Learning Objectives (1 of 3)

• Describe normal structure and functions of the kidneys
• Explain pathogenesis and clinical manifestations of glomerulonephritis, nephrosis, nephrosclerosis, and glomerulosclerosis
• Describe clinical manifestations and complications of urinary tract infections
• Describe causes of renal tubular injury, manifestations, treatment

Learning Objectives (2 of 3)

• Explain mechanism of urinary tract calculi formation, complications, manifestations of urinary tract obstruction
• Differentiate major forms of cystic disease of the kidney and prognoses; common tumors affecting urinary tract
• Describe causes, clinical manifestations, treatment of renal failure
• Describe principles and techniques of hemodialysis

Learning Objectives (3 of 3)

• Differentiate benign prostatic hyperplasia and prostatic carcinoma as to clinical manifestations and methods of treatment
• Describe three most common types of testicular cancer, manifestations, and methods of treatment
• List anatomic structures, functions, and diseases of the male reproductive system

Urinary System

• Kidneys: produce urine
• Excretory duct system
  – Ureter: conveys urine into bladder by peristalsis
  – Renal pelvis: expanded upper portion of ureter
  – Major calyces: subdivisions of renal pelvis
  – Minor calyces: subdivisions of major calyces into which renal papillae discharge
• Bladder: stores urine
  – Discharges urine into urethra during voiding
  – Anatomic configuration of bladder and ureters normally prevents reflux of urine into ureters
• Urethra: conveys urine from the bladder for excretion
Kidneys (1 of 2)

- Paired, bean-shaped organs below diaphragm adjacent to vertebral column
- Divided into outer cortex and inner medulla (renal pyramids and columns)
- Excretory organs, functions along with lungs in excreting waste products of food metabolism
- Three basic functions
  - Excrete waste products of food metabolism
    - CO₂ and H₂O: end-products of carbohydrate and fat metabolism
  - Urea and other acids: end-products of protein metabolism that only the kidneys can excrete

Kidneys (2 of 2)

- Regulate mineral and H₂O balance
  - Excretes excess minerals and H₂O ingested and conserves them as required
  - Body’s internal environment is determined not by what a person ingests but by what the kidneys retain
  - Produces erythropoietin and renin: specialized cells in the kidneys
    - Erythropoietin: regulates RBC production in marrow
    - Renin: helps regulate blood pressure

Nephron (1 of 2)

- Basic structural and functional unit of the kidney
- About 1 million nephrons in each kidney
- Consists of glomerulus and renal tubule
- Glomerulus
  - Tuft of capillaries supplied by an afferent glomerular arteriole that recombine into an efferent glomerular arteriole
  - Material is filtered by a 3-layered glomerular filter
    - Inner: fenestrated capillary endothelium
    - Middle: basement membrane
    - Outer: capillary endothelial cells (with foot processes and filtration slits)
  - Mesangial cells: contractile phagocytic cells that hold the capillary tuft together; regulate caliber of capillaries affecting filtration rate

Nephron (2 of 2)

- Renal tubule: reabsorbs most of filtrate; secretes unwanted components into tubular fluid; regulates H₂O balance
  - Proximal end: Bowman’s capsule
  - Distal end: empties into collecting tubules
- Requirements for normal renal function
  - Free flow of blood through the glomerular capillaries
  - Normally functioning glomerular filter that restricts passage of blood cells and protein
  - Normal outflow of urine

The structure of the renal tubule, illustrating its relationship to the glomerulus and the collecting tubule.

Bowman’s Capsule
Renal Regulation of Blood Pressure

- Renin: released in response to decreased blood volume, low blood pressure, low sodium
- Angiotensin I → angiotensin II by angiotensin converting enzyme (ACE) as blood flows through the lungs
- Angiotensin II:
  - Powerful vasoconstrictor: raises blood pressure by causing peripheral arterioles to constrict
  - Stimulates aldosterone secretion from adrenal cortex: increases reabsorption of NaCl and H₂O by kidneys
  - Net effect: higher blood pressure, increased fluid in vascular system
- System is self-regulating

The role of the kidneys in regulation of blood pressure and blood volume.

Congenital abnormalities

- Renal agenesis: failure of one or both kidneys to develop
  - Bilateral: rare, associated with other congenital anomalies, incompatible with life
  - Unilateral: common, asymptomatic; other kidney enlarges to compensate
- Duplications of urinary tract
  - Complete duplication: formation of extra ureter and renal pelvis
  - Incomplete duplication: only upper part of excretory system is duplicated
- Malposition: one or both kidneys, associated with fusion of kidneys; horseshoe kidney; fusion of upper pole

Glomerulonephritis

- Inflammation of the glomeruli caused by antigen-antibody reaction within the glomeruli
- Immune-complex glomerulonephritis
  - Usually follows a beta-streptococcal infection
  - Circulating antigen and antibody complexes are filtered by glomeruli and incite inflammation
  - Leukocytes release lysosomal enzymes that cause injury to the glomeruli
  - Occurs in SLE; immune complexes trapped in glomeruli
  - Occurs in IgA nephropathy
- Anti-glomerular basement membrane (anti-GBM) glomerulonephritis: autoantibodies attack glomerular basement membrane

Normal kidney glomerulus

Immune complex glomerulonephritis
**Anti-GBM glomerulonephritis**

**Nephrotic Syndrome (1 of 2)**
- Marked loss of protein in the urine
  - Urinary excretion of protein > protein production
  - Protein level in blood falls
  - Causes edema due to low plasma osmotic pressure
- Clinical manifestations
  - Marked leg edema
  - Ascites

**Nephrotic Syndrome (2 of 2)**
- Prognosis
  - In children: minimal glomerular change, complete recovery
  - In adults: a manifestation of severe progressive renal disease
- May result from
  - Glomerulonephritis
  - Diabetes (causing glomerular changes)
  - Systemic lupus erythematosus, SLE
  - Other kidney diseases

**Arteriolar Nephrosclerosis**
- Complication of severe hypertension
- Renal arterioles undergo thickening from carrying blood at a much higher pressure than normal
- Glomeruli and tubules undergo secondary degenerative changes causing narrowing of lumen and reduction in blood flow
  - Reduced glomerular filtration
  - Kidneys shrink
  - May die of renal insufficiency

**Diabetic Nephropathy**
- Complication of long-standing diabetes
- Nodular and diffuse thickening of glomerular basement membranes (glomerulosclerosis), usually with coexisting nephrosclerosis
- Manifestations
  - Progressive impairment of renal function
  - Protein loss may lead to nephrotic syndrome
  - No specific treatment can arrest progression of disease
  - Progressive impairment of renal function may lead to renal failure

**Diffuse glomerulosclerosis**
Gout Nephropathy

- **Pathogenesis**
  - Elevated blood uric acid levels lead to increased uric acid in tubular filtrate
  - Urate may precipitate in Henle’s loops and collecting tubules
  - Tubular obstruction causes damage
- **Manifestations**
  - Impaired renal function
  - May lead to renal failure
  - Common in poorly-controlled gout

Nodular glomerulosclerosis

Urate nephropathy showing multiple depressed scars

Section of kidney revealing white urate deposits within renal pyramid and large urate deposit near tip of pyramid

Urinary Tract Infections (1 of 2)

- Very common; maybe acute or chronic
- Most infections are caused by gram-negative bacteria
- Organisms contaminate perianal and genital areas and ascend urethra
- Conditions protective against infection
  - Free urine flow
  - Large urine volume
  - Complete bladder emptying
  - Acid urine: most bacteria grow poorly in an acidic environment

Urinary Tract Infections (2 of 2)

- Predisposing factors
  - Any condition that impairs free drainage of urine
  - Stagnation of urine favors bacterial growth
  - Injury to mucosa by kidney stone disrupts protective epithelium allowing bacteria to invade deeper tissue
  - Introduction of catheter or instruments into bladder may carry bacteria
Cystitis

- Affects only the bladder
  - More common in women than men; shorter female urethra, and, in young sexually active women, sexual intercourse promotes transfer of bacteria from urethra to bladder
  - Common in older men, because enlarged prostate interferes with complete bladder emptying
- Clinical manifestations
  - Burning pain on urination
  - Desire to urinate frequently
  - Urine contains many bacteria and leukocytes
  - Responds well to antibiotics
  - May spread upward into renal pelvis and kidneys

Pyelonephritis

- Involvement of upper urinary tract from
  - Ascending infection from the bladder (ascending pyelonephritis)
  - Carried to the kidneys from the bloodstream (hematogenous pyelonephritis)
- Clinical manifestations: similar with an acute infection
  - Localized pain and tenderness over affected kidney
  - Responds well to antibiotics
  - Cystitis and pyelonephritis are frequently associated
  - Some cases become chronic and lead to kidney failure

Vesicoureteral Reflux

- Urine normally prevented from flowing back into the ureters during urination
- Failure of mechanisms allows bladder urine to reflux into ureter during voiding
  - Predisposes to urinary tract infection
  - Predisposes to pyelonephritis

Urinary Calculi (1 of 3)

- Stones may form anywhere in the urinary tract
- Predisposing factors
  - High concentration of salts in urine saturates urine causing salts to precipitate and form calculi
    - Uric acid in gout
    - Calcium salts in hyperparathyroidism
  - Urinary tract infections reduce solubility of salts in urine; clusters of bacteria are sites where urinary salts may crystallize to form stone
  - Urinary tract obstruction causes urine stagnation, promotes stasis and infection, further increasing stone formation

Urinary Calculi (2 of 3)

- Staghorn calculus: urinary stones that increase in size to form large branching structures that adopt to the contour of the pelvis and calyces
- Small stones may pass through ureters causing renal colic
- Some become impacted in the ureter and need to be removed
- Manifestations
  - Renal colic associated with passage of stone
  - Obstruction of urinary tract causes hydronephrosis-hydroureter proximal to obstruction
Urinary Calculi (3 of 3)

- Treatment
  - Cystoscopy: snare and removes stones lodged in distal ureter
  - Shock wave lithotripsy: stones lodged in proximal ureter are broken into fragments that are readily excreted

Large staghorn calculus of kidney

Urinary Obstruction

- Blockage of urine outflow leads to progressive dilatation of urinary tract proximal to obstruction, eventually causes compression atrophy of kidneys

- Manifestations
  - Hydroureter: dilatation of ureter
  - Hydronephrosis: dilatation of pelvis and calyces

- Causes
  - Bilateral: obstruction of bladder neck by enlarged prostate or urethral stricture
  - Unilateral: ureteral stricture, calculus, tumor

- Complications: stone formation; infections

- Diagnosis and treatment: pyelogram, CT scan

Possible locations and results of urinary tract obstruction

Marked hydronephrosis and hydroureter

Bisected hydronephrotic kidney
Foreign Bodies in Urinary Tract

- Usually inserted by patient
- May injure bladder
- Predispose to infection
- Treatment
  - Usually removed by cystoscopy
  - Occasionally necessary to open bladder surgically

Renal Tubular Injury

- Pathogenesis
  - Impaired renal blood flow
  - Tubular necrosis caused by toxic drugs or chemicals
- Clinical manifestation
  - Acute renal failure: oliguria, anuria
  - Tubular function gradually recovers
  - Treated by dialysis until function returns

Renal Cysts

- Solitary cysts common; not associated with impairment of renal function
- Multiple cysts
  - Congenital polycystic kidney disease
  - Most common cause of multiple cysts
  - Mendelian dominant transmission
  - Cysts enlarge and destroy renal tissue and function
  - Onset of renal failure by late middle age
  - Suspected by physical examination that reveals greatly enlarged kidneys
  - Some form cysts in liver or cerebral aneurysm

Renal Tumors

- Cortical tumors: arise from epithelium of renal tubules
  - Adenomas: usually small and asymptomatic
  - Carcinomas more common
  - Hematuria often first manifestation
  - Invades renal vein and metastasizes into bloodstream
  - Treated by nephrectomy
- Transitional cell tumor: Arise from transitional epithelium lining urinary tract
  - Most arise from bladder epithelium
  - Hematuria: common first manifestation
  - Low grade malignancy; good prognosis
- Nephroblastoma (Wilms Tumor)
  - Uncommon; highly malignant; affects infants and children

Renal Failure (Uremia) (1 of 2)

- Retention of excessive byproducts of protein metabolism in the blood
- Acute renal failure
  - Causes: tubular necrosis from impaired blood flow to kidneys or effects of toxic drugs
  - Renal function usually returns
- Chronic renal failure
  - From progressive, chronic kidney disease; > 50% from chronic glomerulonephritis
  - Others include congenital polycystic kidney disease, nephrosclerosis, diabetic nephropathy
Renal Failure (Uremia) (2 of 2)

- Clinical manifestations
  - Weakness, loss of appetite, nausea, vomiting
  - Anemia
  - Toxic manifestations from retained waste products
  - Edema: retention of salt and water
  - Hypertension
- Treatment
  - Hemodialysis
  - Hypertension

Hemodialysis

- Substitutes for the functions of the kidneys by removing waste products from patient’s blood
- Waste products in patient’s blood diffuse across a semipermeable membrane into a solution (dialysate) into the other side of the membrane
- Two types
  - Extracorporeal dialysis (more common): patient’s circulation connected to an artificial kidney machine
  - Peritoneal dialysis (less common): patient’s own peritoneum is used as the dialyzing membrane

Renal Transplantation (1 of 2)

- Attempted when kidneys fail
- Kidney is from a close relative donor or cadaver
- Survival of transplant depends on similarity of HLA antigens between donor and recipient
  - Only identical twins have identical HLA antigens in their tissues; others invariably contain foreign HLA antigens
  - Consequently, patient’s immunologic defenses will respond to the foreign antigens and attempt to destroy (reject) foreign kidney

Renal Transplantation (2 of 2)

- Patient’s immune system must be suppressed by drugs
- Kidney is placed in the iliac area, outside the peritoneal cavity
- Prognosis
  - >90% of transplanted kidneys survive for 5 years when donor’s HLA antigens resemble the patient’s
  - Survival rate of cadaver transplants has improved in recent years

Discussion

- How does diabetes affect the kidneys? What are the clinical manifestations in such cases?
- What is the difference between acute and chronic renal failure in terms of causes, clinical manifestations, and treatment?
- What is the relationship between glomerulonephritis and beta-streptococcal infection?

Male Reproductive System: Anatomy

- Components of the male reproductive system
- Penis
- Prostate
- Accessory glands
- Testes
- Duct system to transport sperm from testes to urethra
  - Starts at epididymis
  - Continues on as vasa deferentia
  - Vasa deferentia extend upward in spermatic cords
  - Enter prostatic urethra as ejaculatory ducts
  - Urethra divided into long penile urethra and a short segment traversing the prostate (prostatic urethra)
Prostate (1 of 2)
- Spherical gland that surrounds urethra just below the base of the bladder
- Secretes thin alkaline fluid with a high concentration of an enzyme from prostatic epithelial cells
- Prostatic secretions are discharged into the urethra during ejaculation
- Secretions mix with sperm and secretions from seminal vesicles to form seminal fluid

Prostate (2 of 2)
- Composed of numerous branched glands intermixed with masses of smooth muscle and fibrous tissue
- Inner group of glands
  - Surround urethra as it passes through the prostate
  - May give rise to benign hyperplasia
- Outer or main group of glands
  - Makes up bulk of prostatic glandular tissue
  - May give rise to prostatic carcinoma

Diagrammic cross-section indicating arrangement of inner and outer groups of glands

Benign Prostatic Hyperplasia (1 of 2)
- Moderate enlargement of the prostate gland is relatively common in elderly men
- Usually involves inner group of glands surrounding the urethra
- Obstructs the outflow of urine
- Enlargement is significant if it obstructs neck of the bladder, leading to incomplete emptying, or causes complete urinary tract obstruction
Benign Prostatic Hyperplasia (2 of 2)

- Complications
  - Cystitis: inflammation of urinary bladder
  - Pyelonephritis: inflammation of kidneys and pelvis
  - Calculi formation: stones
  - Hydronephrosis: distention of renal pelvis and calyces with urine due to obstruction
- Gold standard: transurethral resection

Prostatitis

- Acute
  - Acute inflammation of the prostate
    - Spread of infection from bladder or urethra
    - May be secondary to gonococcal infection of posterior urethra
- Chronic
  - Mild inflammation
  - Common
  - Causes few symptoms

Gonorrhea and Chlamydia

- A common sexually transmitted disease
  - Initially, acute inflammation of anterior urethra
  - Inflammation may spread to posterior urethra and transport ducts
  - May also cause an acute inflammation of the rectal mucosa
  - Obstruction of vasa may block sperm transport and cause sterility
- Nongonococcal urethritis
  - Caused by Chlamydia
  - Causes an acute urethritis
  - Clinically very similar to gonorrhea

Carcinoma of the Prostate (1 of 3)

- Usually originates in outer group of glands of the prostate
- Manifestations
  - Common in elderly men; early case may be asymptomatic
  - Urinary obstruction from encroachment of bladder neck
  - Infiltration of tissues surrounding prostate
  - Metastasizes to bones of spine and pelvis
  - Acid phosphatase: secreted by normal prostatic cells and tumor cells; leaks into bloodstream; high levels in prostate cancer
Carcinoma of the Prostate (2 of 3)

- Prostate-specific antigen, PSA
  - Secreted by prostatic epithelial cells
- Tumor often grows slowly; may take ≥ 10 before it obstructs bladder or metastasizes to the bones
- Diagnosis
  - Digital rectal exam: irregularity or nodularity
  - PSA
  - Biopsy

Carcinoma of the Prostate (3 of 3)

- Surgery
  - Radical prostatectomy and radiation: seems to improve survival; controversy on effectiveness in elderly men
  - Radical prostatectomy
    - For small, localized tumor; may cause impotence due to disruption of nerve supply to penis
  - If with metastasis:
    - Surgical removal of testes to eliminate source of testosterone that stimulate tumor growth
    - Drugs that suppress gonadotropic hormones to inhibit testicular testosterone secretion

Cryptorchidism (1 of 2)

- Testis does not descend normally into scrotum
  - Usually retained in abdominal cavity; sometimes in inguinal canal
  - Germ cells require a temperature lower than the normal body temperature
  - Interstitial cells function normally at body temperature
- Manifestations
  - Germ cells are destroyed at higher intra-abdominal temperature
  - Interstitial cells of Leydig function normally and produce testosterone
  - Undescended testis more prone to developing testicular cancer; treat by surgically replacing testis in scrotum

Cryptorchidism (2 of 2)

- In some newborns, testes may not have descended yet into scrotum but usually descend within 6 months after birth
  - If descent has not occurred by 12 months, an ectopic testis that is not in the scrotum should be surgically brought into the scrotum

Descent of the testes

Normal testicular tubules
Intraabdominal testis, showing marked atrophy and fibrosis of testicular tubules.

Testicular Torsion
- Abnormal attachment of testis in scrotum
  - Predisposes to rotary twisting of testis and spermatic cord within scrotum
  - Shuts blood supply to testes
- Manifestations and treatment
  - Acute onset of testicular pain and swelling
  - Leads to hemorrhagic infarction unless promptly untwisted
- Surgery
  - Untwist the torsion, firmly anchor affected testis within scrotum
  - Other testis also anchored in scrotum to prevent possible torsion

Testicular Torsion
- Acute onset of testicular pain and swelling
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Scrotal Abnormalities
- Hydrocele
  - Excess fluid accumulates in tunica vaginalis
  - Treated by aspiration or resection of tunica vaginalis
- Varicocele
  - Varicose veins in spermatic cord
  - Usually involves left side of scrotum
  - May impair fertility
  - Treatment required only if varicocele causes discomfort or impairs infertility

Hemorrhagic infarction of testis caused by torsion

A. Normal tunica vaginalis containing a small amount of fluid. B. Hydrocele. C. Varicocele.
Penis
- Consists of 3 cavernous bodies or cylinders of extremely vascular erectile tissue
  - Two lateral: corpora cavernosa
  - Midline: corpora spongiosum that surrounds penile urethra
  - Surrounded by thick fibrous connective tissue capsule (spongy meshwork of endothelium-lined blood sinuses)
  - Supported by connective tissue and smooth muscle

Erectile Dysfunction
- Inability to achieve and maintain a penile erection
- Common problem and frequency increases with age
- Causes
  - Low testosterone level inhibits sexual desire and arousal
  - Damage to nerves supplying penis (prostate surgery; neurologic disease)
  - Impaired blood supply to penis: arteriosclerosis, diabetes
  - Certain anti-hypertensive drugs that target autonomic nervous system
  - Stress, emotional factors, chronic diseases
- Treatment: depends on cause of dysfunction
  - Use of drugs that inhibit phosphodiesterase to promote blood flow to penis

Physiology of Penile Erection (1 of 3)
- Complex process
- Factors
  - Sexual desire: initiates physiologic events that increase blood flow to penis
  - Arteries supplying cavernous bodies must dilate to deliver a large volume of blood to penis
  - Pressure of blood in cavernous bodies must be high to compress draining veins
  - Blood must flow into penis faster than it drains out or erection cannot be maintained

Physiology of Penile Erection (2 of 3)
- Penile arteries are normally constricted
  - Little blood flows into cavernous bodies
  - Vascular sinuses are collapsed
- In sexual arousal
  - Parasympathetic nerve impulses from sacral part of spinal cord cause release of nitric oxide
  - Nitric oxide causes relaxation of smooth muscle walls of penile arteries and trabeculae
  - Penile arteries dilate and sinuses in cavernous bodies expand

Physiology of Penile Erection (3 of 3)
- In sexual arousal
  - Blood pours under high pressure into the sinuses
  - Increased blood pressure compresses veins retarding outflow of blood from penis
  - Engorgement of sinuses with results in rigidity and erection

Carcinoma of the Testis
- Seminoma: malignant neoplasm of semen-producing epithelium
- Malignant teratoma: composed of several types of malignant tissues
- Choriocarcinoma: arises from trophoblastic tissues in the uterus
- Treatment:
  - Resection of testicle and associated structures
  - Chemotherapy
- Methods for monitoring response to therapy
  - Chorionic gonadotropin (HCG) test
  - Alpha fetoprotein (AFP) test
Carcinoma of the Penis

- Rare in circumcised males
- Caused by Papilloma virus
- Treatment: partial or complete amputation of penis; removal of inguinal lymph nodes

Discussion

- A young man has undescended testis within the abdomen. How does this affect testicular function? What are the likely complications?
- The following statements are true of benign prostatic hyperplasia EXCEPT:
  A. It is a precancerous condition
  B. It causes incomplete emptying of the bladder
  C. It involves the inner group of glands of the prostate
  D. Hyperplasia is secondary to the response to dihydrotestosterone
  E. Obstructing prostatic tissue may be surgically removed