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BIOCHEMICAL PROCESSES AND STRUCTURES IN KIDNEY FUNCTION

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Abstract
The kidneys play a critical role in maintaining bodily homeostasis by carrying out various essential functions, such as filtering the blood, regulating water-electrolyte balance, acid-base homeostasis, and excretion of waste products. These functions are supported by biochemical reactions that occur within the kidneys and ensure their basic physiological processes, including homeostasis, endocrine activity, and metabolic processes.

Keywords: Kidney biochemistry, structural processes, glomerular filtration, tubular reabsorption, metabolite excretion, electrolyte balance, acid-base state, protein metabolism, lipid metabolism, nitrogen metabolism, homeostasis regulation, renin-angiotensin system, nephron.

INTRODUCTION

To analyze data from biochemical tests for diagnosing kidney disorders, a method for structuring information has been employed. This method involves describing functional abnormalities in individual renal structures that lead to specific clinical symptoms and a distinct set of biochemical markers. This approach aids in effective diagnosis and treatment.

Structural and Functional Components of the Kidney

The basic structural unit of the kidney is the nephron. It consists of the glomerulus, which filters blood, the proximal tubule, which reabsorbs water, ions, and nutrients, the Henle's loop, which is involved in urine concentration, the distal tubule, responsible for acid-base regulation, and the collecting duct, which ensures final urine formation.

Blood filtration through renal glomeruli occurs due to hydrostatic pressure in glomerular capillaries, osmotic pressure from plasma colloids, and the selective permeability of the basement membrane. The primary urine produced in this process contains low-molecular-weight compounds, such as water, electrolytes (e.g., sodium, chloride), glucose, and amino acids (e.g., urea), but it lacks proteins and other blood components.

Reabsorption and Secretion in the Renal Tubules

Reabsorption refers to the return of substances from the primary urine back to the blood. Key mechanisms involved in this process include active transport (sodium-potassium pumps, glucose transporters), passive diffusion (water, urea), and osmotic gradients (movement of water following sodium ions). Secretion involves the removal of organic acids, bases, and xenobiotics from the blood into the nephron lumen via membrane transporters.

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Regulation of water and electrolyte balance is carried out by the kidneys. Hormones such as antidiuretic hormone (ADH), aldosterone, and parathyroid hormone regulate the reabsorption of water, sodium, and potassium, respectively, while also controlling calcium and magnesium levels. Maintenance of acid-base balance is achieved through the reabsorption of bicarbonate and the elimination of hydrogen ions. Ammonia and phosphate buffers are also formed to maintain blood pH.

Elimination of nitrogenous waste products, such as urea (from amino acid metabolism), creatinine (from creatine phosphate in muscles), and uric acid (from purine catabolism), is facilitated by the kidneys.

In addition to their metabolic functions, the kidneys also perform endocrine functions. They synthesize and activate hormones like erythropoietin (stimulating red blood cell production), renin (regulating blood pressure), and calcitriol (active form of vitamin D), which are involved in calcium and phosphate metabolism.

Biochemical blood and urine tests are essential for assessing kidney function and identifying conditions such as chronic kidney disease (CKD) and glomerulonephritis.

Regulation of water / electrolyte balance

The kidneys play a key role in maintaining the body's water / electrolyte balance by regulating sodium, potassium, calcium, magnesium, and chlorine levels. The main hormones involved in this process are:

- antidiuretic hormone (ADH) — regulates water reabsorption;
- aldosterone-stimulates sodium reabsorption and potassium excretion;
- parathyroid hormone-regulates the exchange of calcium and phosphorus.
- Acid-base balance

The kidneys maintain the pH of the blood by performing the following functions:

- bicarbonate reabsorption;
- removal of hydrogen ions (H+);
- formation of ammonia (NH_3) and phosphate buffer.

Elimination of nitrogenous metabolites

The kidneys remove protein metabolism products, such as:

- urea (the end product of amino acid metabolism);
- creatinine (produced by the breakdown of creatine phosphate in the muscles);
- uric acid (a product of purine catabolism).

Endocrine function of the kidneysThe kidneys synthesize and activate important hormones, such as:

- erythropoietin-stimulates the formation of red blood cells;
- renin-participates in the regulation of blood pressure;
- calcitriol (active form of vitamin D3) - regulates the exchange of calcium and phosphorus.

Biochemical tests of blood and urine play a key role in assessing the condition of the kidneys. They can detect diseases such as chronic kidney disease (CKD), glomerulonephritis,

pyelonephritis, and kidney failure. These tests help assess the filtration, excretory and endocrine functions of the kidneys, as well as determine the water-electrolyte balance.
Secretion is the process of removing organic acids, bases and xenobiotics from the blood into the lumen of the nephron with the participation of membrane transporters (OAT, OCT).

The main biochemical parameters of blood include:

1. Evaluation of the filter function:
2. Creatinine (norm: 44-106 mmol / L): an increase indicates a decrease in glomerular filtration.
3. Urea (normal: 2.5-8.3 mmol / l): increases with impaired excretion of nitrogenous metabolites.

Glomerular filtration rate (GFR, normal: >90 ml / min/1.73 m2): a decrease indicates renal failure.

2. Indicators of nitrogenous metabolite excretion:

Uric acid (normal: 150-420 mmol / L): its increase may be a sign of gout or kidney failure. Azotemia: excessive accumulation of nitrogenous substances in the blood when renal function is impaired.

3. Electrolyte balance:

Sodium(135-145 mmol / L): its level changes with renal failure. Potassium (3.5-5.1 mmol / L): hyperkalemia is characteristic of acute renal failure. Calcium (2.2–2.6 mmol / L) and phosphorus (0.81-1.45 mmol / L): the balance of these elements is important in chronic kidney disease.

4. Acid-base state:

- Bicarbonates (HCO_3^-, 22-29 mmol / L):
- a decrease indicates metabolic acidosis.
- Anion gap (AG, 8-16 mmol / L): increases with renal acidosis.

5.Indicators of protein metabolism:

Total protein (65-85 g / l) and albumin (35-50 g / L): reduced in nephrotic syndrome. Proteinuria: a sign of glomerular filter damage.

Biochemical urine tests

1. General urinalysis

Relative density of urine: a decrease indicates renal failure. Proteinuria (protein in the urine): indicates damage to the renal membranes.
Glucosuria: a possible sign of diabetic nephropathy.

2. Specific tests

Zimnitsky test: evaluates the concentration capacity of the kidneys.
Nechiporenko urine test: detects inflammatory processes (glomerulonephritis, pyelonephritis).
Daily proteinuria: determines the level of protein in the urine.

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Markers of inflammation and autoimmune diseases

C-reactive protein (CRP): increased in pyelonephritis. Glomerular basement membrane antibodies: important in autoimmune kidney diseases.

A comprehensive study of the biochemical parameters of blood and urine allows timely diagnosis of kidney diseases, determine their stage and monitor the effectiveness of treatment. These tests are an integral part of the diagnosis and monitoring of nephrological pathologies.

Conclusion

The kidneys play a central role in maintaining the body's homeostasis, performing filtration, excretory, metabolic, and endocrine functions. Violations of the biochemical processes in the kidneys lead to the development of diseases such as chronic renal failure, nephrotic syndrome and hypertension. Understanding the biochemistry of the kidneys allows us to develop effective methods for the diagnosis and treatment of renal pathologies.

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