Kidney function in maintaining acid-base balance

Maintaining a constant pH is closely related to maintaining the concentration ratio of conjugated **acids** and **bases** of plasma buffers , especially **bicarbonate buffer** . Plasma concentration of conjugated acid (H 2 CO 3 , i.e. CO 2) is regulated by controlling pCO 2 by changes in pulmonary ventilation . The role of the kidneys is therefore to **maintain the concentration of the conjugate base HCO 3 − .**

Under normal circumstances, more bicarbonate is returned from the kidneys than is supplied to them by the *a. renalis* . This is due to the kidney's ability to produce urine with a low pH (4.5-5.0).

In addition, this amount serves to neutralize non-carbonic acids that were created by metabolism or are from food. In addition, by supplying bicarbonate, the kidneys prevent the decrease of buffering bases.

Bicarbonate is **freely bufferable in the glomeruli** – if it were to be excreted in the urine, its reserves would soon be depleted. Therefore, it is intensively **resorbed** .

The kidneys therefore maintain acid-base balance (hereafter referred to as ABR) *by two mechanisms:*

1. **by regulating the reabsorption of bicarbonate ;**
2. **by excreting 40–80 mmol H + per day** – not excreted freely (urine pH would not correspond to this) – buffered by urinary buffers and bound to NH 3 .

- The kidneys carry out these two processes by secreting H + into the tubular fluid, where bicarbonate is formed from CO 2 and water in the tubular cells.
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Bicarbonate resorption

Tubular transport mechanism

- Bicarbonate resorption is coupled with the reaction (catalyzed by carbonic anhydrase):

  H 2 O + CO 2 H 2 CO 3 [H] + + [HCO 3] − .

- **Formation of H +** : either according to the above-mentioned reaction, or the water molecule is divided into:

  H + and OH −

  While OH − reacts with CO 2 to form bicarbonate (carbonic anhydrase). It follows from both possibilities that the amount of formation and secretion of H + depends on the activity of carbonic anhydrase and pCO 2 .

- The proximal tubule reabsorbs up to 90% of the bicarbonate and reduces the pH of the tubular fluid. H + go into the lumen against the electrochemical gradient **secondarily by active transport by the Na + -H + transporter** (sodium from the lumen into the cell, in exchange for H +).
- Bicarbonate diffuses into the peritubular fluid.
- Balance of the entire process: secretion of H + into the lumen – acidification of the tubular fluid, return of Na + and HCO 3 − ions to the **blood** and thus also to ECT.
- Bicarbonate is additionally resorbed in the **ascending limb of the loop of Henle**, in the distal tubule and the collecting duct.
- What does this imply? As a result of resorption in the urine, the concentration of bicarbonate gradually decreases, and as a result of secretion, the concentration of H + increases.

Regulation of bicarbonate resorption

- **Resorption is not constant** - it rises when there is a lack of bicarbonate in the body and vice versa.
- Resorption is affected by:
  - **The amount of HCO 3 − in the tubules and thus the luminal pH:**
    - with a change in concentration, resorption changes (in the same direction),
    - as the pH of the tubular fluid increases, the secretion of H + increases ,
  - **Peritubular blood pH :**
    - the resorbed proportion of bicarbonate rises with a fall and falls with a rise in peritubular blood pH (opposite direction).
  - **Changes in ECT volume:**
    - Hypovolemia (reduced ECT content) causes an effort in the kidneys to retain Na + (its concentration in the urine decreases and, in order to maintain electroneutrality, the same amount of Cl − as the main anion of the glomerular filtrate must be resorbed . Once the concentration of Na + in the filtrate is, for example, 140 mmol/ la Cl − 115 mmol/l, only 115 mmol/l Na + can be resorbed. The other moles must be resorbed together with the secretion of H + and or K + .)
  - **Changes in plasma concentration of K + :**
    - **Reciprocal relationship** between plasma K + concentration and bicarbonate resorption.

- Aldosterone :
  - stimulates the distal secretion of H + + stimulates the proton pump .

Acid secretion

- Secreted H + is responsible for the resorption of bicarbonate – when more H + is added to the urine, more bicarbonate is formed in the tubular cells, which moves into the blood (for every 1 mmol of H + that reacts with a non- **bicarbonate buffer** in the tubular fluid , in the tubular cell will form 1 mmol of bicarbonate).
- The most important **non-bicarbonate buffers** in the tubular fluid: phosphate buffer , NH 3 , creatinine .
- An important mechanism for the excretion of H + is the **production of NH 3** (the ability of tubular cells to increase ammonia production is the **main adaptive response to acidosis**).
  - NH 3 easily diffuses through the membrane, it is soluble in fats, the ionized form is also in water (however, it diffuses less through the membranes – when it forms in the lumen, it cannot get out).
    - It arises in the tubular cell mainly from glutamine .
    - The main factor regulating the movement of NH 3 into the lumen is the pH of the tubular fluid.

Links

Related Articles

- Kidney (histological preparation)
- Kidneys
- Nephron
- Acid-base balance
- Acidosis
- Alkalosis

References

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