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Role of the Kidney in Acid Base Balance

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ABSTRACT

Non-volatile acids including lactic acid and pyruvic acid, hydrochloric acid, sulphuric acid and phosphoric acid are produced during metabolic process.About50-150Eq of inorganic acid are flashed out through kidney in 24 hours. These acids are partially buffered with cations ,large amount of sodium in the distal tubules of the kidney some of the cations get reabsorbed and PH of the URINE falls .Kidney can buffer acids and conserve fixed bases in the production of ammonia from amino acid. It plays role to neutralize acids when they are formed in excess .In kidney disease ,tubular reabsorption of sodium in exchange for hydrogen and there occurs excessive retention of phosphates and sulphates .As acidosis takes place. It means it causes renal diseases, poisoning by an acid salt, and excessive loss of intestinal fluid and excessive losses of electrolyte.

Key words:
volatile, cations,
amino acids ,buffer,
Acidosis.

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INTRODUCTION:

The Kidney is device for actively reabsorbing, from a protein-free filtrate, ions whose conservation is important to the body-Na+ and other cations, Cl and to some extent HPO_4^{2-} and also glucose and amino, acids, Secondly, it reabsorbs almost all the water presented to it, a vital functions, for a terrestrial animal. Thirdly, it secretes a number of substances unwanted by the body, notably H^+ and NH_4^+, and in doing so helps regulate the acid-base balance of the body fluids.

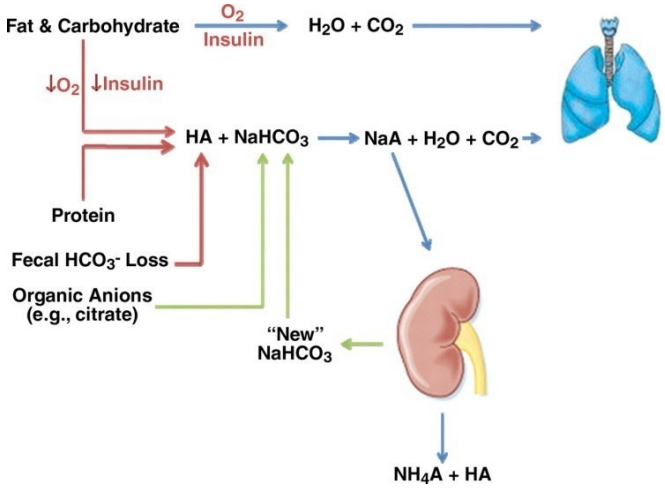

Fig-1 Overview of the role of the kidney in acid base balance .HA-Non-Volatile Acid [7].

MECHANISM OF KIDNEY FUNCTION

Fig-2 Segment HCO_3^-Reabsorption.The Percentage of the filtered load reabsorbed by each segment of the Nephron is indicated PT, Proximal tube. TAL,Thick ascending limb of the of Henel,DT,Distal convoluted tubule,CCD,Cortical collecting duct,MCD,Inner medullary collecting duct[7].

These functions are highly energy-intensive; at rest the kidneys consume about 7% of the total O_2 used by the body. The only primary coupling mechanism between metabolic energy and reabsorptive process so far discovered is the Na^+/K^+ pump. This is very concentrated in the kidney, especially in the cortex (ascending limb of loop of Henle). The pump appears to be located entirely on the basement membrane; it is absent from the luminal side of the cells (apical membrane). This is important as it allows Na^+ entry from the lumen to be coupled in a number of ways.

There is a discrepancy between of the activity of the Na^+/K^+ pump and the turnover of ATP, calculated from the QO_2. Present estimates are that about 50% of the Na^+ entry is linked directly to ATP hydrolysis; perhaps 25% could be exchanged for H^+, but the remaining 25% is unaccounted for, energetically speaking. There is good evidence that in the thick ascending loop of Henle, the apical membrane contains as active Cl^- pump, which brings Na^+ into the cells with it. In view of the absence of a Cl^- reservoir in the body, an active reabsorption of Cl^- is to be expected. However, even at this point the overall pumping of NaCl probably depends on the extrusion of Na^+ through the basement membrane.

It is known that the formation of H+ ions in the proximal convoluted tubules and elsewhere in the kidney depends on carbonic anhydrase activity (Fig. 32.6) since inhibitors of this enzyme prevent acidification of the urine and lead to the appearance in it of HCO_3^- ions. However, nothing is known of the mechanism of H^+ transport across the apical membrane, or whether a simple Na^+/H^+exchange would be energetically favourable.

Reabsorption and exchange mechanisms in the kidney, and their probably relation to the Na^+/K^+ pump. PCT= proximal convoluted tubule; PST = proximal tubule; MTAL, CTAL = medullary and cortical thick ascending limb; DCT = distal collecting tubule; CD = collecting ducts. The substance reabsorbed in the thick ascending limb is shown as NaCl. However, it is agreed that the primary process here is a chloride pump, although it is powered by a Na^+/K^+ ATPase, and Na^+ secondarily enters the tubule cells at this point.

In the proximal tubules, glucose and amino acids are actively absorbed by co-transport with Na+ as in the small intestine. Possibly amino acids are also absorbed by the α-glutamyltransferase mechanism described earlier. Phosphate and Ca^{2+} are also actively reabsorbed. Most of the K+ in the filtrate also appears to be reabsorbed in these tubules, so that the K^+in the filtrate also appears to be reabsorbed in these tubules, so that tubules, so that the K^+ in the filtrate also appears to be reabsorbed in these tubules, so that tubules, so that the K^+present in urine largely arrives by secretion (in competition with H^+) in the distal tubules and collecting ducts.

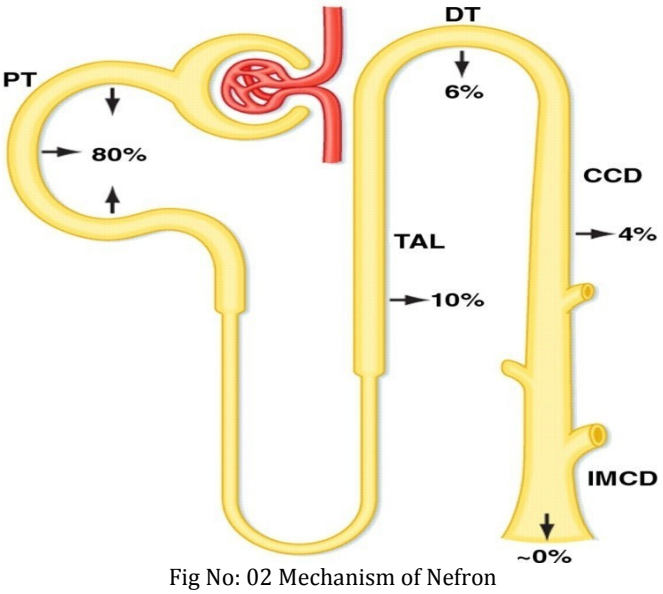

Fig No: 02 Mechanism of Nefron

FLUID FLOW MECHANISM

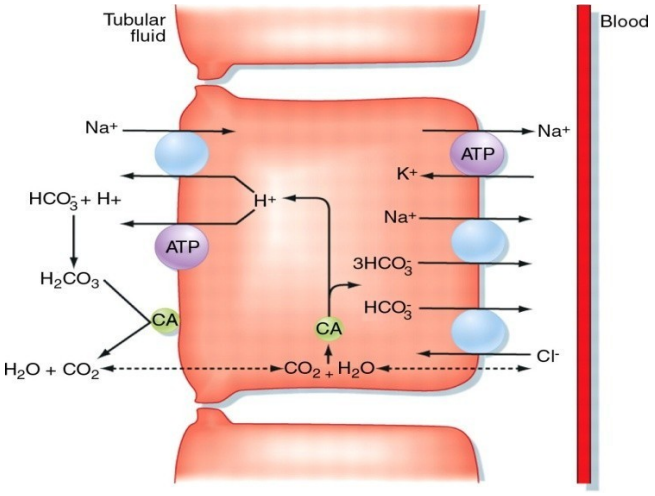

Fig-3-Cellular mechanism for proximal tubule H^+ and HCO_3^- Transport CA, Carbonic anhydrase[7].

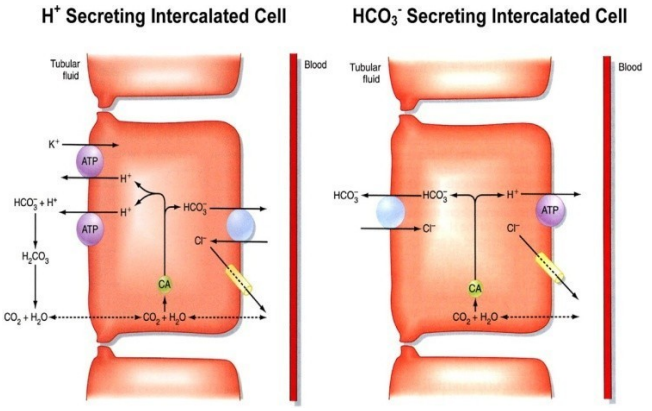

Fig-4-cellular mechanism of H+ and HCO3- secretion by intercalated cell of the collecting duct[7].

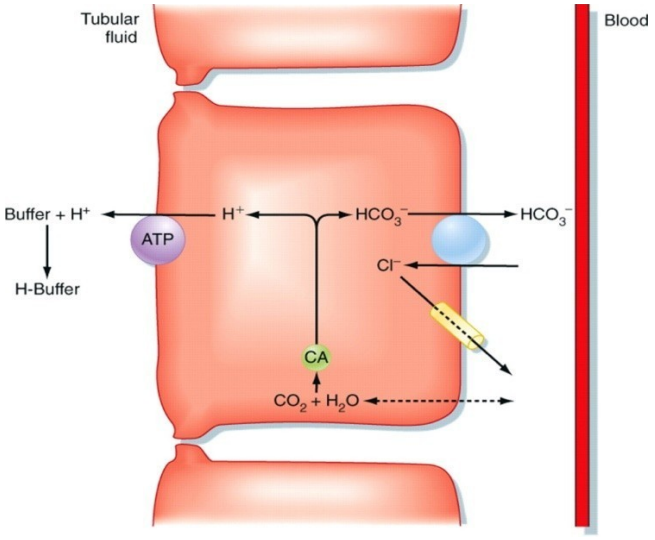

Fig-5-cellular mechanism for the generating "New HCO_3^- "through the titration of urinary buffer[7].

leaving a fluid roughly isotonic with plasma. Urine us however hyoertonic. The final concentration of the tubular fluid is carried out by a countercurrent mechanism, illustrated in Fig. 32.7. The mechanism depends on the establishment of a solute concentration gradient, running from cortex to medulla, maintained by differences in permeability of the tubules at various points.

The active part in this process is played by the ascending tubule, particularly the thick-walled part, and by the collecting tubule. The whole of the ascending tubule is almost impermeable to H_2O, and the upper (thick-walled) part possesses the Cl^- and Na^+ pump referred to earlier . This has the effect of forming in the distal tubule a rather dilute urine, in which the major solute is urea.

By contrast, the collecting tubule is permeable to H_2O, and, progressively towards the collecting duct, to urea also (but not to NaCl). The effect is to produce an increasingly hypertonic urine, in which urea concentration rises eventually ti about 75 mM.the matrix surrounding the tubules is hypertonic; at the upper (cortical) end because of NaCl (concentration 4-600 millionmoles), and in the lower (medullary) end because of a gradient of urea rising to 500 million moles, superimposed on the hypertonic NaCl solution. The total osmolarity at the bottom of the loop of Henle is thus about 1000 mOsm.

(a). Effect of the chloride and sodium pumps on the external osmolarity around the loop of Henle and the collecting ducts. Note that the descending limb of the loop (A) and the collecting tubule (C-D) are permeable only to H_2O, which moves out of the lumen to the higher osmolarity in the surrounding tissue. At the beginning of the ascending loop, the filtrate has become concentrated, so that Na+ and Cl^- ions are pumped out against a concentration gradient.

(b). Effect of Urea permeability on the external osmolarity around the loop of Henleabd the collecting ducts. It is mainly the collecting ducts (D) that are permeable to urea, which flows out from the urine, in which it has become concentrated. The extratubular fluid thus becomes very hyperosmolar in the inner cortex and medulla of the kidney, which assists water loss from the tubular fluid as it flows from A to B. the figures in the left-hand margin refer to the osmolarity with respect to urea.

We may now return to the thin descending loop of Henle, in which the fluid is originally isotonic, but loses water as it flows down into the cortex, so that at the bottom of the loop its

concentration is also 1000mOsm. As it enters the ascending limb, it loses some NaCl and gains some urea by diffusion, but as already mentioned, does not gain H_2O.

The channels for water and for urea in the distal tubules and collecting ducts are controlled by vasopressin, which opens them so that water moves out of the ducts. Vasopressin is known to increase adenylcyclase activity in the membrane and hence the concentration of cAMP. There is increasing evidence that cAMP activates the phosphorylation of one or more membrane protein, which presumably alters the configuration of the membrane, but the precise details of the way in which permeability is changed are not known at the present time.

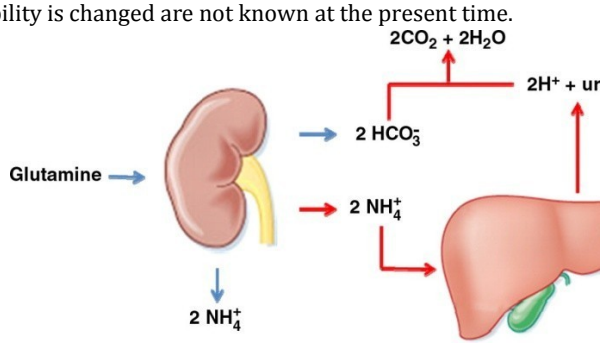

Fig-6-General scheme for the production of HCO3-and NH_4^+ from RENALMETABOLISMS of GLUTAMINE. Showing the conversion of $NH_4^+$to urea by the liver, which generates and H^+ and thus consumes HCO_3^-[7].

CONTROL OF ACID-BASE BALANCE.

The formation of acid, i.e., proton-donating, groups is more common in the body than is the formation of bases, i.e. proton acceptors. The body's defences against acidosis, by the bicarbonate/CO2 system, and by other mechanisms, are more efficient than the defence against alkalosis. A mild degree of acidosis is almost a normal condition: the oxidation of the –SH of cysteine to sulphate, together with the hydrolysis of phosphor-diesters, e.g., nucleic acids, to inorganic phosphate, are a continuous source of non-volatile acid. On a largely vegetarian diet the oxidation of salts of acids such as citrate and malate, effectively to $KHCO_3$ may on the other hand induce a mild alkalosis.

These disequilibria of dietary origin are not serious enough to cause concern. There are processes which release acid into the blood (acidaemia) in sufficient amounts to activate the physiological defence mechanisms; they can be either acute or chronic. The most common are lactic acidosis, usually from intense exercise, and keto-acidosis which is usually only serious if it arises from poorly-controlled diabetes. Other chromic acidosis can arise from inborn errors of metabolism, such as phenylketonuria or maple syrup urine disease, but in these the acidosis is usually less important than the other consequences.

(a). Respiratory response: When acid metabolites enter the blood the pH, falls, and the ratio $[HCO_3]$ / $[CO_2 + H_2CO_3]$ also falls. Stated in another way, the reactions occur.

$HA \rightarrow H^+ + A^-$

$H^+ + HCO_3 \rightarrow H_2CO_3$

Their equilibria are very far to the right. H_2CO_3 dissociates almost completely into H_2O and CO_2 and pCO_2 increases the amount of CO_2 blown off in the lungs. This brings the ratio $[HCO_3^-]$ / $[CO_2 + H_2CO_3]$ which is equivalent to the ratio $[HCO_3^-]$ /qpCO_2 back to normal, and the pH returns to normal.

The acidosis has been compensated by a respiratory response, but the composition of the extracellular fluids is not normal because the absolute concentration of HCO_3^- has been reduced, and the anion A^- of the acid metabolite is still present. If the acidosis is only temporary, the metabolite may be metabolized (as after exercise) or else excreted. The acid-base status then slowly returns to normal with less CO_2 being blown off in the lungs, and the $[HCO_3^-]$ in extracellular fluids rises to its normal level.

This description has concentrated on the response of the bicarbonate/CO_2 system. There are other buffers in blood and extracellular fluid which increase the resistance of the body to changes in $[H^+]$. The most important of these is haemoglobin. Each molecule contains 36 histidyl residues, many of which have *p*K's close to 7.4; only 4 of them are involved in the change of acidity of Hb on oxygenation. The power of the others is quite independent of the state of oxygenation of the red cells. Plasma proteins also contain histidiyl residues, but they are not quantitatively sp important as those of haemoglobin.

From the Henderson-Hasselbalch equation it is possible to determine the acid-base status of an individual by measuring any two of the variables pH, total CO_2 and pCO_2. In interpreting the results, for example by the Siggaard Andersen nomogram, it will be observed that the haemoglobin contents of the blood is taken into account. This is in order to allow for the extra buffering power of the histidyl residues, as described in the previous paragraph.

Apart from the pH itself (value outside the range 7.0-7.6 are barely compatible with life), the amount of Bronsted base (proton acceptors) still remaining in the blood and extracellular fluid is the most important quantity, because this determines the remaining capacity of the respiratory acid-base system, including the blood proteins to respond to further acidotic episodes. It is usual to specify an HCO_3^- concentration of 24 m Eq/litre at pH 7.4, or a pCO_2 of 40 mmHg, as normal. A concentration of HCO_3^- blow this level, when corrected to pH 7.4 is characterized as a base deficit. The base deficit read from the nomogram will be somewhat larger than the HCO_3^- below this level, when corrected to pH 7.4 is characterized as base deficit. The base deficit read from the nomogram will be somewhat larger than the HCO_3^- below deficit read from the nomogram will be somewhat larger than the HCO_3^- deficit, because of the haemoglobin (and plasma protein) supplementation.

This explanation of response to acidosis has been written in terms of an acid metabolite arising in tissues and accumulating in blood. There can also be a *respiratory* acidosis, in which CO_2 is not removed at the normal rate from the lungs. This may be due to acute respiratory failure, drug-induced respiratory paralysis or lung congestion. In these situations pCO_2 will be high with pH low, but $[HCO_3^-]$ will be normal or even slightly high.

(b). Renal response; It is clear that in respiratory acidosis the acid-base status of the blood cannot be returned to normal by a physiological response of lung function. If the kidneys are functioning normally, it is they which compensate for the disturbance. The kidneys also play a part in compensating acidosis of non-pulmonary origin, unless the latter are very short-lived. A brief outline of the mechanism of kidney function is included at the end of this chapter. Here the chemical events will be summarized, with the kidneys treated as a 'black box'.

The response to respiratory acidosis provides the simplest picture. From the Henderson-Hasselbalch equation, one may infer that the pH will be restored to normal if the concentration of HCO_3^- increase, so that the ratio $[HCO_3]/[CO_2+H_2CO_3]$ returns to normal. In ordinary circumstances, HCO_3^- is

completely absorbed from the glomerular filtrate (for a mechanism see Fig. 32.8). Any increase in plasma [HCO_3^-]therefore depends on two factors. The first is exchange of $H^+$for Na^+, so that in effect the tubule cells are manufacturing H_2CO_3 from endogenous CO_2 but are secreting $NaHCO_3$ into the plasma. The second factor (usually neglected) is the constancy of the osmotic pressure of plasma and ECF; this demands that an increase of [HCO_3] must be balanced by a decrease of [Cl^-]. There must therefore be an increase in the net excretion of Cl^- into urine.

METABOLIC ACIDOSIS

As we have seen, the respiratory response to a mild metabolic acidosis may leave the blood pH completely normal, but there will be a base deficit, a lowered pCO_2, and an excess of the corresponding anion in the plasma. If this anion is lactate, it will be removed from plasma, chiefly by liver. Other anions must be excreted, but excretion is not normally a problem– the ion is Fig. 32.8. The acidification of urine and ammonium ion excretion by the kidney. The diagram shows reabsorption of HCO_3^- both by diffusion into the tubular cells and by conversion to H_2CO_3 (H_2O + CO_2) NH_4^+ is shown exchanging with Na^+; the latter also exchanges with H^+ or K^+. The permanent anion A is not reabsorbed, and leaves the kidney largely neutralized by NH_4^+.

Simply not reabsorbed in the tubular system– but maintenance of electrical neutrality is a problem with which the body may find it very difficult to cope. In effect, unless the metabolic acid is undissociated at the pH of the urine, an equivalent cation has to be excreted for every anion. This cannot be H+ because of the limited capacity of the kidneys to excrete an acid urine. The point may be made explicit by reference to sulphate a normal constituent of urine. Normal urine contains about 50 m Eq/litre of SO_4^{2-}, but one does not suppose that urine is 0.05 N in H_2SO_4. The sulphate ions are balanced by cations, either Na^+ or K^+. this daily occurrence is not a problem, particularly as the intake of both Na^+ and K^+ are usually greater than minimal requirements.

However, in serious metabolic acidosis the provision of cations, whether Na^+, NH_4^+, intercellular K^+ or Ca^{2+} from bone, may become limiting so that renal compensation of acidosis is incomplete. Before outlining this important topic of cations in urine, it is convenient to discuss the capacity of the kidneys to acidify urine.

EXCRETION OF H^+ IN URINE

The minimum pH of urine is about 4.5: this is equivalent to 0.03 mEq/litre, a trivial amount. The only way for excretion of H^+ to be increased is by the simultaneous excretion of a Bronsted base – a proton acceptor with a pK of 4.5 or greater. In normal urine the only such base of importance is HPO_4^{2-}. Daily excretion of phosphate is about 50 mEg. The amount of H^+ removed from solution by transfer if phosphate ion (pK 6.8) from an environment of pH 7.4 to one of pH 4.5 is about 80% of the phosphate excreted, i.e., about 40 mEq in a normal person. This is a maximum; if the urine pH is 6 the amount of proton removed is slightly less. All other acid excretion has to be balanced by fixed cations, or by proton uptake by the acid anion itself.

The acid to be found in urine have a wide range of pK's. As already mentioned, H_2SO_4 will always be fully ionized. Lactic acid (pK 3.9) will also be fully ionized, but the second dissociation constant of malic and citric acids (-5) ensures that one $RCOO^-$ of each of these acids can act as a proton acceptor in urine. These acids are metabolically unimportant, bit acetoacetic acid (pK 3.6) and 3-hydroxybutyric acid (pK 4.4) can be excreted in considerable amounts in ketosis. Acetoacetic acid will always be fully ionized but 3-OH butyrate can accept about0.5H^+equilelant per equivalent of acid at pH 4.5 There is usually more 3-OH butyric than acetoacetic acid in ketotic blood and urine.

There are two Bronsted bases that can appear in urine, which seem at first sight to be suitable acceptors for a significant amount of H^+. These are bicarbonate and ammonia;

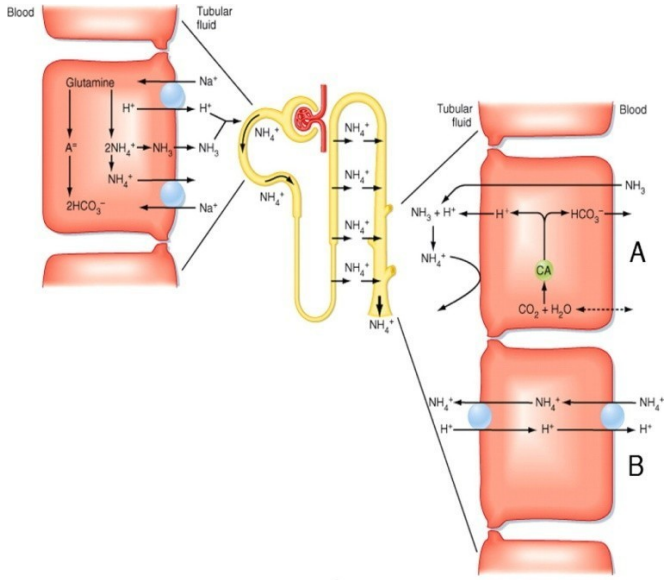

Fig-07 Renal handling of NH_4^+. Two mechanisms for the secretion of NH_4^+ by the collecting duct are shown. *A*: nonionic diffusion and diffusion trapping of NH_3. *B*: secretion of NH_4^+ via Rh glycoprotein (RhCG)[7].

(A).$H^+ + HCO_3^-$ $\xrightarrow{\text{base}}$ H_2CO_3pK 6.1
And

(B).$H^+ + NH_3$ $\longrightarrow$ NH_4^+pK 9.2

In neither case, however, do these reactions lead to a net loss of H+ from the kidney. H_2CO_3 formed on (a) returns (as CO_2) to the tubule cells and re-dissociates into H^+ and HCO_3^- there. The bicarbonate is transferred to the blood, but the H^+ remains in the cells.

With (b), the proton is retained in the cells before the uncharged ammonia diffuses into the lumen Thus for every proton bound in the urine, an equivalent proton is gained by the tubule cells.

Failure of HCO_3^- to act a proton acceptor in urine. The H_2CO_3 that is formed diffuses back into the tubular cells and re-dissociates forming the same amount of H^+ there as before (b) Failure of HN_3 to buffer protons in urine. The hydrolysis of glutamine release NH_4^+ in the tubule cells. For this to pass through the wall of the lumen as NH_3 in must leave a proton behind, which is exactly equivalent to the proton that is taken up in the luminal fluid.

It is nevertheless true that taking protein catabolism as a whole, the transition from the It is nevertheless true that taking protein catabolism as a whole, the transition from the neutral peptide bond –CO–NH– to the neutral molecul urea H_2N–CO–NH_2 involves no net proton changes, while the transition from the peptide bond to the formation (and excretion) of an ammonium ion NH_4^+ result in the formal loss of one H^+ from the system. This approach is unrewarding, however, because it implies that urea and ammonia are alternatives which replace each other according to the acid-base status of the individual. In fact, NH_4^+ formation and excretion is entirely under the

control of the kidney, while urea synthesis occurs quite independently in liver, in response to the nitrogen balance of the organism, and can be manipulated independently of the acid base state. It is more useful to consider NH_4^+ as a slow, but very important mechanism for conserving cation, confined entirely to the kidneys. This is considered in more detail in the next section.

It must be remembered that we are here considering only the net loss to the body of H^+ the total rate of secretion of H^+ into the lumen is very much greater than the net loss.

ALKALI CATIONS IN ACIDOSIS

Normal urine contains about 150 mEg/litre Na^+ (and Cl^-) and about 60 mEg/litre. It also contains about 40 mEg/litre NH_4^+ and is slightly acid. The amount of Na^+ and K^+ excreted is very variable because it depends on the intake (usually in excess of requirements and on other circumstances e.g. loss through sweating. With a normal acid-base status, the loss of Na^+ (and Cl^-) can be reduced almost to zero to conserved cation, although there is always a slight loss of K^+ (because there is not plasma directed K^+ pump).

When the urine becomes more acid than pH 6 the compensatory mechanism described above come into play. Buffering by phosphate actually conserves Na^+ because of the effective replacement of Na_2HPO_4 (in plasma) by NaH_2PO_4 (in urine), but the excretion of organic anions in metabolic acidosis or Cl^- in respiratory acidosis necessarily implies the loss of fixed base which is very largely Na^+. there is only a limited reservoir of Na^+ within the body, and an acute massive acidosis can lead to immediate problems of reduced extracellular fluid volume, increased haematocrit, and so on. In chronic severe acidosis, there is some supplementation by mobilization of Ca^{2+} from bone, K^+ from cells (by replacement with H^+) and even of Mg^{2+}. However the major relief of Na^+ loss comes from quite a different mechanism.

This involves replacement of Na^+ by NH_4^+(produced by the hydrolysis of glutamine in the kidney). In general the mechanism is slow-acting; it takes about 5 days for a significant change to become established although increased NH_4^+ output is seen after short-term lactic acidosis produced by exercise, or respiratory acidosis induced by re-breathing CO_2. However the final response, which comes partly from synthesis of new glutaminase protein, can be very large. 500-600 m Eg NH_4^+ can be secreted per day over an indefinite period and Na^+ excretion can fall well below the normal level. The glutamine required for this mechanism is synthesized in liver, but as mentioned above, the liver does not regulate amino acid group catabolism. A negative N balance is quite common in acidosis.

It should be pointed out that the continued excretion of large quantities of anions, whether neutralized by NH_4^+ or not, does produce a marked dieresis. If the acidosis is a result of uncontrolled diabetes, this is likely to be made worse by glucosuria.

ALKALOSIS

The body's defences against alkalosis are less effective than against acidosis. This is because the H_2CO_3/HCO_3^- buffer system has less capacity at pH's above 7.4 and also because the urine has very little capacity to buffer OH ions, and indeed no known mechanism for secreting these ions directly. It is fortunate that alkalosis is not as common as acidosis: quite often it is a response to hypokalaemia.

(a) Respiratory response: the respiratory centre is sensitive to pCO_2 and to pH. A rise in pH will cause under-breathing, which raises the blood pCO_2 so bringns the ratio $[HCO_3^-]/[CO_2 + H_2CO_3]$ back to normal. However under breathing leads to O_2 deficit and thus cannot be continued indefinitely the respiratory response to alkalosis is consequently limited.

(b) Renal response: Even if there were to be direct secretion of OH^- into urine (e.g., in exchange for Cl^-) the reaction would ensure that bicarbonate ion would be the apparent product. Thus the response to alkalosis resolves itself into the secretion of an alkaline urine containing HCO_3^-. This has immediate consequences for electrolyte balance because a cation (usually Na^+) must also be excreted. The excretion of NH_4^+ is not possible because the hydrolysis of glutamine in the kidney is inhibited almost completely by a rise in pH.

BICARBONATE IN URINE

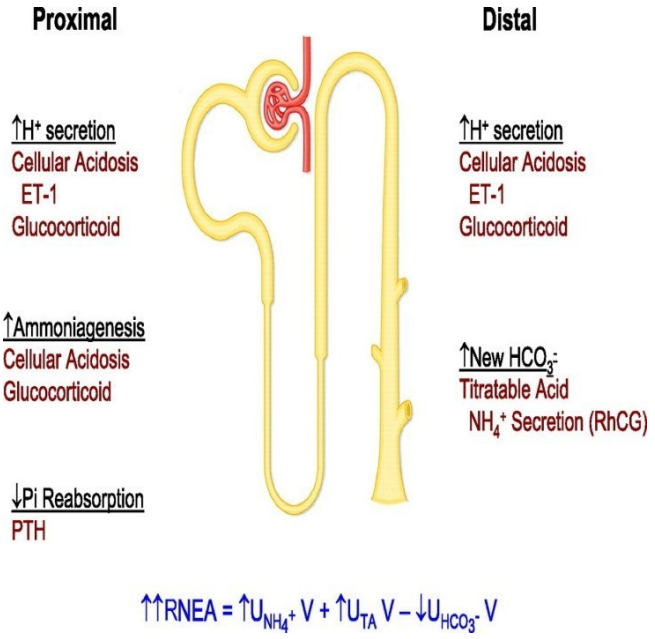

Fig -8 Response of the kidneys to acidosis.. ET-1, endothelin-1; PTH, parathyroid hormone; RNAE, renal net acid excretion; U, urine concentration; V, urine flow rate; TA, titratable acid[7].

The glomerular filtrate contains ca. 25 mM HCO3-but normal urine contains little or no bicarbonate. As the filtrate volume is approximately 200 litres/24 hr. some 5000 mEg of HCO_3^- are removed from urine every day. Most people think that the mechanism is by secretion of H^+, which converts the HCO_3^- and subsequently to CO_2, which diffuses out from the lumen This would imply that the total excretion of H^+ into the lumen of the tubules would also be of this order of magnitude. The mechanism is for the moment irrelevant; the question is, what controls the appearance of the ion in the final urine?

Recent research has shown that reabsorption of HCO_3^- is inversely related to the arterial blood volume. If the volume is expanded above normal, reabsorption of HCO_3^- and Na^+ is depressed, HCO_3^- begins to appear in urine, and a threshold maximum concentration of 28 mEg/l in plasma has been observed experimentally.

However, it the blood volume is below normal, no plateau for HCO_3^-rebsorption is seen. The view that there is no absolute plasma maximum value is strengthened by the fact that in respiratory acidosis the plasma (HCO_3^-) may rise to 40 mEg/l, yet no bicarbonate appears in the urine.

If the effects of changes in blood volume are allowed for, it seems that HCO_3^-begins to appear in urine when $[H^+]$ secretion falls off, as a result of rising pH. Although this agrees in a general way with the mechanism depicted in the precise relation between pH and H^+ secretion is not known.

VOMITING:

Loss of any fluid with a ratio of $[Cl^-]/[HCO_3^-]$ greater than that found in plasma typically gastric juice- will lead to alkalosis. Control by excretion of an alkalosis urine may be difficult because the fluid loss will reduce the blood volume .

Hypokalaemia: In part of the renal tubules there is a secretory mechanism in which K^+ and H^+ ions compete with each other. Consequently if the plasma (K^+) is low, more H^+ ions are secreted into the lumen, and the plasma becomes alkaline. It is to be thought that this alkalosis could only be released by administration of K^+, but it has been found that expansion of the extracellular fluid volume with NaCl solution will depress HCO_3^- reabsorption sufficiently to correct the alkalosis.

A frequent cause of potassium alkalosis is increased aldosterone in the blood, which increases the reabsorption of Na^+ and the excretion of K^+.

SUMMARY:

The most important component of the renal response to acidosis is the ability of the kidney to increase ammoniagenesis and NH_4^+ excretion. In the setting of acidosis, it is often useful to calculate the urinary net charge (UNC):

$UNC = [Na^+] + [K^+] - [Cl^-]$

The role of the kidneys in the acid-base balance is to excrete net acid (RNAE) at an amount equal to daily NEAP. In so doing, the kidneys generate "new HCO_3^-" to replace the HCO_3^- lost in the titration of net endogenous acids. RNAE reflects the transport of H^+ and HCO_3^- by the cells of the nephron, which, in turn, serves to reabsorb the filtered load of HCO_3^-, excrete TA, acidify the urine, and excrete NH_4^+.

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