McCance: Pathophysiology, 6th Edition

Chapter 35: Structure and Function of the Renal and Urologic Systems

Key Points – Print

SUMMARY REVIEW

Structures of the Renal System

1. The kidneys are paired structures lying bilaterally between the twelfth thoracic and third lumbar vertebrae.
2. The kidney is composed of an outer cortex containing the glomeruli and an inner medulla containing the tubules and collecting ducts.
3. The calyces join to form the renal pelvis, receive urine from the collecting ducts, and are continuous with the upper end of the ureter.
4. The nephron is the urine-forming unit of the kidney and is composed of the glomerulus, proximal tubule, hairpin loops of Henle, distal tubule, and collecting duct.
5. The glomerulus contains loops of capillaries. The capillary walls serve as a filtration membrane for the formation of the primary urine. The layers of the glomerular capillary include the endothelium, basement membrane, and epithelium.
6. Mesangial cells and matrix lie between and support the glomerular capillaries.
7. Juxtaglomerular cells secrete rennin and are located around the afferent arteriole. They are contiguous with the sodium-sensing macula densa cells of the distal convoluted tubule.
8. The Bowman space is the space between the visceral and parietal epithelium.
9. The proximal tubule is lined with microvilli to increase surface area and enhance reabsorption.
10. The hairpin-shaped loops of Henle transport solutes and water, contributing to the hypertonic state of the medulla.
11. The distal tubule adjusts acid-base balance by excreting acid into the urine and forming new bicarbonate ions.
12. The collecting duct contains principal cells that resorb sodium and water and excrete potassium and intercalated cells that secrete hydrogen or bicarbonate and potassium.
13. The ureters extend from the renal pelvis to the posterior wall of the bladder. Urine flows through the ureters by means of peristaltic contraction of the ureteral muscles.
14. The bladder is a bag composed of the detrusor and trigone muscles and innervated by parasympathetic fibers. When accumulation of urine reaches 250 to 300 ml, mechanoreceptors, which respond to stretching of tissue, stimulate the micturition reflex.

Renal Blood Flow

1. Renal blood flows at about 1000 to 1200 ml/min, or 20% to 25% of the cardiac output.
2. Blood flow through the glomerular capillaries is maintained at a constant rate in spite of a wide range of arterial pressures (autoregulation).
3. The GFR is the filtration of plasma per unit of time and is directly related to the perfusion pressure of renal blood flow.
4. Autoregulation of RBF and sympathetic neural regulation of vasoconstriction maintain a constant GFR.
5. The renal blood vessels are innervated by the sympathetic noradrenergic nerves that regulate vasoconstriction.
6. Renin is an enzyme secreted from the juxtaglomerular apparatus; it causes the generation of angiotensin I, which is converted to angiotensin II by the action of ACE. Angiotensin II stimulates release of aldosterone from the adrenal cortex and is a potent vasoconstrictor. Thus the renin-angiotensin-aldosterone system is a regulator of renal blood flow and blood pressure.
7. Natriuretic peptides promote sodium and water loss by inhibiting aldosterone and increasing sodium chloride excretion.

Kidney Function

1. The major function of the nephron is urine formation, which involves the processes of glomerular filtration, tubular reabsorption, and tubular secretion and excretion.
2. Glomerular filtration is favored by capillary hydrostatic pressure and opposed by oncotic pressure in the capillary and hydrostatic pressure in the Bowman capsule. The balance of favoring and opposing filtration forces is the NFP.
3. The GFR is approximately 120 ml/minute, and 99% of the filtrate is reabsorbed.
4. The proximal tubule reabsorbs about 60% to 70% of the filtered sodium and water and 90% of other electrolytes.
5. Because most molecules are reabsorbed by active transport, the carrier mechanism can become saturated at the T_m. Molecules not reabsorbed are excreted with the urine.
6. The distal tubules actively reabsorb sodium and secrete potassium and hydrogen for the regulation of electrolyte and acid-base balance.
7. The concentration of the final urine is a function of the level of ADH that stimulates the distal tubules and collecting ducts to reabsorb water. The countercurrent exchange system of the long loops of Henle and their accompanying capillaries establishes a concentration gradient within the renal medulla to facilitate the reabsorption of water from the collecting duct.
8. The distal nephron regulates acid-base balance by excreting hydrogen ions and forming new bicarbonate.

9. The kidney secretes or activates a number of hormones that have systemic effects, including vitamin D_3 (1,25-OH_2D_3) and erythropoietin, which stimulates erythropoiesis when there is hypoxia.

Tests of Renal Function

1. Tests that measure renal clearance indicate how much of a substance can be cleared from the blood by the kidneys per given amount of time.
2. Creatinine, a substance produced by muscle, is measured in plasma and urine to calculate a commonly used clinical measurement of GFR (creatinine clearance).
3. The plasma creatinine concentration, cystatin C plasma concentration, and BUN levels indicate glomerular function. Plasma creatinine and cystatin C are measured to monitor progressive renal dysfunction; BUN is an indicator of hydration status.
4. PAH clearance is used to determine renal plasma flow and blood flow.
5. Urinalysis involves evaluation of color, turbidity, protein, pH, specific gravity, sediment, and supernatant.
6. Presence of bacteria, red blood cells, white blood cells, casts, or crystals in the urine sediment may indicate a renal disorder.

Aging and Renal Function

1. As a person grows older, a decrease occurs in the number of nephrons. Renal blood flow and glomerular filtration rate decline.
2. Tubular transport and reabsorption decrease with age. Response to acid-base changes and reabsorption of glucose are delayed. Drugs eliminated by the kidney can accumulate in the plasma, causing toxic reactions.
3. Neurogenic and myogenic changes in the bladder may lead to symptoms of urgency, frequency.