Potassium Balance and Management of Hypokalemia

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Objectives

- **Understand normal potassium homeostasis, ICF/ECF balance, and the relationship of serum K to total body K**
- **Understand how disease and drug therapy can cause hypokalemia**
- **Recognize the clinical manifestations of hypokalemia**
- **Design K-replacement therapy appropriate for an individual patient**
- **Know commonly used drugs that may alter distribution or excretion of K**

Suggested Reading

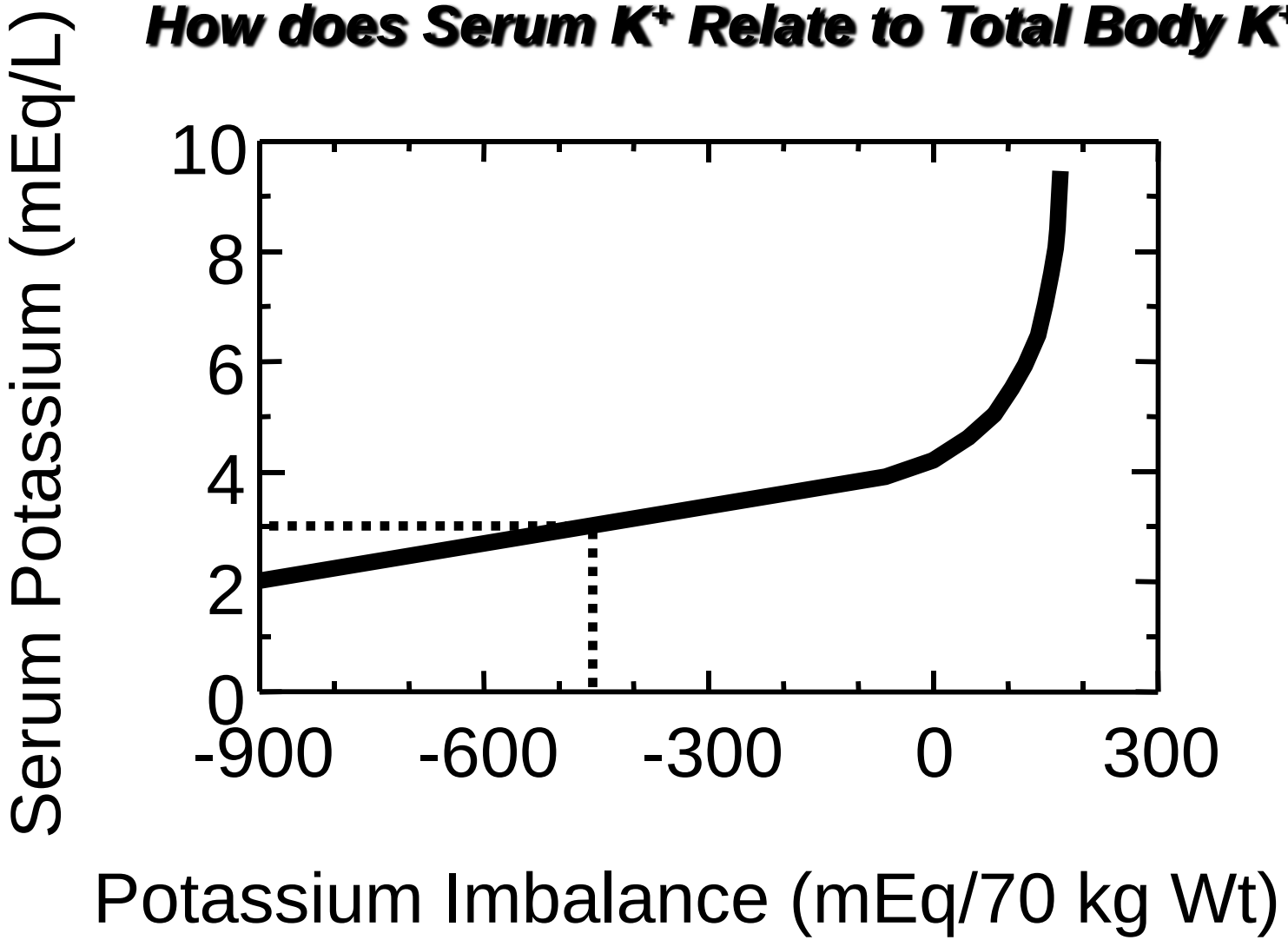
Pharmacotherapy, 10th edition

Pages 759-763

Potassium Homeostasis

- **Normal adult total body K^+ 50-55 mMol/kg; >95% intracellular**
- **Avg daily turnover 50-150 mMol; excretion 90% renal, 10% GI; aldosterone ↑'s excretion**
- **Aldosterone secretion is modulated by K level**
- **ICF / ECF distribution**
  - **Na/K ATPase in cell membranes**
  - **Insulin increases intracellular K**
  - **β_2 adrenergic receptor stim. (e.g. epinephrine) increases intracellular K**
  - **exchange with H^+ (variable effect of pH on K)**
- **Serum K^+ normally 3.5-4.8 mMol/L**

How does Serum K^+ Relate to Total Body K^+ ?



Causes of Hypokalemia

- **Poor diet (unlikely as sole cause, unless marked, prolonged reduction in food intake)**
- **Intracellular shift**
  - **Insulin; β_2 agonist use, endogenous sympathetic tone (epinephrine); alkalemia; xanthines**
- **GI losses: diarrhea, vomiting, laxative or enema abuse**
- **Urinary losses**
  - **mineralocorticoid excess (aldosterone; steroid Rx)**
  - **↑'d Na excretion- high Na intake, diuretic Rx, osmotic diuresis, salt-wasting nephropathies**
  - **magnesium deficiency**
  - **metabolic alkalosis**
  - **high dose Rx with penicillin class; amphotericin B Rx**

Potassium and Diuretic Therapy

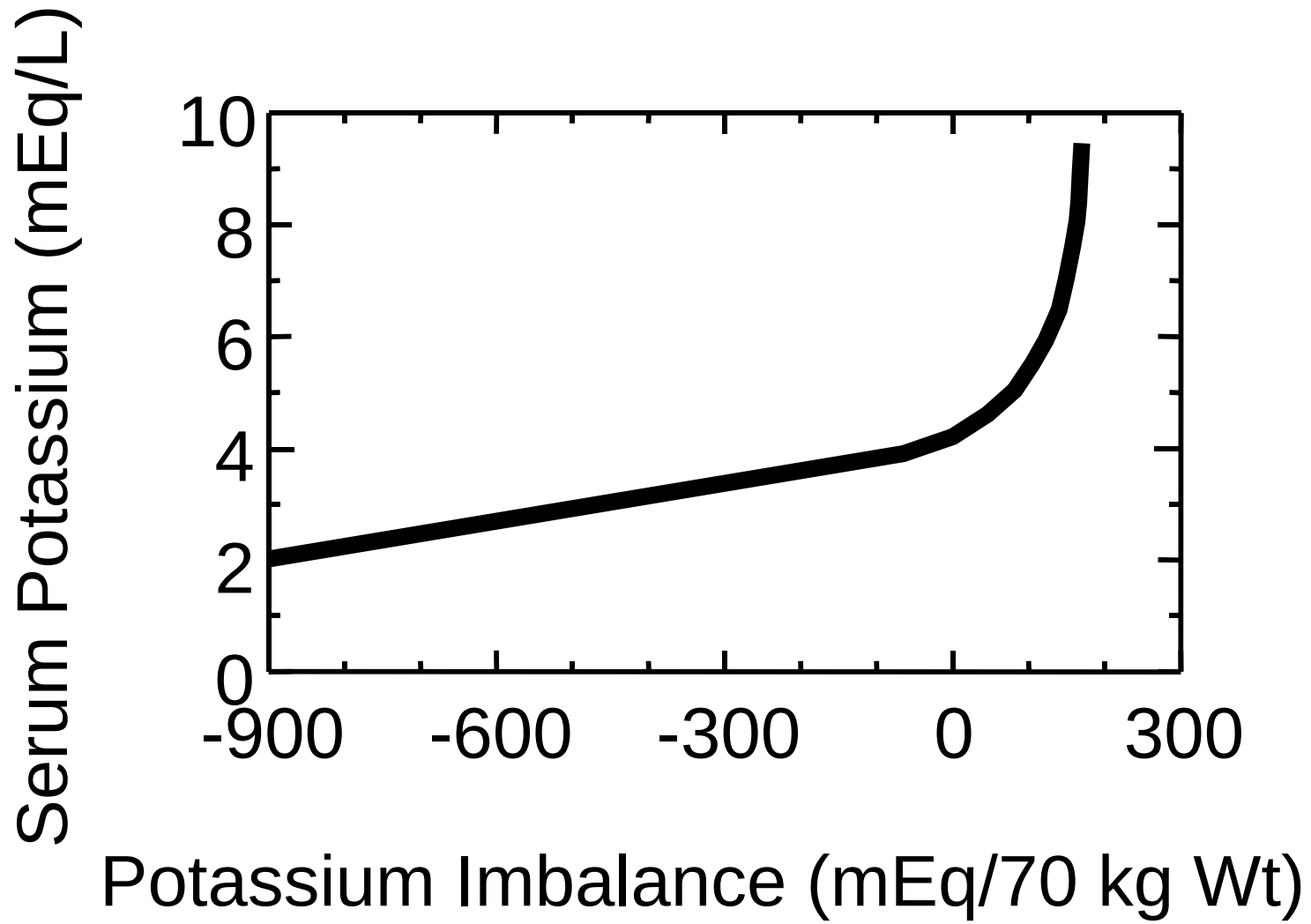
- **K losses are *related to the amount of Na excreted*- greatest during Rx of edema or when Na intake high**
- **Hypokalemia associated with diuretics most common early after start of Rx or after increase in dose- not common during chronic maintenance diuretic Rx for hypertension**
- **K-sparing diuretics are effective to avoid hypokalemia, but risk of *hyper*kalemia if K intake increases or reduced renal function**

Manifestations of Hypokalemia

- **Muscle weakness/paralysis**
  - **associated with serum K<2.5 mMol/L**
  - **gut (constipation or ileus)**
  - **skeletal muscle (lower extremities most sensitive; cramps, tetany, paresthesia, weakness, tenderness; ischemia-rhabdomyolysis, myoglobinuria)**
- **Cardiac effects**
  - **U-waves; digitalis toxicity; arrhythmias in *unhealthy* hearts**
- **Renal effects**
  - **impaired concentrating ability; metabolic alkalosis**
- **Glucose intolerance- depressed insulin secretion**

Management of Hypokalemia

Serum K^+	Treatment
3.0<K<3.5	Usu asymptomatic; p.o. supplement if on digitalis, otherwise dietary K adequate
2.5<K<3.0	Treat with p.o. supplements (40-60 mMol, 3-4X/day until serum K >3.0)
2.0<K<2.5	Some clinical manifestations likely; Rx promptly with p.o. supplements; i.v. supplement if p.o. route questionable or if receiving i.v. fluids
K<2.0	Severe hypokalemia with probable total body deficit 400-900 mMol K; i.v. supplement should start immediately


Serum Potassium (mEq/L)
10
8
6
4
2
0
-900
-600
-300
0
300
Potassium Imbalance (mEq/70 kg Wt)

Oral Potassium Supplements

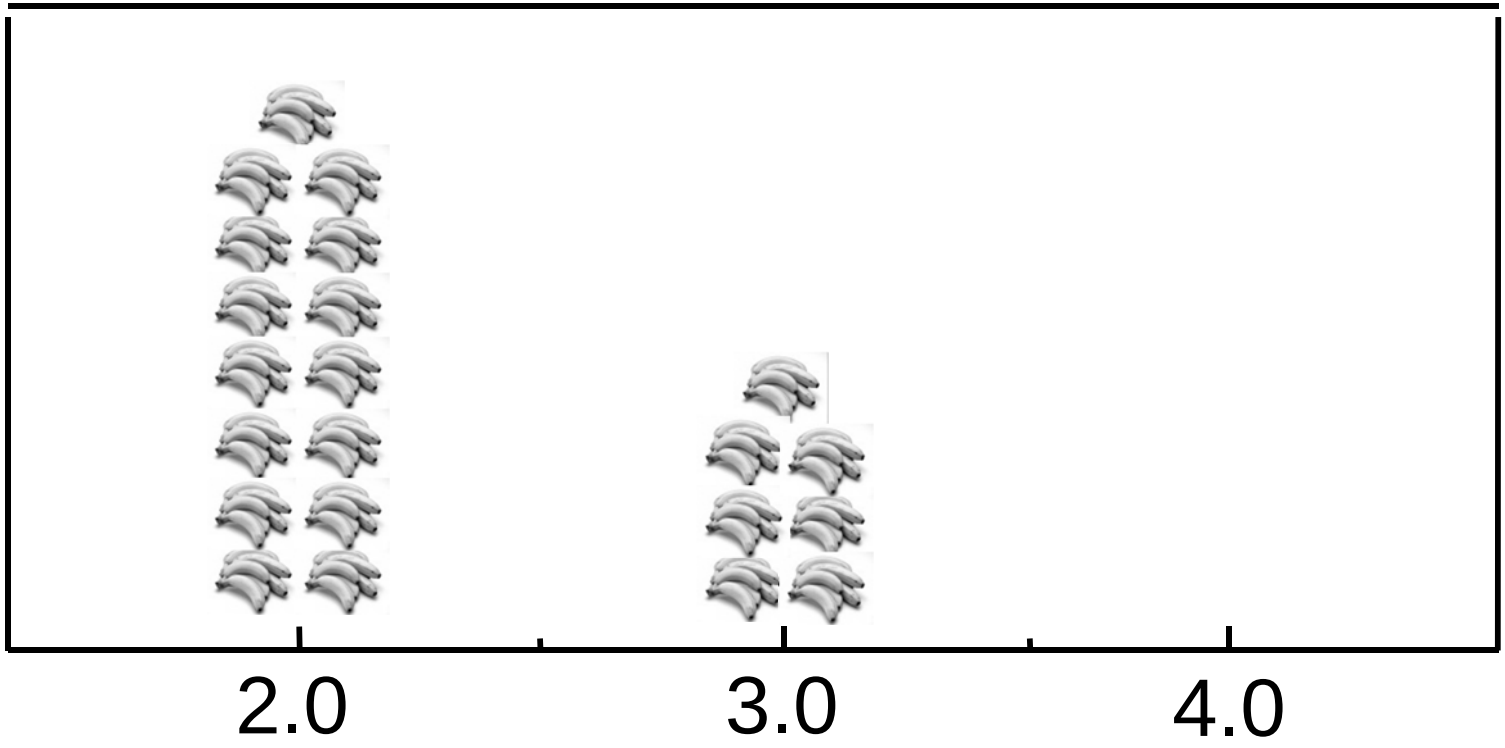
- **Choice of salt**
  - **KCl preferred in most cases; Cl^- deficit commonly accompanies K^+ deficit (e.g. gastric losses, diuretics)**
  - **Non-Chloride salts-- Bicarbonate, citrate, acetate, lactate or gluconate salts useful when bicarbonate deficit (metabolic acidosis) also present (e.g. lower GI losses)**
  - **KPhosphate in pts with phosphate deficit**
- **Choice of dosage form**
  - **Solutions effective, inexpensive, unpalatable**
  - **Wax matrix tablets (8, 10 mMol)**
  - **Microencapsulated capsules (8, 10 mMol)**
  - **Sustained release microcrystalloids (10, 20 mMol)**

Dietary Sources of Potassium

Grams of food needed to obtain 10-12 mMol K^+

- **Lean meat or chicken 120 g**
- **Fruits**
  - **banana 150 g; orange juice 250 g; oranges 200 g; grapes 200 g; pears 400 g; apples 450 g**
- **Vegetables**
  - **cauliflower 150g; mushrooms 100g; potatoes 100g; broccoli 150g; carrots 250g; lettuce 200 g; spinach 100g; tomatoes 200g**
- **Legumes**
  - **canned beans 230g; peas 260g; dry chickpeas 60g**
- **Salt Substitute 1 g KCl**

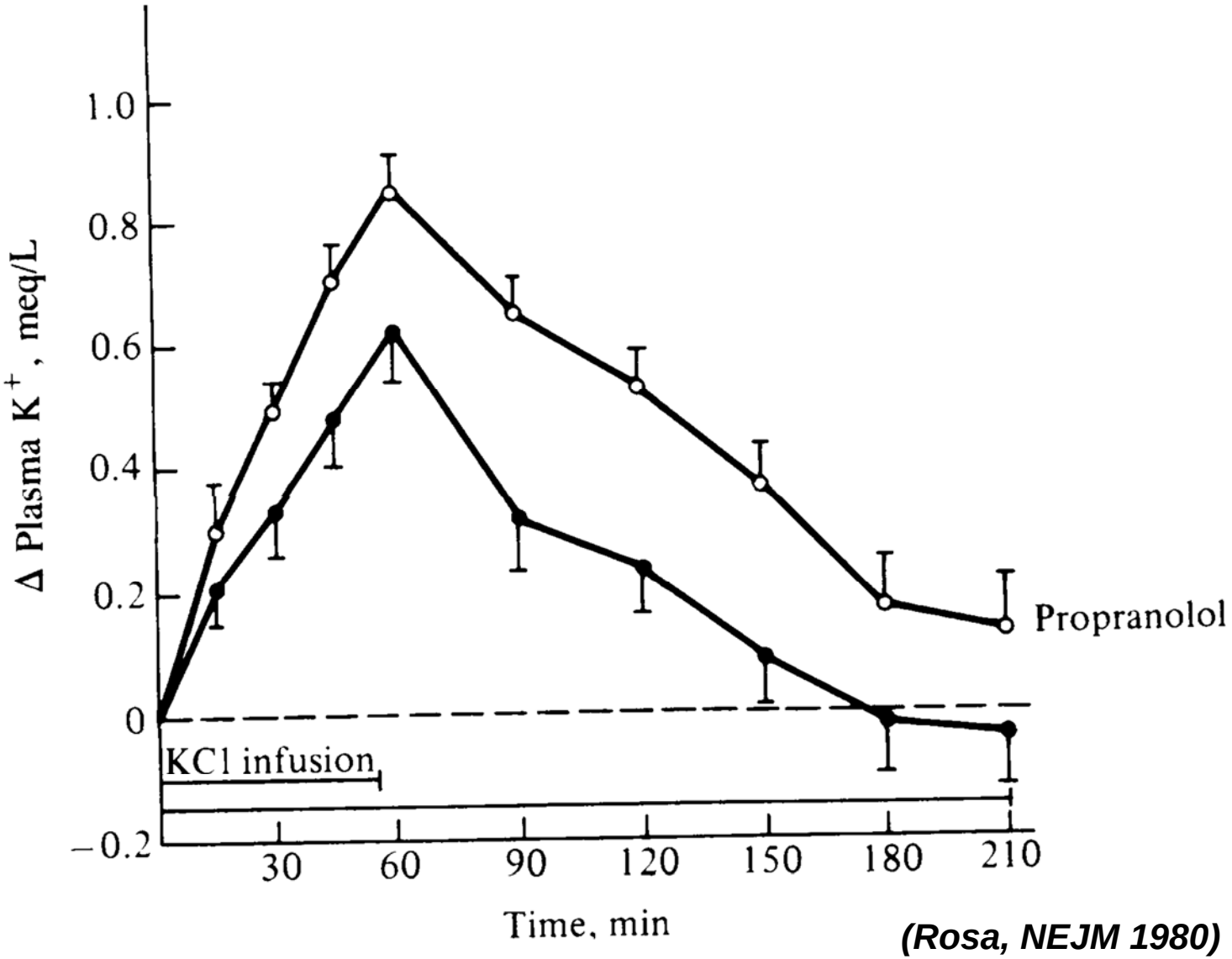
Number of Bananas Needed to Restore Potassium Balance



Cautions for Potassium Rx

Potassium levels may rise higher than expected if compromised ability to excrete K or shift K into ICF normally

- **Decreased renal function**
- **K-sparing diuretic (spironolactone, amiloride, triamterene) Rx; Trimethoprim Rx; Heparin Rx**
- **ACE inhibitor or A-II antagonist Rx**
- **Beta-2-blocker Rx**



(Rosa, NEJM 1980)

i.v. Potassium Therapy

- **In patients receiving i.v. fluid via peripheral vein, may include up to 40 mMol K per liter**
- **Higher concentrations tolerated via central vein- use pump for safety**
- **Often administered as piggyback i.v. in 10 mMol increments, infused over an hour**
- **For urgent situations:**
  - **10-20 mMol/hr infusion rate via central vein**
  - **Use dextrose-free i.v. fluid**
  - **Monitor ECG for ≥20 mMol/hr**
  - **40 mMol/hr- extreme emergency**