Lec 9 Potassium

- K^+ is major cation of intracellular compartment
- daily K^+ intake is about 100 mEq/day, & the K^+ intake will affect the extracellular K^+ level
- intracellularly we have 140 mEq/L of K^+ & 28L of fluid volume ... so $140 \cdot 28 = 3920$ mEq
- extracellularly we have 4.2 mEq/L of K^+ & 14L of fluid ... $4.2 \cdot 14 = 59$ mEq
- we want to make sure that the extracellular K^+ level stays in narrow range, so we dont have hypo/hyper-Kalemia, b/c this can cause adverse affects on heart & neural activity .... we keep K^+ in narrow window by making sure the K^+ intake = K^+ output * ... how?
- urine excretes 92 mEq/day, & GI (feces) excretes 8 mEq/day ... $92 + 8 = 100$

* GI 8 mEq/day is fixed not regulated

- if we ↑ K^+ intake by 50 mEq, this will ↑ extracellular K^+ conc. by double (overshoot), causing hyperkalemia, & if you exercise after that intake, you could have a heart attack ... so we have mechanisms to regulate this

What Causes hyperkalemia

* moving K^+ from ICF to ECF

- hypotonic fluid infusion causes cell lysis & K^+ goes to ECF

- Strenuous exercise
- β-2 blockade
- protons (H^+) inhibit Na^+/K^+ ATPase, so (↓ PH) Acidosis will cause K^+ to accumulate in ECF
- high osmolarity of interstitial fluid makes H_2O leave cells into the ECF... this means K^+ conc. inside cell will be high, so K^+ will leave cell throug leaky channels, & go to ECF

Consequences of hyper K^+

- partial depolarization of cell membrane, no matter how much Na^+ there is
- Cardiac toxicity, asystole, or V-Fib b/c heart cant fully contract

What Causes hypo K^+

* K^+ goes from ECF to ICF
- Insulin lets glucose & K^+ into cell
- Aldosterone ↑ activity of Na^+/K^+ ATPase
- Sympathetic System catecholamines bind β-2 adrenergic receptors & allow K^+ into cell
- ↑ PH / Alkalosis allows K^+ into cell

Consequences of hypo K^+

- hyperpolarization → hard to create action potential → Delayed ventricular repolarization
- fatigue, muscle weakness → hypoventilation

* although we have barriers btwn ECF & ICF, change in one compartment affects the other

K^+ homeostasis

- controlled by 3 processes (filtration, Reabsorption, Secretion) mainly by principal & intercalated cells
- K^+ filtration load = GFR · K^+ plasma conc
  ↓ 180 · ↓ 4.2 = 756 mEq/day
- PCT reabsorbs 65% of Na^+, K^+, & H_2O = 491 mEq/day of K^+
- Thick ascending actively reabsorbs 27% = 204 mEq using Na/K/Cl channel

this means 92% is reabsorbed, & 8% is excreted ... but what about secreted K^+? ....

- late distal & collecting tubules make adjustments depending on our daily intake (fine toning) & should secrete about 4% (31 mEq) ... so a total of 12% (92 mEq) is excreted

Regulation by Intercalated Cells

- important in acid/base balance
- remember we have Na/K ATPase on basolateral surface, & this gradient drives all other ion movement
- we have 2 types of intercalated cells:

Type A

- has H^+ ATPase & H^+/K^+ ATPase channels facing tubular lumen ... so, in hypokalemia, Na^+/K^+ ATPase function will ↓, creating a gradient for H^+ & H^+/K^+ channels → K^+ will be

reabsorbed & H^+ will be secreted & we have net K^+ reabsorption

Type B

- H^+/K^+ ATPase on basal surface, facing capillaries, & Cl^-/HCO_3^- facing tubular lumen (apical) ... in hyperKalemia Na^+/K^+ ATPase function ↑, K^+ comes in from capilleries to tubular cells, & will be secreted into tubular lumen, while H^+ is reabsorbed ... b/c H^+ is reabsorbed, HCO_3^- will be secreted

Principal Cells

now.. in hyperK^+ we said Na/K ATPase ↑ ... principal cells have ENaC channels that will secrete the accumulated K^+ from the cell into the tubular lumen through leaky channels called ROMK & big/Maxi-K^+ channels

* Aldosterone is major regulator of this b/c it acts on ENaC

Control of Principal Cell K^+ Secretion

- ↑ extracellular K^+ conc ↑ K^+ secretion due to electrochemical & conc. gradient
- Aldosterone ↑ K^+ secretion
- ↑ Na leads to ↑ ECF volume → ↑ RBF & ↑ GFR ... The high Na^+ conc in tubular fluid causes volume expansion, & all this fluid will flush or wash out the K^+

* the more tubular flow rate, the more flushing of K^+, & more K^+ secretion

- Acidosis → ↓ K^+ secretion , Alkalosis → ↑ K^+ secretion