ACID - BASE BALANCE

Introduction

When we speak of the acid base balance of the kidney, the regulation of H_2 ion conc. in body fluid is actually meant.

Only slight changes in H_2 ion conc. from the normal value can causes the remarkable alteration in the rate of chemical reaction in cell, some being depressed and other accelerated. For this reason the regulation of H_2 ion conc is a most important thing.

To prevent the acidosis or alkaliosis, several spearial control system are available —

(a) All the body fluid are supplied with acid - base buffer which immediately combined with acid or base and thereby prevent the excess changes of H_2 ion conc.

(b) If the H_2 ion conc. changes measurable the respiratory center is stimulated to remove the CO_2 from the body fluid by the altering the rate of breathing.

(c) When the $[H^+]$ conc. changes from normal the kidney excreated either acidier or bases urine.

ROLE OF KIDNEY IN REGULATION OF $[H_2^+]$

The kidney controls the $[H^+]$ of the extra cellular fluid by excreating either acidic or alkaline urine. Excreting an acidic urine reduces the amount of acid in the E.C.F where as excreting an alkaline urine remove bases from the E.C.F.

Kidney normally eliminate 40-80 ml equivalent of non-volatile acids in 24 hours and conserves bases by minimizing their urinary elimination the PH of the glomerular filtrate is 7.4. As it enters to P.C.T then the PH falls about 6.9, then to about 6-6.5 in the D.C.T and finally 4.5-4.7 in the collecting duct.

The urinary PH is maintained by a co-operation between the urinary buffers and the renal ion exchange mechanism. Urinary buffer consists of bicarbonate and phosphate buffer which come into the urine by filteration from the glomeruli. As the filtrate proceeds along the tubuls, the ratio between acid member and base member of each urinary buffers falls progressively with a consequent fall in the urinary PH.

In renal ion exchange mechanism (3)
some Na^+ actively reabsorbed by the tubular cell, In exchang equivalent $[H^+]$ is secreted to the tubular filtration. Of the total amount of H^+ secreted in the filtrate, 85% are secreted by P.C.T and remaining 15% are secreted by D.C.T and collecting duct. The H^+ is arise from the ionization of H_2CO_3 formed by CO_2 and H_2O by carbonic anhydrase.

$$CO_2 + H_2O \underset{\text{anhydrase}}{\overset{\text{carbonic}}{\rightleftharpoons}} H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

Though most of the H^+ secreted by the proximal tubul but H^+ conc in the proximal tubular lumen does not exceed 3.2 times, that in the blood plasma, because of 3 reasons ⟶

(1) In the tubular filtrate, most of H^+ is secreted are buffered by HCO_3^-; filtrate from the plasma into the glomerular filtrate

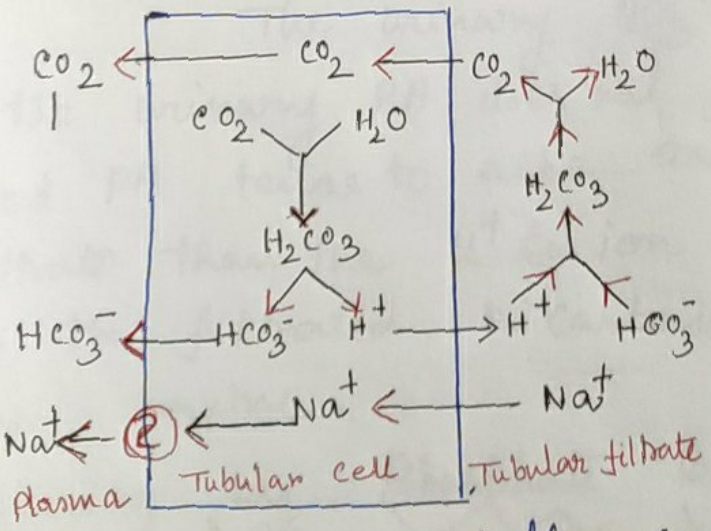
(2) H_2CO_3 formed in the P.C.T is immidiately removed through its clearage into H_2O and CO_2. Therefore it cannot play

any role in lowering PH.

(3) The tubular fluid continues to remain dilute in the P.C.T and is still isotonic to plasma. Thus the bicarbonate mediates buffering of H_2 ion allow neither the $[H_2]$ to exceed 1.26×10^{-7} mol/L nor the PH to fall bellow 6.9 in the P.C.T.

Buffering by Carbonate Buffer :-

The epithelial cell of the P.C.T, assending limb of Henly's loop and DCT secrets H^+ ion into the tubulare fluid by active transport mechanism This elastrated in the fig below-



The figur shows that the secretion process begins with CO_2 which diffuse into or formed by metabolism in the epithelial cell.

CO_2 under the influence of carbonic anhydrase decosiate into HCO_3^- and H^+ ion. H^+ ion is secreted into tubular by the mechanism of $Na^+ - H^+$ counter transport or antiport

Normally about 3.5 mmol of H^+ is secreted into tubular fluid every minute. Most of the H^+ is buffered by HCO_3^- and produce H_2CO_3, leaving a small amount of free H^+ to pass through urine. The H_2CO_3, formed in this process is immediately cleared into H_2O and CO_2. This CO_2 is diffuse very radially into the P.C.T and there from the blood.

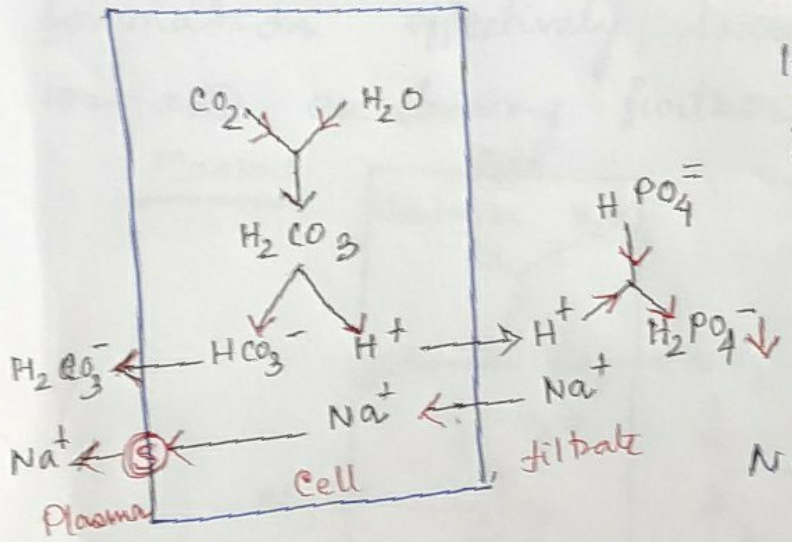
Thus whenever H_2^+ are secreted excess due to the fall of PH in plasma. Then the diffused HCO_3^- changes into carbonic acid by combined with H^+ ion and turn to the plasma as CO_2 to restored its bicarbonate ion cone.

The urinary HCO_3^- is negligible so long as the urinary PH does not exceed 6. But whenever blood PH tense to rise, much more HCO_3^- filtrate than the H^+ ion secreted. So some of the filtrated bicarbonate ion is eliminated in urine.

Buffering by Phosphate Buffer

Some secreted H^+ ion is buffered by phosphate buffer, perticularly in DCT. $HPO_4^=$ is filtrated in glomerular filtrate, accept H^+ ion to form $H_2PO_4^-$. This changes

the ratio of $HPO_4^{=} / H_2PO_4^{-}$ is 4 to ·02 and finally OH^{-} in urine. This low ratio is acidified the urine



But unlike H_2CO_3, $H_2PO_4^-$ is eliminated in the urine carrying some Na^+ and it consiquently causes urinary loss of Na^+. More over the conc of $HPO_4^{=}$ is far less than the bicarbonate ion and consiquently in the glomerular filtrate. So the total buffering capasity of the phosphate buffer is farless than the bi-carbonate buffer.

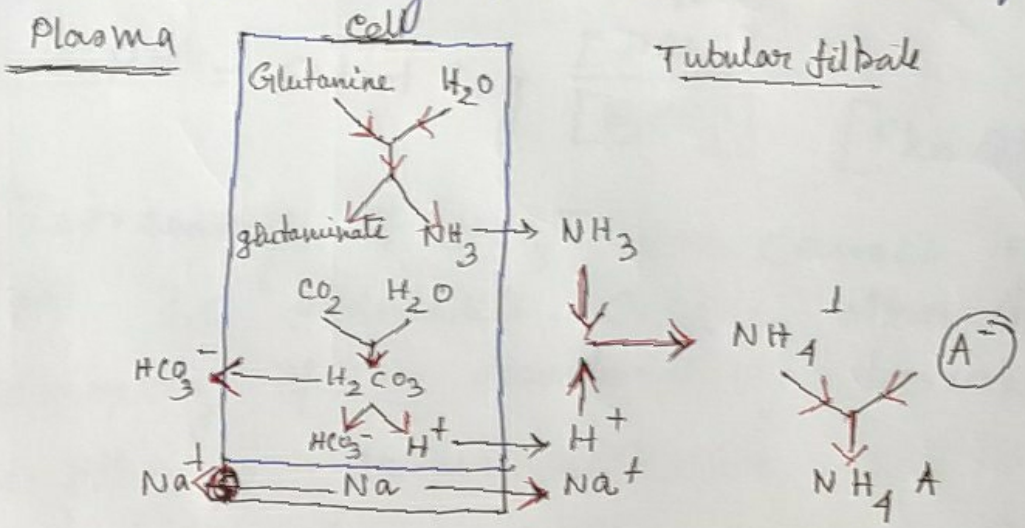
<u>Buffering by ammonia</u> :=

Some H^+ ions are buffered by the base ammonia, synthesized and secreted by the distal tubular cell.

Glutaminase hydolise glutamine in the renal mitochondria into glutaminate and NH_3. In the tubular lumen NH_3 combines with H^+ and forms NH_4^+ and secreted in the urine in association

with anion like Cl^- and $SO_4^=$, left behind by reabsorbed Na^+.

NH_4^+ behaves like a weak acid and it does not dissociated much. So its formation effectively lowers the conc. of H^+ ion and enabling further secretion of H^+



Elemination of free acids

Some H^+ ions are accepted by their strong congugated base such as lacted, aceto-acetate urate, and oxalate ion replacing the Na^+ reabsobed from their salt. Free weak acid may secreted without any base such as aceto acetic acid, uric acid, because the dissociation const. of these acid is very poor and their elimenation changes the urinary pH very little.

Renal Correction of acidosis and alkalosis

According Henderson Hasselbalch equation →

$$pH = P.Ka + \log \frac{[base]}{[acid]}$$

for the bicarbonate buffer this will be.

$$pH = 6.1 + \log \frac{[HCO_3^-]}{[H_2CO_3^-]} \quad [Pka \text{ of } H_2CO_3 = 6.1]$$

Increasing of HCO_3^- ion causes rise of pH i,e alkalosis. On the other hand increasing of the dissolved CO_2 decreasing the pH i,e. causes acidosis.

Correction of acidosis :- decreasing the elemination of urinary bicarbonate ion causes acidosis, So, as to retain bicarbonate ion in blood for raising the ratio of HCO_3^- / H_2CO_3.

In acidosis, the tubular cell secreted H^+ ion than that bicarbonate ion filtrated from glomeruli. This reason enable all bicarbonate ion to form H_2CO_3 which will reabsorbed as CO_2 in the tubul.

Connection of alkalosis

Increasing of bicarbonate ion causes alkalosis. The ratio of HCO_3^-/H_2CO_3 is low and blood pH is normal. In alkalosis blood carry high ammount of HCO_3^- that secreted in the tubul. So, tubular cell cannot reabsorbed HCO_3^-. So HCO_3^- ion is eleminated through urine. So conc. of HCO_3^- is decreased from blood.