Common electrolyte disturbances

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Faculty/Presenter Disclosure

- **Faculty:** Andrea Mazurat

- **Relationships with commercial interests:**
  None

Objectives

1. Identify common electrolyte abnormalities seen in the outpatient setting
2. Initial approach to common electrolyte abnormalities in the outpatient setting
3. Management of common electrolyte abnormalities in the outpatient setting

4. **Identify common manifestations of electrolyte disturbances and formulate a strategy for logical investigations and treatment options**

A QUICK NOTE

- Tried to make everything a practical/clinical approach to outpatient electrolyte abnormalities

- Included algorithms (as a resource)

Common electrolyte disorders

- Hyponatremia
- Hypernatremia
- Hyperkalemia
- Hypokalemia

Common electrolyte disorders

- **Hyponatremia**
- Hypernatremia
- Hyperkalemia
- Hypokalemia

Hyponatremia

- Serum sodium <135 mmol/L
- The level of serum sodium correlates inversely with clinical risk
  - Levels <120 mmol/L considered "severe"
- Can be classified as acute (<48 hours) *vs* chronic and symptomatic *vs* asymptomatic
- Prevalence ranges from 7% in ambulatory populations up to 38% in acutely hospitalized patients
- Clinically important because:
  - Acute severe hyponatremia can cause substantial morbidity and mortality

Adrogue, H. *J Am Soc Nephrol*. 2012 Jul; 23(7): 1140-8

Acute hyponatremia

- Acute “severe” hyponatremia or acute on chronic hyponatremia that is symptomatic **will not** be discussed here
  - The level that is dangerous depends on:
  - The baseline sodium
  - Rate of change (<48 hours vs slow increase)
  - Clinical status

- Can cause an increase in the intracranial pressure and lead to brain herniation = medical emergency

- Needs to be managed in an inpatient setting
  - Rate of correction should not exceed 8 mmol/L per 24 hours

What I will be focusing on

- Bloodwork done in an asymptomatic patient and sodium comes back low
  - Serum Na between 130-135 mmol/L
  - Approach to diagnosis and treatment (if any) in the outpatient setting

- Most of the literature is focused on inpatient management
- Very little data to guide mild hyponatremia and outpatient management

Signs and symptoms

- **Asymptomatic**
- Nausea, vomiting
- Headache
- Diploplia
- Falls
- Seizures
- Coma
- Cerebral edema
- Osmotic demyelination (during treatment)

Serum sodium vs volume status

- Serum sodium reflects the **concentration** of sodium (mmol) per liter of extra cellular fluid

- Volume status reflects the *total body* sodium content
  - In hyponatremia, there is a relative excess of fluid compared to sodium

Volume status in hyponatremia

- Hypovolemic: Sodium and water loss, but relatively more depleted in sodium
- Euvolemic: Total body sodium normal, but excess free water
- Hypervolemic: Excess total body sodium and water, but relatively more water than sodium

Most common causes of hyponatremia

- Hypovolemic:
  - Diuretics
  - GI losses
- Euvolemic:
  - SIADH
- Hypervolemic:
  - Chronic kidney disease
  - Cardiac disease
  - Liver failure

Recommended testing

Serum creatinine
Serum glucose
Serum potassium
Serum osmolality
Urine sodium
Urine potassium
Urine osmolality

Consider:
TSH, Cortisol, uric acid, urine chloride

Blood glucose and sodium correction

- Correction factor for hyperglycemia:

  For every 10 mmol/L increase in serum glucose, sodium decreases by 3 mmol/L

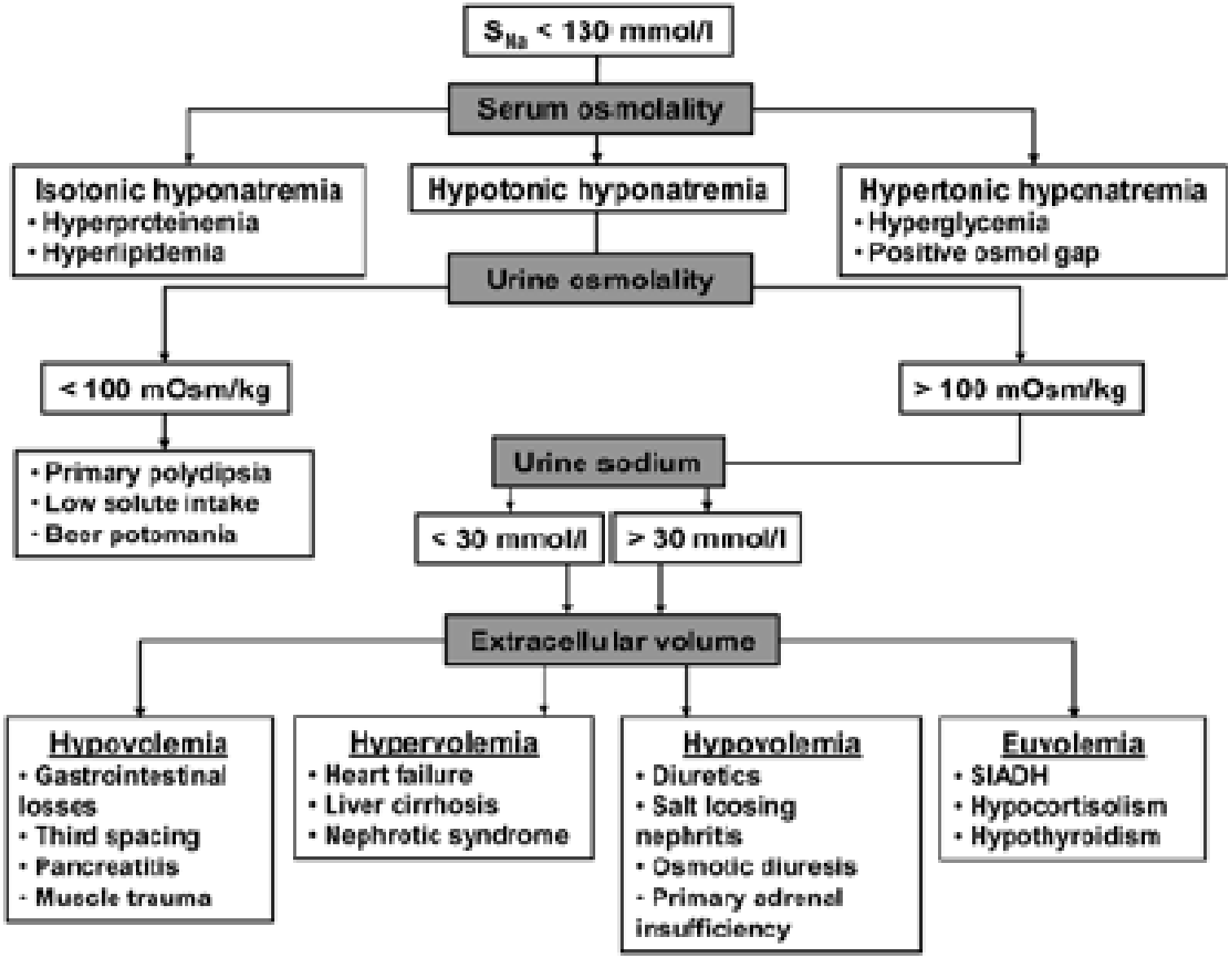
  - Example:
    - Glucose of 26 mmol/L and sodium of 130 mmol/L
  - Sodium decreases by 3 mmol/L for every 10 mmol/L increase in glucose
  - Glucose elevated by 20 mmol/L = sodium decrease by 6 mmol/L
  - 130 mmol/L (actual sodium) + 6 mmol/L (correction) = 136 mmol/L = normal range

CLINICAL ASSESSMENT APPROACH

Hypovolemia	Euvolemia	Hypervolemia
<u>Renal loss</u> Diuretics Salt-losing nephropathy Osmotic diuresis (glucose, mannitol) Bicarbonaturia *vs* <u>Extra-renal loss</u> GI (vomiting, diarrhea) "Third spacing" (burns, pancreatitis)	<u>Impaired free water excretion</u> Primary adrenal insufficiency (may be hypovolemic) Hypothyroidism SIADH – diagnosis of exclusion *vs* <u>Excess free water intake</u> Primary polydipsia	<u>Renal (kidney function impaired)</u> Acute Chronic *vs* <u>Non-renal</u> Cardiac disease Liver failure Nephrotic syndrome
<u>Urine Na</u> & <u>Osm</u> <u>FeNa</u> >20 <400 >1% Renal loss (eg diuretic) <20 >400 <1% Non-renal loss (eg diarrhea)	<u>Urine Osmo</u> >100 impaired renal water excretion (eg SIADH) <100 excess water intake (primary polydipsia)	<u>Urine Na</u> & <u>Osm</u> <u>FeNa</u> >20 <400 >1% Renal failure <20 >400 <1% Non-renal (eg CHF)

Bernstein, Keevin. Nephrology Notes: A Made-in-Manitoba Undergraduate Resource. 2019

Alternate approach



Hoorn, et al. Guideline for the management of electrolyte disorders. The Netherlands Journal of Medicine. April 2013, 71 (3)

BARRIERS TO IMPLEMENTATION IN AN OUTPATIENT SETTING

- Serum osmolality and urine electrolytes not done as part of routine labs
  - Unable to use the algorithms without that information
  - Need to repeat lab work
- Patient isn't always in front of you to do a volume exam

My initial approach to hyponatremia

1. Are they **hyperglycemic**? Does sodium correct into normal range when accounting for glucose?
   - Example:
     - Glucose of 36 mmol/L and sodium of 127 mmol/L
   - Sodium decreases by 3 mmol/L for every 10 mmol/L increase in glucose
   - Glucose elevated by 30 mmol/L = sodium decrease by 9 mmol/L
   - 127 mmol/L (actual sodium) + 9 mmol/L (correction) = 136 mmol/L = normal range

2. Is the patient known to have hyponatremia (ie is it chronic) with condition known to cause hypervolemic hyponatremia?
   - CHF, liver cirrhosis, chronic kidney disease
   - Remind patient to salt/fluid restrict
   - May need to increase diuretics if volume overloaded

3. Is it **mild** and new with an obvious etiology (new diuretics, viral gastro)
   - Stop/decrease diuretics
   - Can they take PO? Encourage salty fluid (packaged soup or tomato juice)
   - If they can't take PO: need ER/UC for IV fluids

4. Are they on a medication *known* for causing hyponatremia?

- Stop the medication
- Follow-up bloodwork in 1-2 weeks

Medications that can cause hyponatremia

- Thiazide diuretics

SIADH:

- Antidepressants: SSRIs, Tricyclic, MAOI, Venlafaxine
- Anticonvulsants: Carbamazepine, Valoproic acid, lamotrigine
- Antipsychotics: Phenothiazines
- Anticancer drugs: Cyclophosphamide, methotrexate, platinum compounds
- Vasopressin analogues: Desmopressin, oxytocin
- Other: PPIs, Opiates, NSAIDs, Nicotine, Amiodarone

5. They aren't on culprit medications and appear euvolemic?

- Do they drink many liters per day? May be primary polydipsia
- Need to go through the algorithm for other causes (usually **SIADH**), consider ordering TSH and other investigations
- Consider referral to Nephrology

Other causes of SIADH

- CNS disturbances:
  - Stroke, hemorrhage, infection, trauma
- Malignancy:
  - **Small cell lung cancer**, rarely caused by other malignancies
  - Consider chest imaging (CXR or CT)
- Pulmonary disease:
  - Pneumonia, asthma, atelectasis, acute respiratory failure
- Hormone deficiency
  - Hypopituitarism, hypothyroid
- HIV
- Genetic
- Idiopathic

Common electrolyte disorders

- Hyponatremia
- **Hypernatremia**
- Hyperkalemia
- Hypokalemia

Hypernatremia

- Serum sodium concentration >145 mmol/L
- Much less common than hyponatremia
- Can be acute or chronic, symptomatic or asymptomatic
- When hypernatremia is acute or when severe symptoms are present, immediate treatment is indicated
- When chronic, serum sodium should be corrected gradually

Volume status in hypernatremia

- Hypovolemic: Sodium and water loss, but relatively more depleted in free water
- Euvolemic: Total body sodium normal, but depleted in free water
- Hypervolemic: Excess total body sodium and water, but relatively more sodium than water

CLINICAL ASSESSMENT APPROACH

Hypovolemia	Euvolemia	Hypervolemia
<u>Renal loss</u> Osmotic diuresis (glucose, mannitol) *vs* <u>Extra-renal loss</u> Excessive sweating Diarrhea	<u>Renal loss</u> Diabetes insipidus *May be hypovolemic if no access to water *vs* <u>Non-renal loss</u> Sweating	**Usually iatrogenic** <u>Renal source</u> **Renal failure** with $NaHCO_3$ or hypertonic NaCl *vs* <u>Non-renal</u> Cardiac disease with $NaHCO_3$ or hypertonic NaCl
<u>Urine Na</u> & <u>Osm</u> or <u>FeNa</u> >20 variable >1% Renal loss (eg glycosuria) <20 >400 <1% Non-renal loss (eg diarrhea)	<u>Urine Osmo</u> Uosm < Posm Renal loss	<u>Urine Na</u> & <u>Osm</u> <u>FeNa</u> >20 <400 >1% Renal loss <20 >400 <1% Non-renal (eg CHF)

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ANOTHER APPROACH

Table 5. *Differentiation of hypernatraemia*

	Inadequate water intake	Diabetes insipidus	Osmotic diuresis	Extrarenal water loss	Positive sodium balance
Urine osmolality	Maximal	$U_{osm} < P_{osm}$	$U_{osm} > P_{osm}$	Maximal	Maximal
Urine sodium	<25 mmol/l	<25 mmol/l	>25 mmol/l	<25 mmol/l	>25 mmol/l
Urinary flow rate	Oliguria	Polyuria	Polyuria	Oliguria	Normal to high

- Urine osmolality >400 can be considered maximally concentrated

Hoorn, et al. Guideline for the management of electrolyte disorders. The Netherlands Journal of Medicine. April 2013, 71 (3)

Investigations

- Serum creatinine
- Serum urea
- Serum glucose
- Serum calcium
- Serum potassium
- Urine sodium
- Urine osmolality

Practically

- Not seen commonly as an outpatient
- Correct obvious causes
  - If patient is on diuretics: decrease/stop the dose
  - If GI losses and able to take PO: drink fluids

- If significant polyuria/polydipsia and concern regarding diabetes insipidus:
  - **Endocrinology** referral

Common electrolyte disorders

- Hyponatremia
- Hypernatremia
- **Hyperkalemia**
- Hypokalemia

HYPERKALEMIA

- Serum potassium > 5.5 mmol/L

Symptoms:

- Asymptomatic
- Muscle cramps
- Muscle weakness

Complications

- Arrhythmia
- Paralysis
- Death

Common causes of hyperkalemia

- Pseudohyperkalemia:
  - Hemolysis (usually related to blood withdrawal)
    - K: 5.7*
  - Can also be caused by thrombocytosis and leukocytosis
- Shift:
  - Metabolic acidosis (DKA)
  - Cell death (tumour lysis, rhabdomyolysis)
- Renal failure
  - Acute or chronic decrease in GFR

Common causes of hyperkalemia

- Reduced renal tubular secretion of potassium (Medications)
  - Disruption of the renin-angiotensin-aldosterone system
  - Inhibition of the epithelial sodium channel (ENaC)
- Increased dietary potassium intake (in the setting of another underlying abnormality)

Recommended diagnostic testing

Serum creatinine

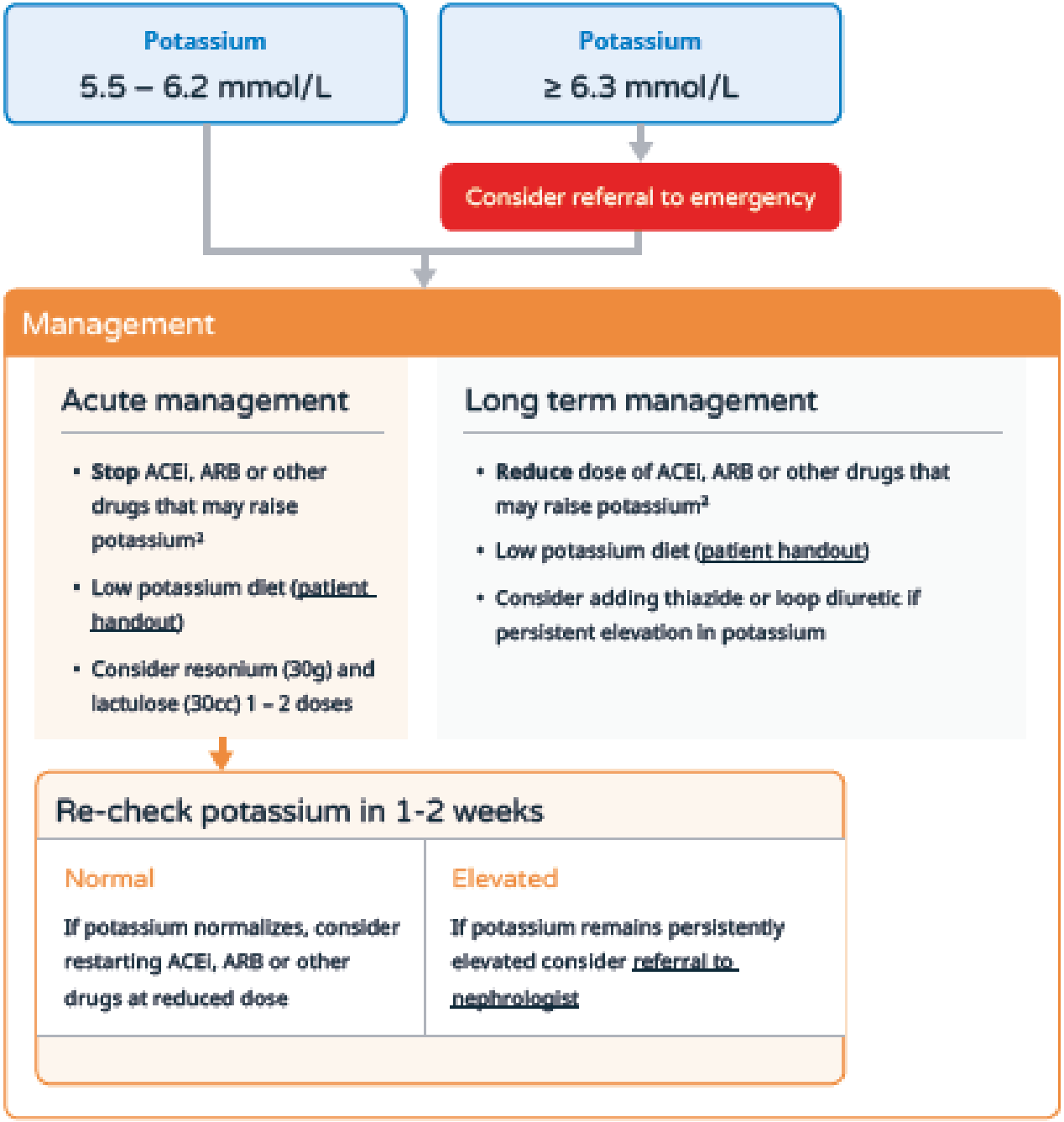
CBC (for platelets and white blood cells)

Total CO2 (for acid base status)

- Low TCO2 indicates acidosis

Common medications that may raise potassium

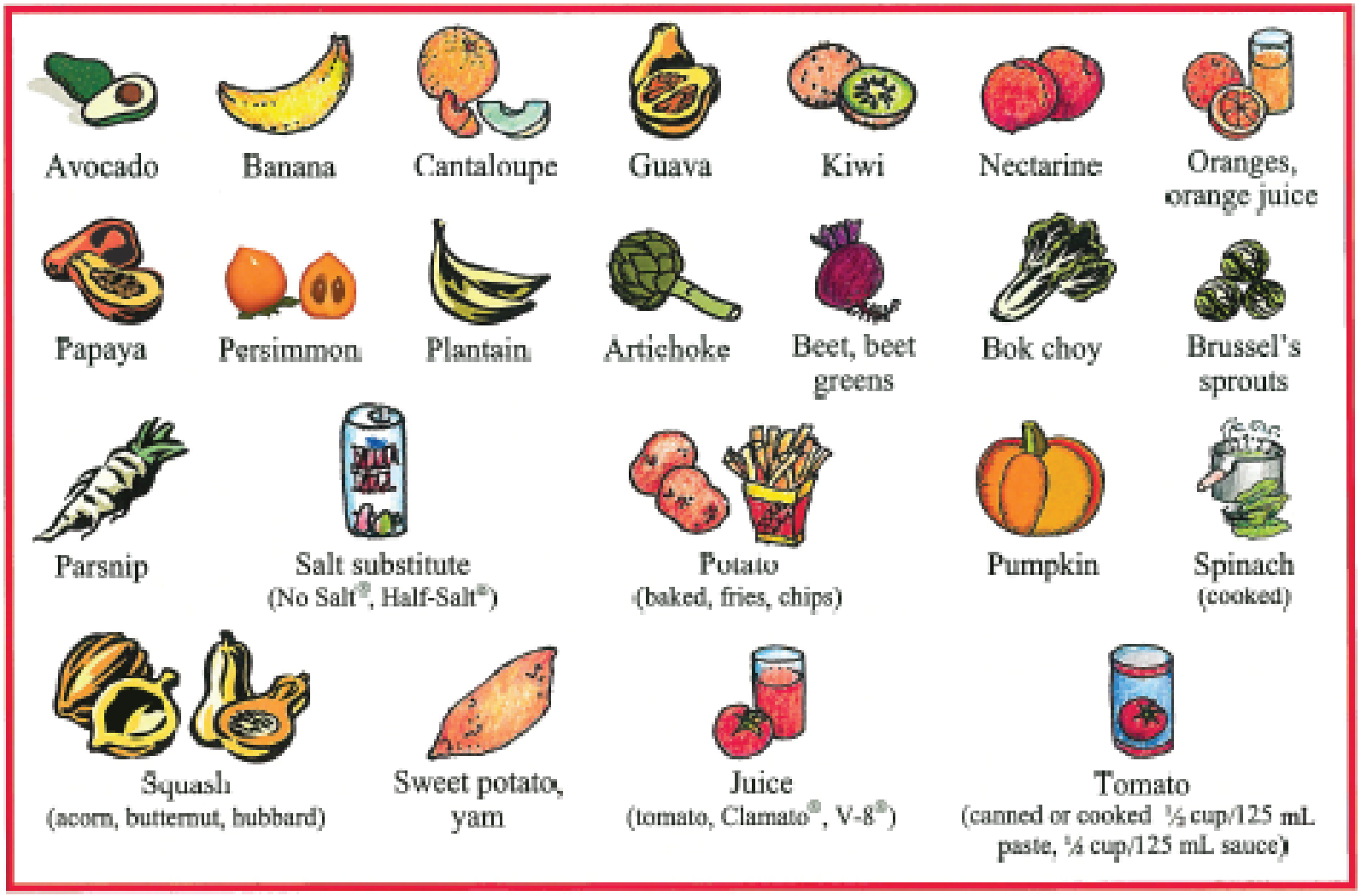
- ACE-I: Ramipril, Enalapril
- ARBs: Losartan, Candasartan
- Mineralocorticoid receptor blockers: Spironolactone
- NSAIDs
- Beta blockers
- Antifungals: Fluconazole
- Heparin
- Calcineurin inhibitors: Cyclosporine, tacrolimus
- TMP-SMX (Septra)



We generally use kayexalate: 15-30g PO for a couple days

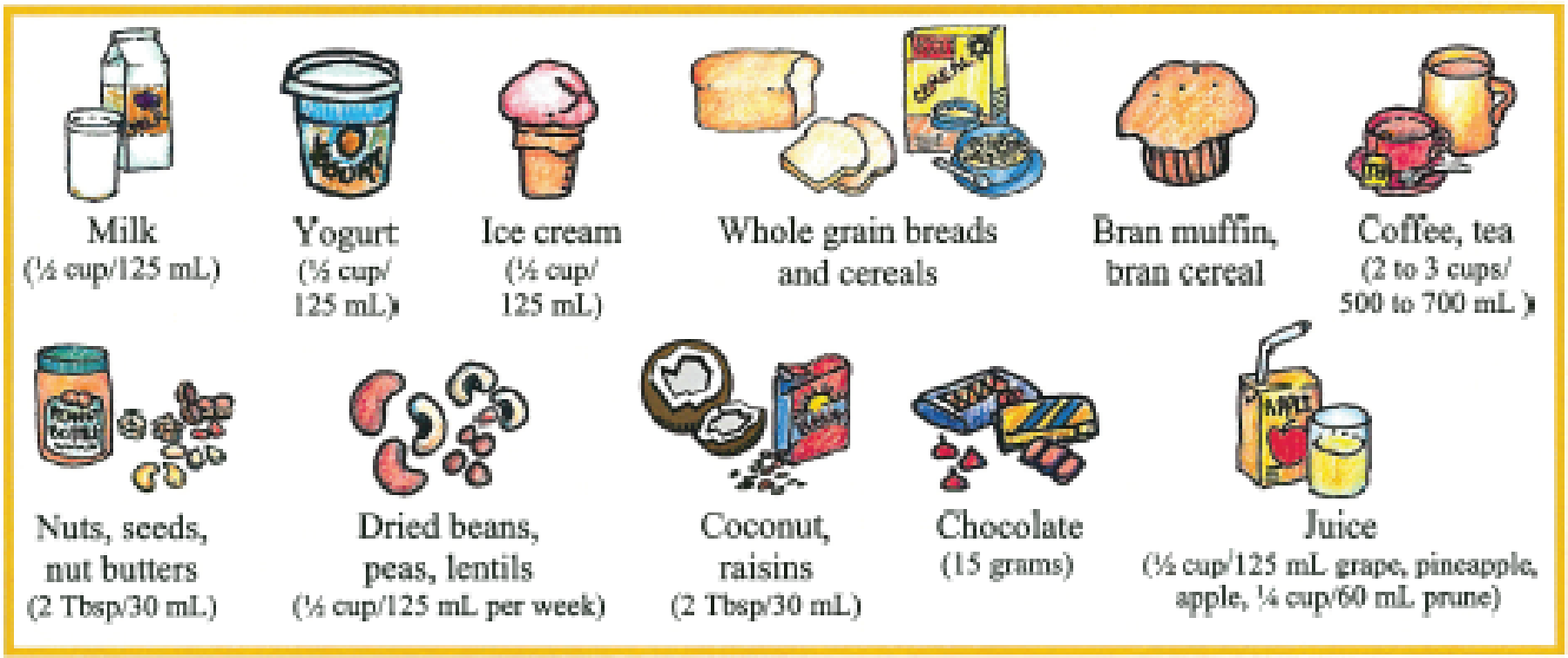
www.CKDPathway.ca

HIGH POTASSIUM FOODS



http://www.ckdpathway.ca/Content/pdfs/Management_of_elevated_serum_potassium.pdf

Medium potassium foods



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Common electrolyte disorders

- Hyponatremia
- Hypernatremia
- Hyperkalemia
- **Hypokalemia**

Hypokalemia

- Serum potassium <3.5 mmol/L
- Severe hypokalemia (usually serum <2.5 mmol/L) associated with symptoms
  - Muscle cramps
  - Muscle weakness
  - Paresthesia

- Complications:
  - Arrhythmia
  - Paralysis
  - Ileus
  - Rhabdomyolysis
  - Urinary concentrating defect

Causes

- Renal loss of potassium
  - Hyperaldosteronism
  - Diuretics
  - Genetic defects (Bartter, Gitelman syndrome)
  - Hypomagnesemia

- Extra-renal loss of potassium
  - Diarrhea
  - Laxative abuse
  - Vomiting

Causes

- Decreased intake:
  - Unusual given that most diets are rich in potassium

Recommended diagnostic testing

Serum creatinine
Serum magnesium
Blood pressure

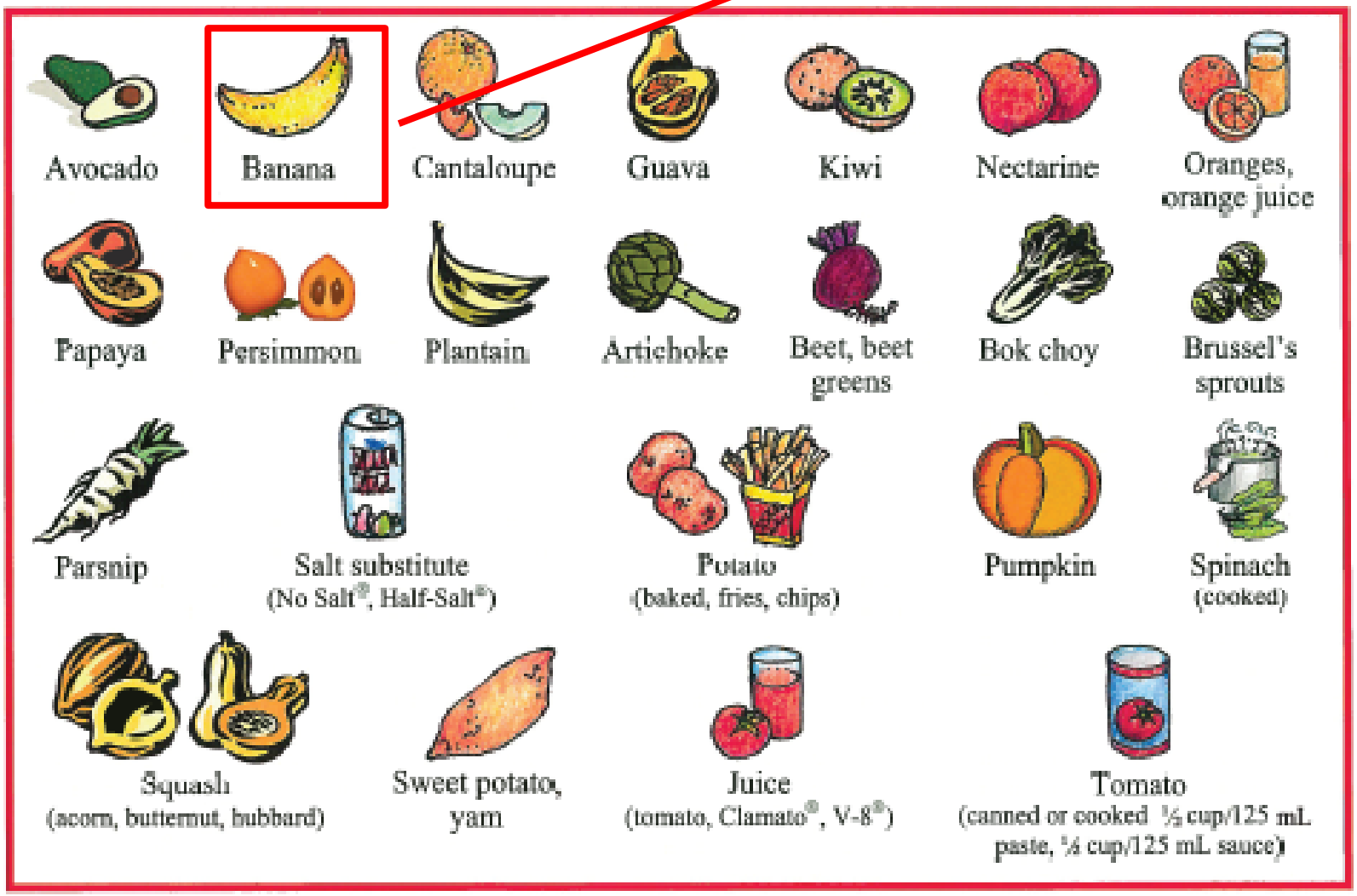
Consider:
Urine potassium
Serum bicarbonate
Urine chloride
Plasma renin and aldosterone

Treatment

- If medication-related and no absolute indication for the medication, discontinue
  - Avoid the “prescribing cascade”
- Make sure they are magnesium replete
  - Can’t replace potassium if magnesium is low
- Treat with diet first
  - Use the same potassium sheets for hyperkalemia
- Follow-up labs in 2 weeks

HIGH POTASSIUM FOODS

One banana ~ 1 slow-K tab (8 meq)



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TREATMENT

- If dietary interventions are unsuccessful

Winnipeg Regional Health Authority / Office régional de la santé de Winnipeg
Caring for Health / À l'écoute de notre santé

kidneyhealth.ca
manitoba renal program

Potassium Chloride Products *Note: liquid potassium chloride can be hard to tolerate (GI side effects) and is unpalatable. Consider tablets if needed for long term treatment.			
Covered by Pharmacare, Blue Cross and NIHB			
Drug Strength and Dosage form	**Brand Name**	**DIN**	**NPN**
8 mEq (600 mg) Sustained release capsule	Micro-K Extencaps	02042304	–
8 mEq Sustained release tablet	APO-K	00602884	–
8 mEq Tablet Sustained release tablet	Jamp-K8; Jamp-K 600	–	80013005
8 mEq Sustained release tablet	Slow K	00074225	80040226
20 mEq/15 mL Oral Liquid	K-10	01918303	80024360
20 mEq/15 mL Oral Liquid	PMS-Potassium Chloride	02238604	N/A
20 mEq/15 mL Oral Solution	JAMP-Potassium Chloride	–	80024835
20 mEq Sustained release tablet	Jamp K-20; Jamp K-1500	–	80013007
20 mEq (1500 mg) Sustained release tablet	Pharma-K20	–	80040416
Covered by NIHB only			
8 mEq Sustained release tablet	Euro K 600; Sandoz-K 8	02246734	–
8 mEq Sustained release tablet	Mk 8;M-K8 L.A.; Potassium Chloride 600 mg	–	80035346
8 mEq Sustained release tablet	Pro-600K	00613274	–
8 mEq Sustained release tablet	Riva-K 8 Sr	02244068	–
20 mEq Sustained release tablet	Bio-Potassium K20	–	80026265
20 mEq Sustained release tablet	Euro K 20; Sandoz-K 20	02242261	–
20 mEq Sustained release tablet	M-K20 L.A.	–	80025624
20 mEq Sustained release tablet	Odan K-20	–	80004415
20 mEq (1500 mg) Sustained release tablet	Pro-K 20	–	80053887
20 mEq Sustained release tablet	Riva-K 20 Sr	02243975	–

Treatment

- Start with one 8 meq potassium tablet daily (depending on the level) and increase as needed

Complications of oral potassium

- May cause GI upset/irritation
- May lead to GI ulceration
  - Solid dosage forms such as Slow K equivalents
  - Caution with anti-cholinergic medications
- May cause hyperkalemia

Hypokalemia and Hypertension has its own differential

- Renal artery stenosis
- Renin-producing tumour
- Primary aldosteronism
- Liddle's syndrome
- Syndrome of mineralocorticoid excess

- Consider with extremes of age
- New onset hypertension
- Sudden worsening of hypertension
- Refer to Nephrology or Endocrinology

Resources

pbfluids.com : The Electrolyte Book (free electronic electrolyte/acid base textbook)

Ckdpathway.ca : "Medical management" tab. Has elevated serum potassium algorithms and hand-outs

Kidneyhealth.ca: Nutrition section