REGULATION OF BODY POTASSIUM

K+ is the major intracellular ion. Only 2% is in the ECF at a concentration of only 4 mEq/L. K is taken up by all cells via the Na-K ATPase pump. It is one of the most permeable ion across cell membranes and exits the cells mostly via K channels (and in some cells via K-H exchange or via K-Cl cotransport).

1. Roles of K

- K is the major ion determining the resting membrane electrical potential, which in turn, limits and opposes K efflux. Thus changes in K concentrations (particularly in the ECF) have marked effects on cell excitability (heart, brain, nerve,muscle).
- K is the mayor intracellular osmotically active cation and participates in cell (intracellular) volume regulation (exits with Cl when cells swell).
- A constant cell K concentration is critical for enzyme activities and for cell division and growth.
- Intracellular K participates in acid base regulation through exchange for extracellular H and by influencing the rate of renal ammonium production.
- Regulation of extracellular K is by tissue buffering (uptake of K excess) and by slower renal excretion.

2. Cellular K buffering

When K is added to the ECF, most of the added K is taken up by the cells, reducing the ECF K+ increase. Similarly, if K is lost from the ECF, some K+ leaves the cells, reducing the ECF K decline.

Buffering of ECF K through cell K uptake is impaired in the absence of aldosterone or of insulin or of catecholamines.

Cell K exit to the ECF increases when osmolarity increases (as in diabetes mellitus) and in metabolic acidosis, when it is exchanged for ECF protons (H+). When cells die, they release their very high K content to the ECF.

3. Renal regulation of Potassium

In normal function, renal K excretion balances most of the K intake (about 1.5 mEq/Kg per day). The kidneys excrete about 15 % of the filtered K load of 10 mEq/Kg per day.

Along the proximal tubule the K concentration remains nearly equal to that in plasma. Since the PCT reabsorbs about 2/3 of the filtrate water, it also reabsorbs about 2/3 (66%) of the filtered K. This reabsorption is mostly passive and is driven by the positive tubule electrical potential present along the S2 and S3 segments and by paracellular solvent drag.

Along the descending limb of the loop of Henle, K is secreted into the tubule lumen from the interstitium. Along the thick ascending limb, K is reabsorbed via Na-K-2 Cl cotransport. In the loop, there is net K reabsorption of 25% of the filtered K.

Along the distal tubule and collecting ducts, there is net secretion of K which is stimulated by aldosterone and when there is dietary K excess. Secretion decreases and becomes net reabsorption in K deficiency. Regulation of renal K excretion is in the CD and is mostly by changes in the rate of K secretion.

In the CD, K secretion is by the principal cells (via luminal K channels and basolateral Na-K ATPase) and K reabsorption is by the alpha intercalated cells via a luminal H-K ATPase.

K secretion from principal cells into the CD lumen is enhanced by luminal and cellular determinants:

Luminal determinants that stimulate K secretion are increases in tubule urine flow (which reduces the intratubular K concentration), the delivery of sodium to the CD, and the delivery of poorly reabsorbed anions (other than Cl) to the CD. Na delivery followed by its reabsorption increases K secretion by increasing the lumen negative electrical potential and by stimulating the activity of the Na-K ATPase which results in enhanced accumulation of K in the cells. The presence in the CD of poorly reabsorbed anions (SO_4^{2-}, excess of HCO_3, beta hydroxybutyrate, or HPO_4^{2-})enhances the negativity of the CD lumen, favoring K secretion.

Cellular determinants of K secretion are the activity and abundance of K channels at the luminal cell membrane and of Na-K ATPase at the basolateral membrane. Both of these are enhanced primarily by aldosterone, and also by ADH (by decreasing urine flow, ADH reduces K secretion, but by increasing luminal permeability, ADH promotes it) and by dietary K excess. K deficiency is associated with increased activity and expression of luminal H-K ATPase in the alpha intercalated cells of the CD, which act to promote reabsorption of K from the lumen.