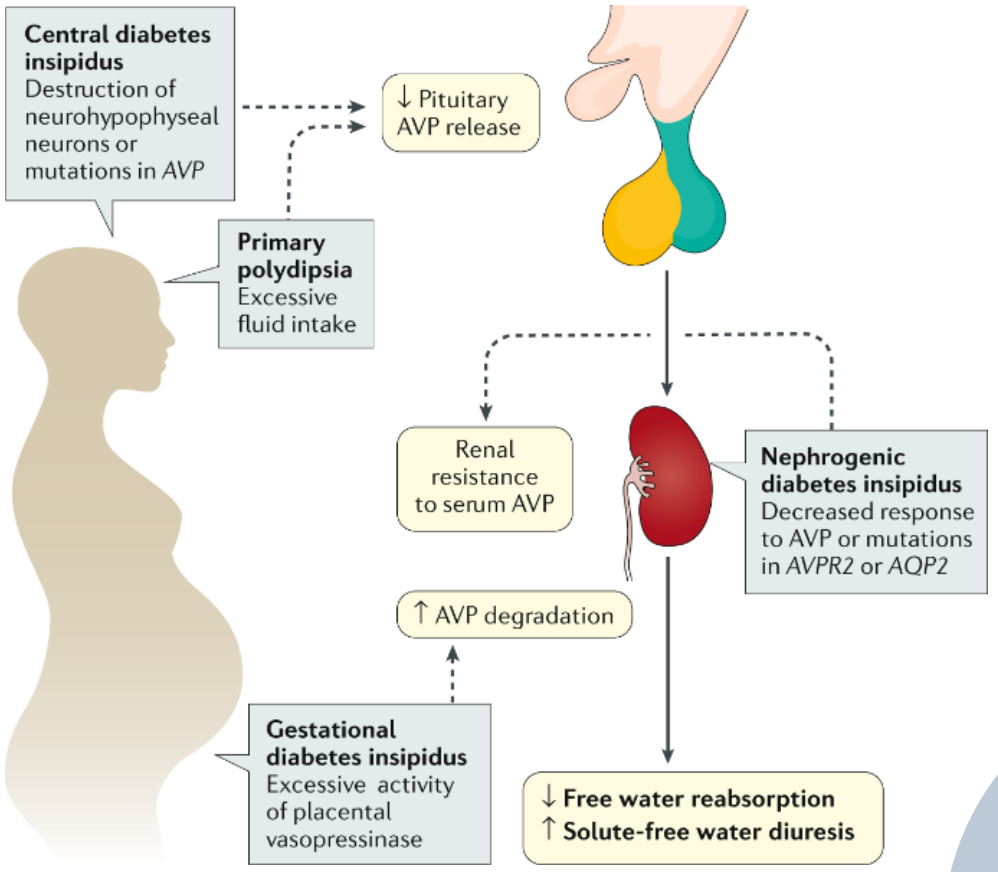
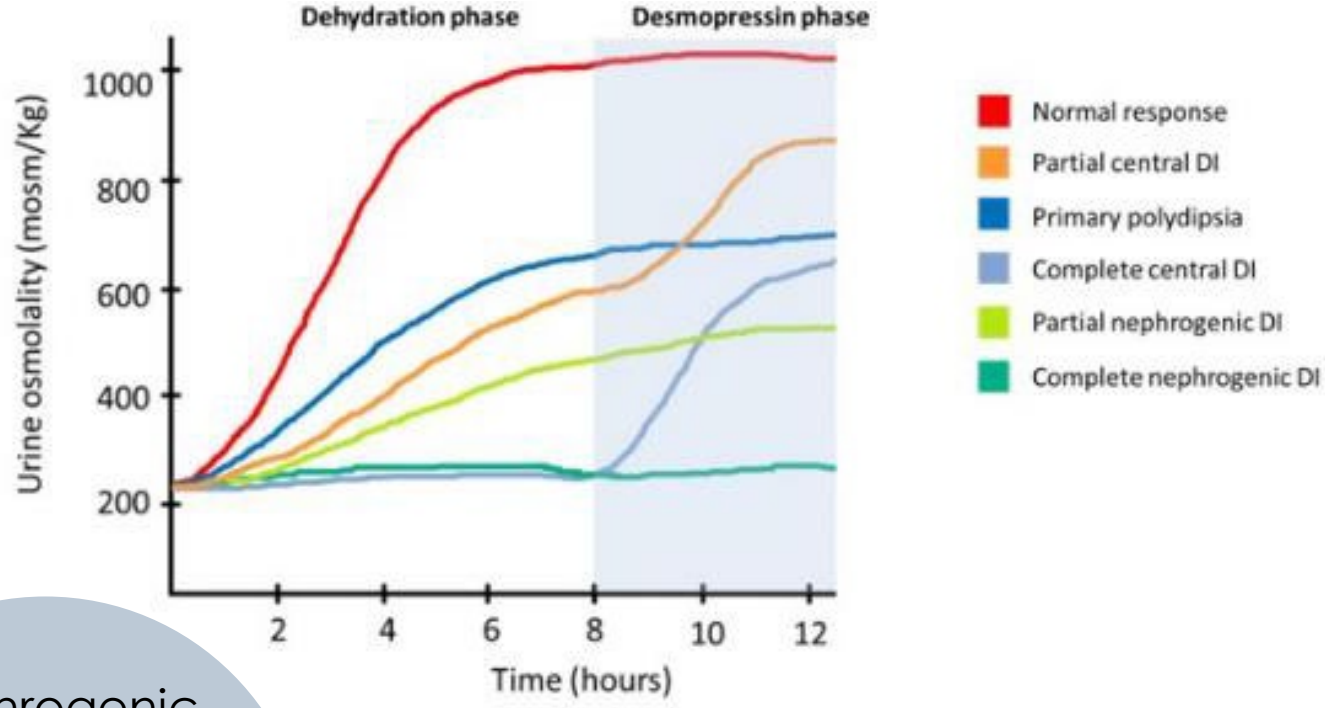
☐ **Abstract—Background: Intentional massive sodium chloride ingestions are rare occurrences and are often fatal. Objectives: There are a variety of treatment recommendations for hypernatremia, ranging from dialysis to varying rates of correction. We report a case of acute severe hypernatremia corrected with rapid free-water infusions that, to our knowledge, has not been previously reported. Case Report: A 19-year-old man presented to the Emer-**

associated iatrogenic morbidity and mortality (1,2). Other iatrogenic causes of acute hypernatremia include incorrect dilution of oral rehydration solution, as well as hypertonic intravenous fluids, enemas, gastric lavage, and peritoneal lavage (1,3–5). Acute sodium chloride poisoning in adults generally occurs as a suicide attempt in the setting of mental or emotional disorders (2).

1qt ~ 946ml
15ml Soy Sauce ~ 950mg Na+
He drank 59,850mg of sodium!

DIABETES INSIPIDUS

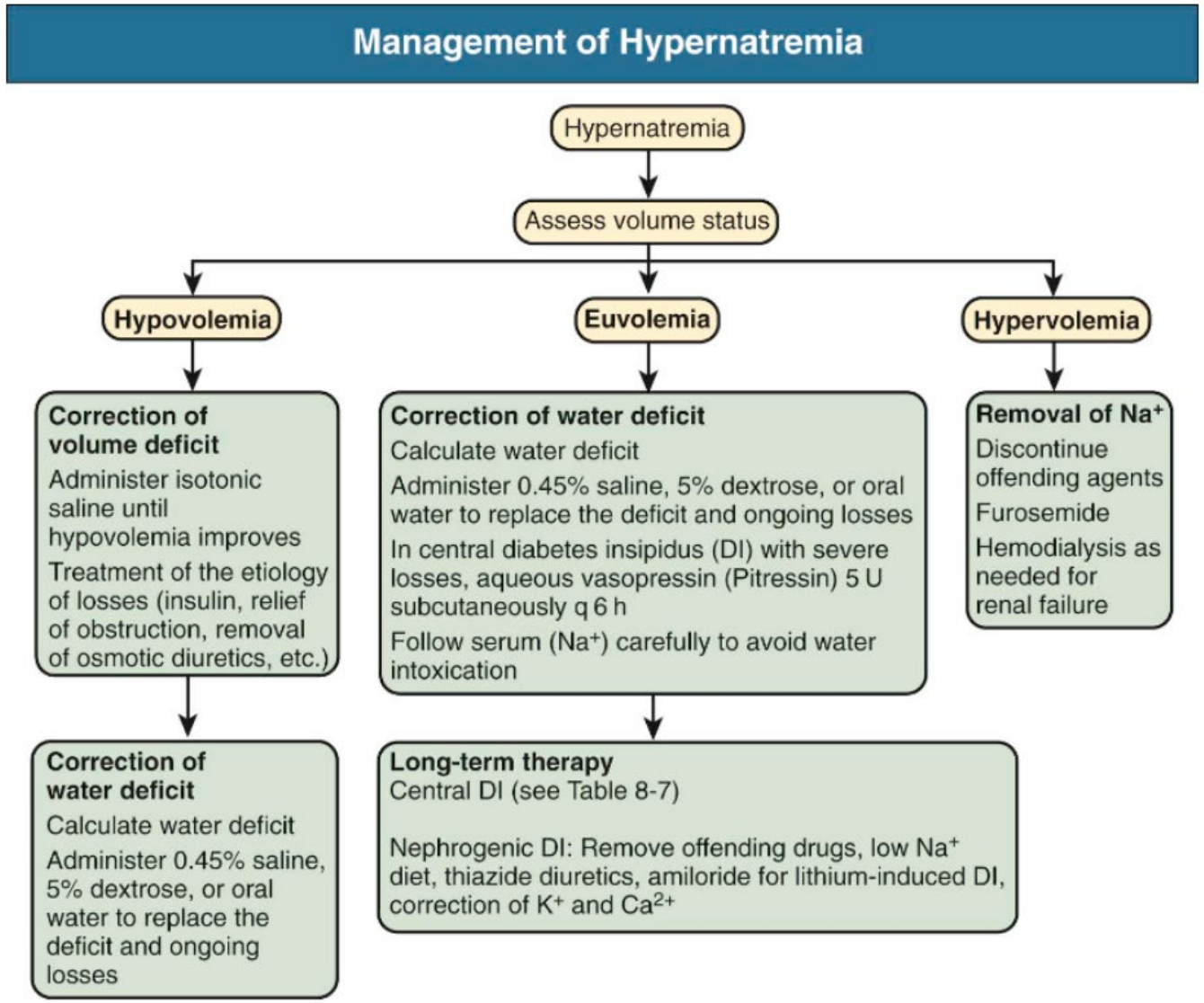




Nephrogenic DI:

- CKD
- Hypokalemia
- Hypercalcemia
- Meds
- Pregnancy

MANAGEMENT OF HYPERNATREMIA

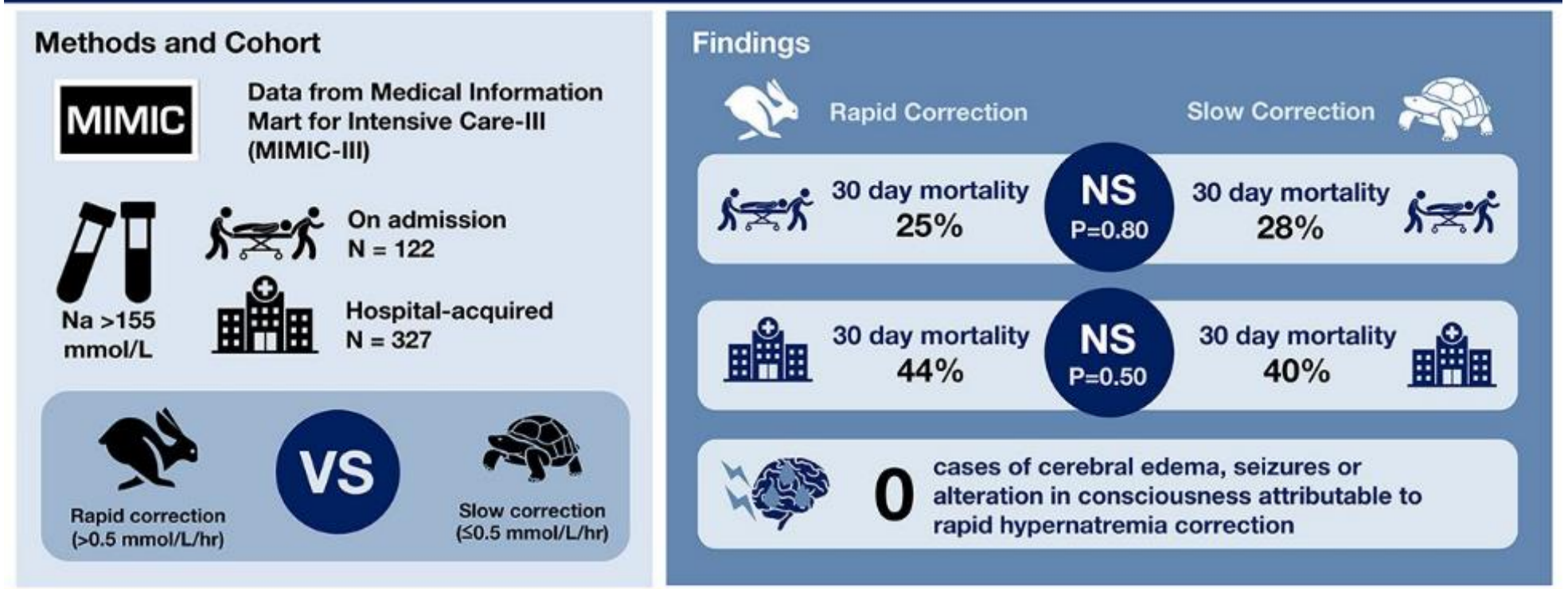


***Free Water Deficit

Change in serum sodium per L of infusate: (Infusate Sodium) – (Serum Sodium) / (TBW + 1)

Is the rate of correction of hypernatremia associated with clinical outcomes?

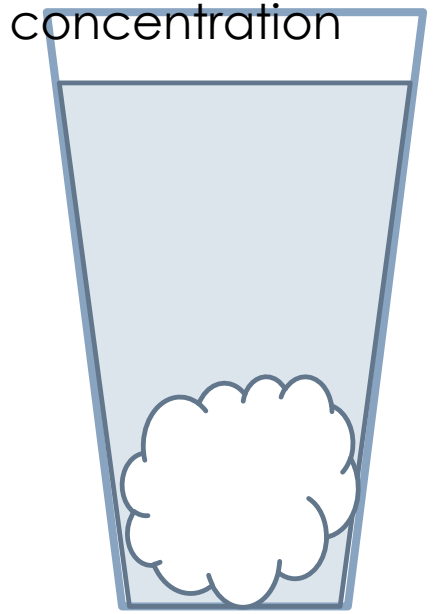
CJASN
Clinical Journal of American Society of Nephrology



Conclusions Rapid correction of hypernatremia was not associated with a higher risk for mortality, seizures, alteration of consciousness and/or cerebral edema in critically ill adults with either admission or hospital-acquired hypernatremia.

Kinsuk Chauhan, Pattharawin Pattharanitima, Niralee Patel, Aine Duffy, et al. ***Rate of Correction of Hypernatremia and Health Outcomes in Critically Ill Patients.*** CJASN doi: 10.2215/CJN.10640918. **Visual Abstract by Michelle Lim, MBChB**

HYPONATREMIA

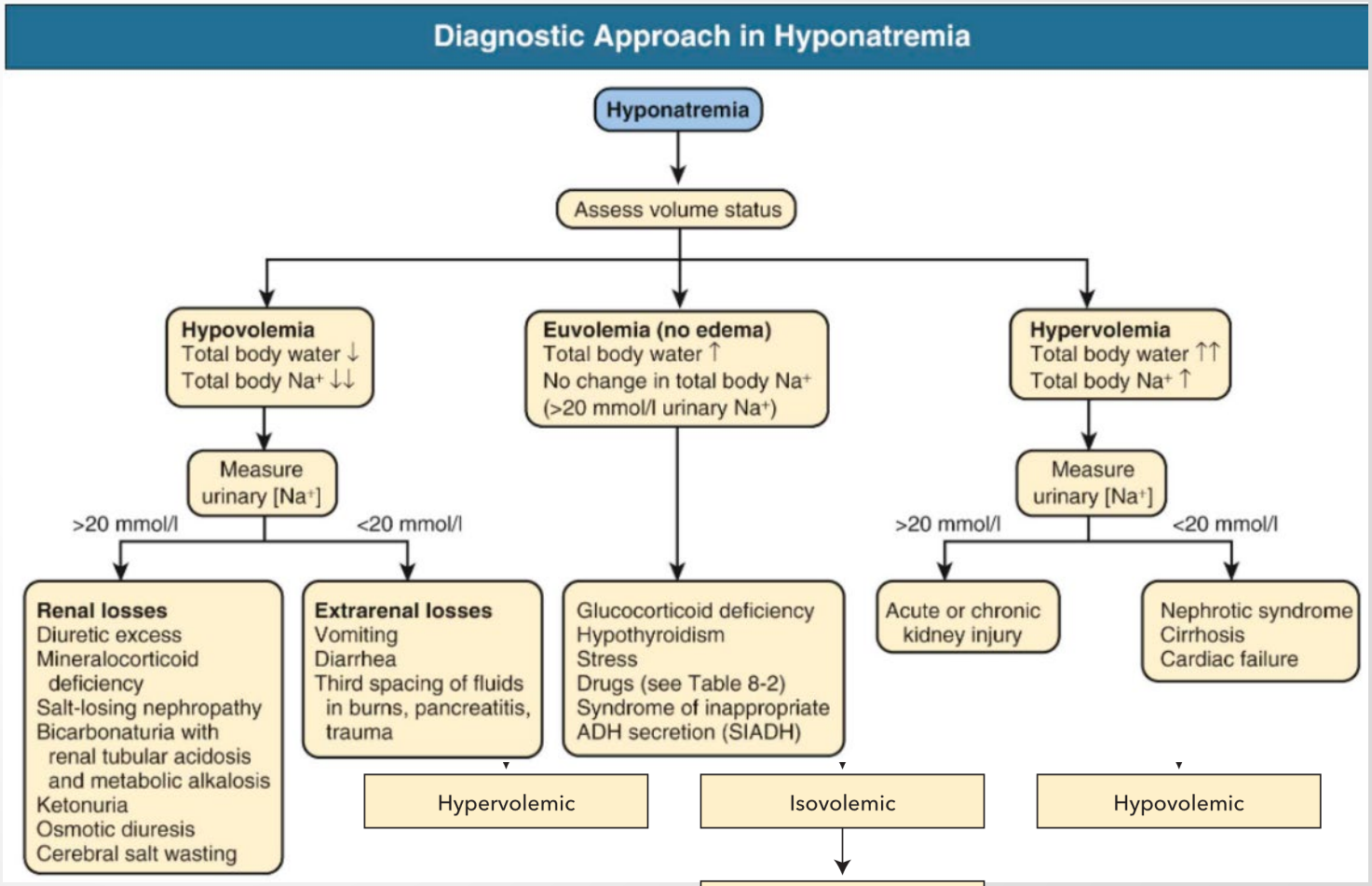


MY PATIENT HAS HYPONATREMIA, WHAT SHOULD I DO?

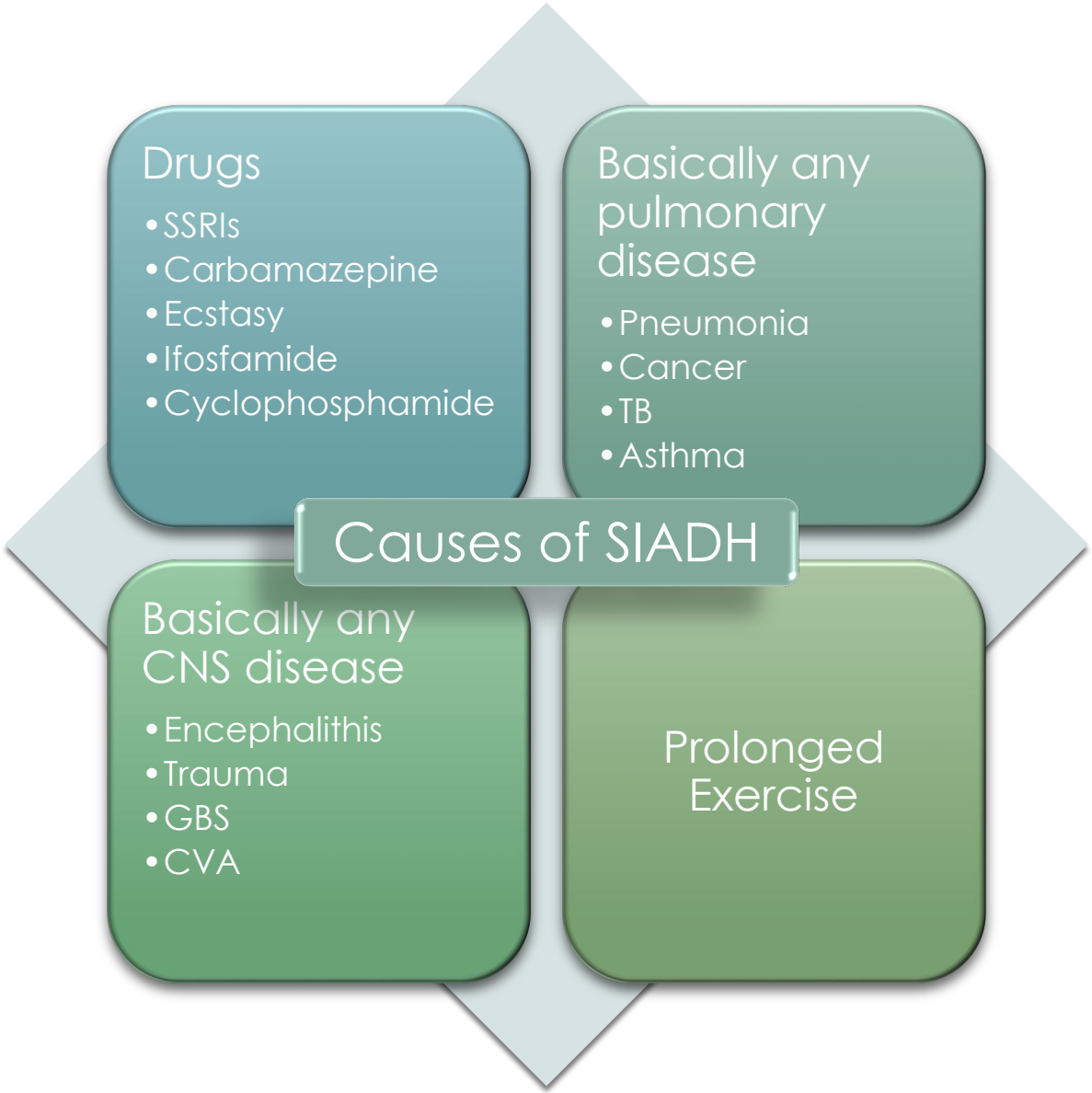
History and Physical Exam and Medication Review

Serum Osmolality

- Hypertonic, usually hyperglycemia → 100mg/dl Glu ↑Na^+ by 1.6-2.2
- Isotonic – PseudohypoNa^+ → Severe hypertriglyceridemia or MM
- Hypotonic
  - Volume status
  - History
  - Urinalysis
  - Urine sodium



Osm = 2 [Na+] + Glucose + BUN + Other osmoles


Causes of SIADH
Drugs
•SSRIs
•Carbamazepine
•Ecstasy
•Ifosfamide
•Cyclophosphamide
Basically any pulmonary disease
•Pneumonia
•Cancer
•TB
•Asthma
Basically any CNS disease
•Encephalithis
•Trauma
•GBS
•CVA
Prolonged Exercise

HYPONATREMIA TREATMENT

Symptomatic

- Acute (<48 h)
  - Hypertonic Saline (3%) @ 1-2ml/kg/h or a 100mL bolus for resolution of symptoms
- Chronic (>48 h)
  - High risk for complications (CPM)
  - Hypertonic saline (3%) at 1-2ml/kg/hr but not > 8-10mEq/L/24hrs
    - Can add D5W or DDVAP lock
  - If potassium is replaced, this will also increase plasma sodium

Asymptomatic

- Review for reversible causes
- Fluid restriction
- Tolvaptan
- Increased salt intake (salt tablets)
- Oral Urea
- SGLT 2 inhibitors?

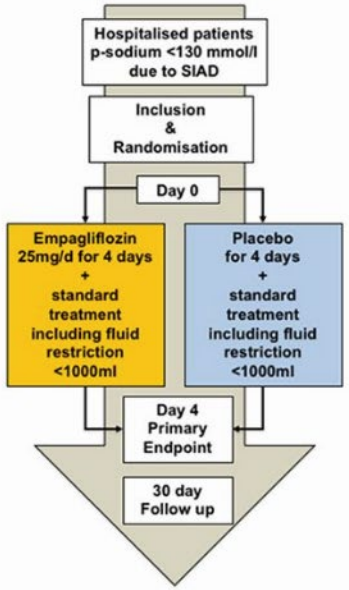
OUTPATIENT TREATMENT OF EUVOLEMIC HYPONATREMIA

Treatment of Chronic Asymptomatic Hyponatremia				
Treatment	**Mechanism of Action**	**Dose**	**Advantages**	**Limitations**
Fluid restriction	Decreases availability of free water	<800ml-1,000ml/day	Effective and inexpensive; not complicated	Noncompliance
Pharmacologic Inhibition of Vasopressin Action				
Lithium	Inhibits kidney's response to vasopressin	900-1,200 mg/day	Unrestricted water intake	Polyuria, narrow therapeutic range, toxicities
Demeclocycline	Inhibits kidney's response to vasopressin	300-600 mg twice daily	Effective; unrestricted water intake	Neurotoxicity, polyuria, photosensitivity, nephrotoxicity
Tolvaptan	Antagonizes vasopressin action	15mg-60mg/day	Addresses underlying mechanisms	Limited clinical experience Very expensive Limited to 1 month of therapy Liver toxicity
Increased Solute (Salt) Intake				
With furosemide	Increases free water clearance	Titrate to optimal dose; coadminister 2-3 g NaCl	Effective	Ototoxicity, K^+ depletion
With urea	Osmotic diuresis	30-60 g/day	Effective; unrestricted water intake	Polyuria, unpalatable, gastrointestinal symptoms

SGLT2 INHIBITORS???

Empagliflozin increases plasma sodium levels in patients with the syndrome of inappropriate antidiuresis (SIAD)

METHODS

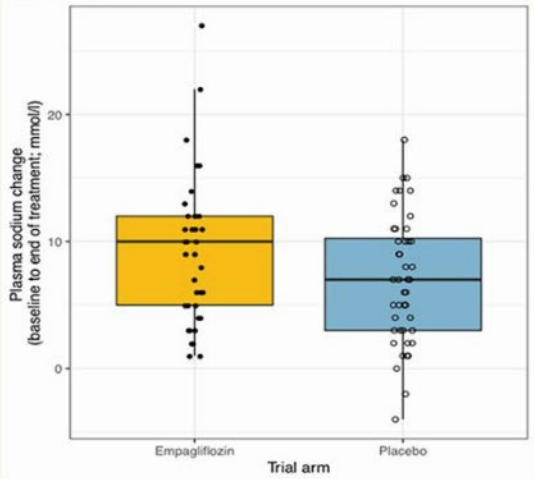


Median (IQR) increase p-sodium in mmol/l:

Empagliflozin 10 (5,10)

Placebo 7 (3,11)

OUTCOME



CONCLUSION Empagliflozin in addition to fluid restriction leads to a higher increase in plasma sodium levels compared to placebo in hospitalized patients with SIAD.

doi: 10.1681/ASN.2019090944

JASN
JOURNAL OF THE AMERICAN SOCIETY OF NEPHROLOGY

SUMMARY

- Overall, the most important clues that will lead you to a diagnosis are in the history, physical exam and medication review
- Any patient with concerning or severe symptoms or severe electrolyte disbalance, send to an ER
- Hyperkalemia
  - Limits use of many beneficial agents, maybe with new binders we can improve outpatient management
- Hypokalemia
  - Urine electrolytes will help distinguish between renal and non renal losses

SUMMARY

- Hypernatremia
  - Most common cause of hypernatremia is loss of hypotonic body fluids with inadequate water replacement because of lack of access or adipsia
  - Oral hydration is preferred method for treatment
- Hyponatremia
  - The most helpful in differential diagnosis is volume status
  - SGLT2 inhibitors may help with chronic SIADH


Thank
you!!!

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