PATHOPHYSIOLOGY AND FUNCTIONS OF THE KIDNEYS: AN INTEGRATIVE OVERVIEW

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Abstract: The kidneys are essential for maintaining internal homeostasis through their roles in filtration, reabsorption, secretion, and hormone production. Disruption in kidney function leads to a wide range of systemic complications. This review discusses the primary physiological functions of the kidneys and explores the underlying pathophysiological mechanisms in common renal diseases such as acute kidney injury (AKI), chronic kidney disease (CKD), and glomerulonephritis.

Keywords: kidney, nephrology, renal physiology, renal failure, glomerular filtration, AKI, CKD

1. Introduction

The kidneys are paired bean-shaped organs located retroperitoneally on either side of the vertebral column. Each kidney filters approximately 180 liters of plasma daily, ensuring removal of metabolic waste, regulation of fluid and electrolyte balance, and endocrine function. The kidneys play a pivotal role in maintaining systemic homeostasis, and their dysfunction can be life-threatening.

2. Functions of the Kidneys

2.1 Filtration

The nephron, the functional unit of the kidney, filters blood through the glomerulus. This ultrafiltration process is driven by hydrostatic pressure and selectively permits water and solutes to pass while retaining proteins and cells.

2.2 Reabsorption and Secretion

After filtration, essential substances like glucose, amino acids, and electrolytes are reabsorbed in the renal tubules. Waste products such as urea, creatinine, and drugs are secreted into the tubules for excretion in urine.

2.3 Regulation of Electrolyte and Fluid Balance

The kidneys regulate sodium, potassium, calcium, phosphate, and water levels in response to hormonal signals (e.g., aldosterone, antidiuretic hormone).

2.4 Acid-Base Balance

Through the reabsorption of bicarbonate and excretion of hydrogen ions, the kidneys maintain blood pH within the normal range (7.35–7.45).

2.5 Endocrine Functions

The kidneys produce erythropoietin (stimulates red blood cell production), renin (regulates blood pressure), and convert vitamin D into its active form (calcitriol), which is essential for calcium homeostasis.

3. Pathophysiology of Kidney Disorders

3.1 Acute Kidney Injury (AKI)

AKI is characterized by a rapid decline in renal function, often due to ischemia, toxins, or obstruction. It is marked by elevated serum creatinine and decreased urine output. Early intervention can lead to full recovery, but severe cases may progress to chronic kidney disease.

3.2 Chronic Kidney Disease (CKD)

CKD involves progressive and irreversible loss of renal function over months or years. Common causes include diabetes mellitus and hypertension. CKD leads to accumulation of toxins, anemia, electrolyte imbalance, and increased cardiovascular risk.

3.3 Glomerulonephritis

An inflammatory disorder affecting the glomeruli, glomerulonephritis can be acute or chronic. It is often immune-mediated and presents with proteinuria, hematuria, and reduced glomerular filtration rate (GFR).

3.4 Nephrotic and Nephritic Syndromes

Nephrotic syndrome involves significant protein loss in urine, hypoalbuminemia, and edema. Nephritic syndrome includes hematuria, hypertension, and variable proteinuria, often secondary to glomerular inflammation.

4. Conclusion

The kidneys are vital organs responsible for a wide array of homeostatic functions. Pathophysiological alterations in renal function can lead to acute or chronic diseases with systemic manifestations. Timely diagnosis and management of renal disorders are critical to prevent irreversible damage and improve patient outcomes. Advancements in nephrology continue to enhance our understanding of kidney function and disease.

References

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