Tubular Secretion

In tubular secretion, certain substances move from the plasma of the peritubular capillary into the fluid of the renal tubule to be eliminated in urine. The most important substances secreted by the tubules are H^+ and K^+. However, a large number of normally occurring organic anions, such as choline and creatinine, are also secreted.

Secretion of H^+

Acidification of the urine occurs by secretion of H^+ from the tubular cells into the lumen in proximal tubules, distal tubules, and collecting ducts.

In the proximal tubule

The reaction for H+ secretion in proximal tubules involves Na^+- H^+ exchange. In this mechanism, Na^+ is removed from the cells into the interstitium by the action of Na^+- K^+ ATPase leading to lower its intracellular concentration. This causes Na+ to enter the cell from the tubular lumen, with coupled extrusion of H^+. The H^+ comes from intracellular dissociation of H_2CO_3, and the HCO_3^- that formed diffuses into the interstitial fluid. It appears that, for each H+ ion secreted, one Na+ ion and one HCO_3^- ion enter the interstitial fluid. The enzyme carbonic anhydrase catalyzes the formation of H_2CO_3, so the drugs that inhibit this enzyme decrease both secretion of acid by proximal tubules and the reactions which depend on it.

In the distal tubules and collecting ducts

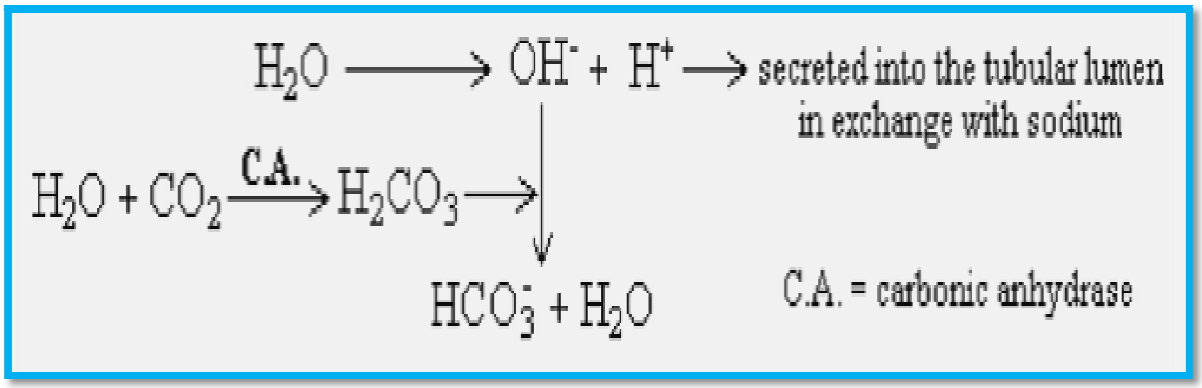
In contrast to the mechanism mentioned above in the proximal tubules, H+ secretion in both distal tubules and collecting ducts is relatively independent of Na^+ in the tubular lumen. So, another mechanism involves an ATP-driven proton pump is used for H^+ secretion in this part of the renal tubules. Aldosterone acts on this pump to increase distal H^+ secretion.

Factors affecting acid secretion

(i) Intracellular PCO_2

When the PCO_2 is high, as in case of respiratory acidosis, more intracellular

H_2CO_3 is formed and becomes available to buffer the hydroxyl ions. This results in enhancement of H^+ secretion. In case of reduction of intracellular PCO_2, the reverse is true.



(ii) Activity of carbonic anhydrase

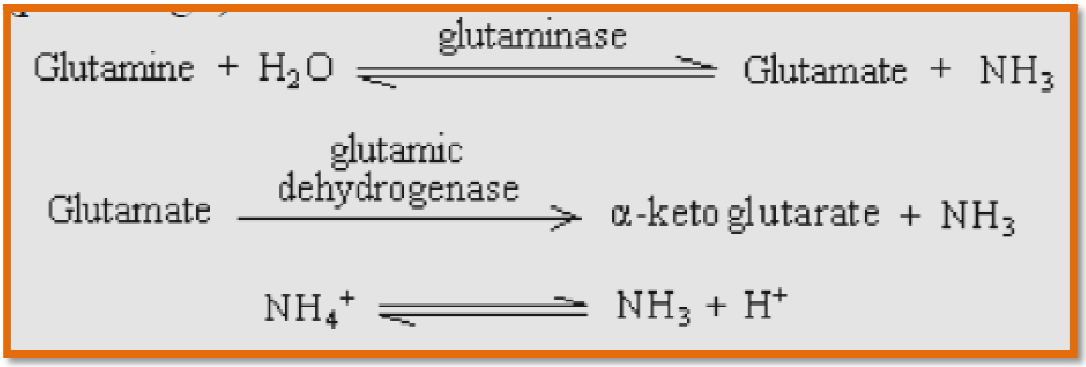
Inhibition of carbonic anhydrase activity causes reduction in the acid secretion, because the production of H_2CO_3 by the action of mentioned enzyme is decreased.

(iii) Aldosterone and other adrenocortical steroids

Aldosterone and other adrenocortical steroids enhance tubular reabsorption ofsodium and increase the secretion of acid and potassium.

Secretion of ammonia

Cells are permeable to NH_3 (because it dissolves in the lipid) but not to the ionized ammonium (NH_4^+). NH_3 thus diffuses into the tubular lumen and reacts with H^+ to form NH_4^+, the latter remains in the tubule lumen and excreted in the urine.



If the blood is acidic (Low pH)

If the blood is acidic the kidney brings it back to normal by excreting hydrogen ions (H^+) and ammonia, while reabsorbing sodium ions and bicarbonate ions. The hydrogen ions and ammonia are excreted during tubular excretion at the distal tubule.

If the blood is alkaline (high pH)

If the blood is alkaline, fewer hydrogen ions are excreted and fewer sodium and bicarbonate ions are reabsorbed.

Secretion of potassium

Much of filtered potassium ion is reabsorbed actively in the proximal tubules. However, potassium is added to the urine again in the distal convoluted tubule by the secretory activity of the tubular cells in exchange for sodium, and this process is stimulated by aldosterone. The movement of K^+ is passive. The rate of K^+ secretion is proportionate to the flow rate of the tubular fluid through the distal tubule, i.e. with rapid flow there is no tendency to rise the K^+ concentration in the tubular fluid hence the secretion could be increased and vice versa. Normally, the amount of K^+ secreted is approximately equal to the K^+ intake, and potassium balance is maintained. Potassium and hydrogen compete for this exchange in the distal tubule cells. So, deficiency of potassium promotes the secretion and excretion of H^+ ion in the urine which may lead to alkalosis (plasma pH is elevated), whereas excess of cellular potassium favours potassium secretion and excretion.

Creatinine

In man, creatinine is not reabsorbed but it is secreted by the renal tubule in small amounts. This compound is normally formed by the muscles and is of particular interest because it can be used in studies of renal function in a manner similar to inulin. It is formed in the body at a relatively constant rate, and monitoring its excretion allows study of renal function without injection of a foreign substance. Creatinine is apparently derived from the metabolism of the high-energy phosphate compound, phosphocreatine.

Certain exogenous substances

Certain substances such as diodone, mercurial diuretics, penicillin are secreted from the plasma into the proximal tubular fluid by active cellular work.