Chapter 18

Urinary System Disorders
Urinary System: Review

- Removes metabolic wastes
- Removes hormones from the body
- Removes drugs other foreign material from body
- Regulates water, electrolyte, acid-base balance
- Secretes erythropoietin
- Activates vitamin D
- Regulate blood pressure through the renin-angiotensin-aldosterone system
Urinary System: Review (Cont.)

- Anatomy

  Kidneys
  ↓
  Ureters
  ↓
  Urinary bladder
  ↓
  Urethra
Gross Anatomy of the Urinary System
Anatomy of the Kidney

- Capsule (fibrous)
- Cortex
- Minor calyces
- Major calyces
- Fat
- Renal pelvis
- Medullary pyramid
- Medulla
- Renal papilla of pyramid
- Hilum
- Renal sinus
- Renal column
- Interlobular arteries
- Ureter


Kidney

- Nephrons—functional units of the kidneys
- Each kidney has over a million nephrons.
  - Renal corpuscles
    - Glomerulus
    - Bowman capsule
  - Renal tubules
    - Proximal convoluted tubules
    - Loop of Henle
    - Distal convoluted tubules
    - Collecting duct
Nephron

- Complete nephron
Formation of Urine

- **Filtration**
  - In renal corpuscles
  - Large volume of fluid passes from glomerular capillaries into the tubule (Bowman capsule)
    - Wastes, nutrients, electrolytes, other dissolved substances
    - Cells and protein remain in the blood.

- **Reabsorption**
  - Reabsorption of essential nutrients, water, and electrolytes into the peritubular capillaries
  - Control of pH and electrolytes
Reabsorption

- Transport mechanisms for reabsorption
  - Active transport
  - Co-transport
  - Osmosis—water

- Proximal convoluted tubules
  - Most of water reabsorption
  - Glucose reabsorption
  - Nutrients and electrolytes to maintain homeostasis
Schematic Illustration of Urine Formation

1. FILTRATION
   - WATER

2. REABSORPTION
   - GLUCOSE
   - AA
   - Na+
   - WATER
   - (Aldosterone effect)
   - Na+
   - Water (ADH effect)

3. REABSORPTION SECRETION
   - WATER
   - Na+
   - Cl–
   - H+
   - K+

KEY
- AA: Amino acids
- B–: Bicarbonate ions
- Cl–: Chloride ions
- H+: Hydrogen ions
- K+: Potassium ions
- Na+: Sodium ions

Hormones Involved in Reabsorption

- **Antidiuretic hormone (ADH)**
  - Secreted by the posterior pituitary
  - Reabsorption of water in distal convoluted tubules and collecting ducts

- **Aldosterone**
  - Secreted by adrenal cortex
  - Sodium reabsorption in exchange for potassium or hydrogen

- **Atrial natriuretic hormone**
  - Hormone from the heart
  - Reduces sodium and fluid reabsorption
Blood Flow through the Kidney

Specialized pattern:
Renal artery → interlobar artery → arcuate artery → interlobular artery → *afferent arteriole*
→ glomerular capillaries → *afferent arteriole* → peritubular capillaries → interlobular vein → arcuate vein → interlobar vein → renal vein
Glomerular Filtration Rate

- Afferent and efferent arterioles of the glomerulus
  - Autoregulation and hormones control pressure in the glomerular capillaries by:
  - Vasoconstriction of afferent arteriole
    - Decreased glomerular pressure—decreased filtrate
  - Dilation of afferent arteriole
    - Increased pressure in glomerulus—increased filtrate
  - Vasoconstriction of efferent arteriole
    - Increased pressure in glomerulus—increased filtrate
Control of Glomerular Filtration Rate

NORMAL FILTRATION

AFFERENT ARTERIOLE: DILATION

EFFERENT ARTERIOLE: CONstriction

AFFERENT ARTERIOLE: CONstriction
Glomerular Filtration Rate (Cont.)

Control of arteriolar constriction by three factors:

- **Autoregulation**
  - Local adjustment in diameter of arterioles
    - Made in response to changes in blood flow in kidneys

- **Sympathetic nervous system**
  - Increases vasoconstriction in both arterioles

- **Renin**
  - Secreted by juxtaglomerular cells when blood flow to afferent arteriole is reduced
  - Renin-angiotensin mechanism
Composition of Blood, Filtrate, and Urine

<table>
<thead>
<tr>
<th>Substance</th>
<th>Blood (mg/L)</th>
<th>Filtrate (mg/L)</th>
<th>Urine (mg/L)</th>
</tr>
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<tbody>
<tr>
<td>Water (L)</td>
<td>180</td>
<td>180</td>
<td>1.4</td>
</tr>
<tr>
<td>Cells</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Glucose (mg/L)</td>
<td>1000</td>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>Protein (mg/L)</td>
<td>40,000</td>
<td>o-trace</td>
<td>o-trace</td>
</tr>
<tr>
<td>Urea (mg/L)</td>
<td>260</td>
<td>260</td>
<td>18,000</td>
</tr>
<tr>
<td>Na⁺ (mEq/L)</td>
<td>142</td>
<td>142</td>
<td>128</td>
</tr>
<tr>
<td>K⁺ (mEq/L)</td>
<td>5</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>HCO₃⁻ (mEq/L)</td>
<td>28</td>
<td>28</td>
<td>14</td>
</tr>
</tbody>
</table>
Incontinence and Retention

- **Incontinence**
  - Loss of voluntary control of the bladder

- **Enuresis**
  - Involuntary urination by child age older than 4 years
    - Often related to developmental delay, sleep pattern, psychosocial aspect

- **Stress incontinence (more common in women)**
  - Increased intra-abdominal pressure forces urine through sphincter.
    - Coughing, lifting, laughing
    - Multiple pregnancies
Incontinence and Retention (Cont.)

- Overflow incontinence
  - Incompetent bladder sphincter
  - Older adults
    - Weakened detrusor muscle may prevent complete emptying of bladder—frequency and incontinence
  - Spinal cord injuries or brain damage
    - Neurogenic bladder—may be spastic or flaccid
    - Interference with CNS and ANS voluntary controls of the bladder
Incontinence and Retention (Cont.)

● Retention
  - Inability to empty bladder
  - May be accompanied by overflow incontinence
  - Spinal cord injury at sacral level blocks micturition reflex
  - May follow anesthesia (general or spinal)
Diagnostic Tests
Urinalysis: Appearance of Urine

- Straw colored with mild odor
  - Normal urine, specific gravity 1.010 to 1.050
- Cloudy
  - May indicate the presence of large amounts of protein, blood, bacteria, and pus
- Dark color
  - May indicate hematuria, excessive bilirubin, or highly concentrated urine
- Unpleasant or unusual odor
  - Infection or result from certain dietary components or medication
Urinalysis: Urinary Infection

- Heavy purulence and presence of gram-negative and gram-positive organisms
Urinalysis: Abnormal Constituents of Urine

● Blood (hematuria)
  - Small amounts
    • Infection, inflammation, or tumors in urinary tract
  - Large amounts
    • Increased glomerular permeability or hemorrhage

● Elevated protein level (proteinuria, albuminuria)
  - Leakage of albumin or mixed plasma proteins into filtrate

● Bacteria (bacteriuria)
  - Infection in urinary tract
Urinalysis: Abnormal Constituents of Urine (Cont.)

- Urinary casts
  - Indicate inflammation of kidney tubules

- Specific gravity
  - Indicates ability of tubules to concentrate urine
  - Low specific gravity—dilute urine (with normal hydration)
  - High specific gravity—concentrated urine (with normal hydration)
    - Related to renal failure

- Glucose and ketones
  - Found when diabetes mellitus is not well controlled
Urinalysis: Red Blood Cell Casts in Urine
Blood Tests

- Elevated serum urea and serum creatinine levels
  - Indicate failure to excrete nitrogen wastes
    - Caused by decreased GFR
- Metabolic acidosis*
  - Indicates decreased GFR
  - Failure of tubules to control acid-base balance
- Anemia*
  - Indicates decreased erythropoietin secretion and/or bone marrow depression

*In the absence of other problems.
Blood Tests (Cont.)

- **Electrolytes**
  - Depend on related fluid balance

- **Antibody level**
  - Antistreptolysin O or antistreptokinase titers
    - Used for diagnosis of poststreptococcal glomerulonephritis

- **Elevated renin levels**
  - Indicate kidney as a cause of hypertension
Other Tests

- Culture and sensitivity studies on urine specimens
  - Identification of causative organism of infection
  - Help select appropriate drug treatment
- Radiologic tests
  - Radionuclide imaging, angiography, ultrasound, CT, MRI, intravenous pyelography
  - Used to visualize structures and possible abnormalities, flow patterns, and filtration rates
Other Tests (Cont.)

- **Clearance tests**
  - Examples: creatinine or inulin clearance
  - Used to assess GFR

- **Cystoscopy**
  - Visualizes lower urinary tract
  - May be used to perform biopsy or remove kidney stones

- **Biopsy**
  - Used to acquire tissue specimens
Diuretic Drugs

- Used to remove excess sodium ions and water from the body
  - Increased excretion of water though the kidneys
  - Reduces fluid volume in tissues and blood
  - Prescribed for many disorders
    - Renal disease, hypertension, edema, congestive heart failure, liver disease, pulmonary edema
  - Several different mechanisms to increase urine volume based on specific drug
  - Some drugs are potassium-wasting and some are potassium-sparing.
Examples of Diuretic Drugs

<table>
<thead>
<tr>
<th>Name of Drug</th>
<th>Action</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrochlorothiazide (Hydro DIURIL)</td>
<td>Inhibits reabsorption of Na(^+) and water in distal tubule (thiazide type)</td>
<td>Increase excretion of fluid in hypertension, CHF, edema</td>
</tr>
<tr>
<td>furosemide (Lasix)</td>
<td>Decreases reabsorption of Na(^+) and water in the proximal and distal tubules and the loop of Henle (a loop diuretic)</td>
<td>Reduce body fluids in hypertension, CHF, edema, renal disease, liver disease</td>
</tr>
<tr>
<td>spironolactone (Aldactone)</td>
<td>Aldosterone antagonist, blocks reabsorption of Na(^+) and K(^+) in distal tubule (potassium-sparing diuretic)</td>
<td>Decrease Na(^+) and water in body, but conserve K(^+) in CHF, hypertension, liver disease</td>
</tr>
<tr>
<td>acetazolamide (Diamox)</td>
<td>Carbonic anhydrase inhibitor blocks reabsorption of Na(^+) and secretion of H(^+)</td>
<td>Reduce fluids in CHF, glaucoma</td>
</tr>
<tr>
<td>mannitol (intravenous)</td>
<td>Increases osmotic pressure and water in the filtrate, reduces Na(^+) absorption (osmotic diuretic)</td>
<td>Cerebral edema, glaucoma</td>
</tr>
</tbody>
</table>
Dialysis

- Provides filtration and reabsorption
- Two forms
  - Hemodialysis
  - Peritoneal dialysis
- Sustains life during kidney failure
- Used to treat patients with acute kidney failure
  - Until primary problem reversed
- For patients in end-stage renal failure
  - Until kidney transplant becomes available and is successful
Principles of Dialysis
Hemodialysis

- In hospital, dialysis center, or home with special equipment and training
- Patient’s blood moves from an implanted shunt or catheter in an artery to machine
  - Exchange of wastes, fluids, and electrolytes
  - Semipermeable membrane between blood and dialysis fluid (dialysate)
    - Blood cells and proteins remain in blood.
  - After exchange is completed, blood returned to patient’s vein
Hemodialysis (Cont.)

- Usually required three times a week
  - Each lasts about 3 to 4 hours.
- Potential complications
  - Shunt may become infected.
  - Blood clots may form.
  - Blood vessels involved in shunt may become sclerosed or damaged.
  - Patient has an increased risk of infection with hepatitis B, hepatitis C, or HIV if Standard Precautions are not followed.
Hemodialysis (Cont.)

A and B From Patton KT, Thibodeau GA: Anatomy & Physiology, ed 8, St. Louis, 2013, Mosby.

Peritoneal Dialysis

- Usually done on outpatient basis
- May be done at night (during sleep) or while patient is ambulatory
- Peritoneal membrane serves as the semipermeable membrane.
- Catheter with entry and exit points is implanted into the peritoneal cavity
- Dialyzing fluid is instilled into cavity
- Dialysate is drained from cavity via gravity into container
Peritoneal Dialysis (Cont.)

- Takes more time than hemodialysis
- Requires loose clothing to accommodate bag of fluid
- Major complication
  - Infection resulting in peritonitis
- With both types of dialysis
  - Prophylactic antibiotics with either form of dialysis
  - Any additional problem occurring in patient such as infection may alter dialysis requirements
  - Caution is required with many drugs because toxic level buildup can occur.
Disorders of the Urinary System
Urinary Tract Infections (UTIs)

- Very common infections
- Urine is an excellent growth medium.
- Lower urinary tract infections
  - Cystitis
  - Urethritis
- Upper urinary tract infections
  - Pyelonephritis
- Common causative organism
  - *Escherichia coli*
Urinary Tract Infections (UTIs) (Cont.)

- Other species of organisms associated with UTIs
  - *Klebsiella*
  - *Proteus*
  - *Enterobacter*
  - *Citrobacter*
  - *Serratia*
  - *Pseudomonas*
  - *Enterococcus*
  - Coagulase-negative *Staphylococcus*
  - *Chlamydia*
  - *Mycoplasma*
Urinary Tract Infections (UTIs) (Cont.)

- More common in women because of:
  - Shortness of urethra
  - Proximity to anus

- Older men
  - Prostatic hypertrophy
  - Urine retention

- Congenital abnormalities in children

- Other common predisposing factors
  - Incontinence
  - Retention of urine
  - Direct contamination with fecal material
Causes of Infection in the Urinary Tract
Cystitis and Urethritis

- Bladder wall (cystitis) and urethra (urethritis) are inflamed.
  - Hyperactive bladder and reduced capacity
- Pain is common in pelvic area
- Dysuria, urgency, frequency, and nocturia
- Systemic signs may be present.
  - Fever, malaise, nausea, leukocytosis
- Urine often cloudy, with unusual odor
- Urinalysis indicates bacteriuria, pyuria, microscopic hematuria
Pyelonephritis

- One or both kidneys involved
- From ureter into kidney
- Purulent exudate fills pelvis and calyces
- Recurrent or chronic infection can lead to scar tissue formation.
  - Loss of tubule function
  - Obstruction and collection of filtrate → hydronephrosis
  - Eventual chronic renal failure if untreated
Pyelonephritis (Cont.)

- Signs of cystitis plus pain associated with renal disease
  - Dull, aching pain in lower back or flank area
- Systemic signs include high temperature
- Urinalysis
  - Similar to cystitis
  - Urinary casts are present.
    - Reflection of renal tubule involvement
- Treatment with antibacterials
Inflammatory Disorders: Glomerulonephritis

- Many forms
- Presence of antistreptococcal (ASO) antibodies
  - Formation of an antigen-antibody complex
  - Activates complement system
  - Inflammatory response in glomeruli
    - Increased capillary permeability—leakage of some protein and large numbers of erythrocytes
- Severe inflammatory response
  - Congestion and cell proliferation
    - Decreased GFR—retention of fluid and wastes
Inflammatory Disorders—Glomerulonephritis (Cont.)

- Urine becomes dark and cloudy
- Facial and periorbital edema—initially
  - General edema follows
- Elevated blood pressure
  - Caused by increased renin secretion and decreased GFR
- Flank or back pain
  - Edema and stretching of renal capsule
- General signs of inflammation
- Decreased urine output
Inflammatory Disorders: Glomerulonephritis (Cont.)

- Blood tests
  - Elevated serum urea and creatinine levels
  - Elevation of anti-DNase B, streptococcal antibodies, antistreptolysin, antistreptokinase
  - Complement levels decreased (use in renal inflammation)

- Metabolic acidosis

- Urinalysis
  - Proteinuria, hematuria, erythrocyte casts
  - No evidence of infection
Inflammatory Disorders: Glomerulonephritis (Cont.)

• Treatment
  ➢ Sodium restriction possible
  ➢ Protein and fluid intake decreased in severe cases
  ➢ Drug treatment
    • Glucocorticoids to reduce inflammation
    • Antihypertensives
Poststreptococcal Glomerulonephritis

- **STREPTOCOCCAL INFECTION**
- **ANTIBODY FORMATION**
  - Several weeks later — elevated ASO and ASK titer
- **ANTIGEN - ANTIBODY COMPLEX**
  - Deposits in glomerulus
- **ACUTE INFLAMMATION AND DAMAGE**
- **INCREASED PERMEABILITY OF CAPILLARY**
  - Hematuria, Albuminuria
- **GLOMERULUS SWELLING**
  - Congestion — Decreased GFR
  - Oliguria and elevated serum urea
- **CELL PROLIFERATION**
  - Stimulation of renin secretion
  - Elevated BP and edema
  - Majority: Full recovery
  - A few: Acute renal failure
  - Some: Chronic glomerulonephritis (fibrosis)
  - Death
  - Chronic renal failure

Poststreptococcal Glomerulonephritis (Cont.)

NORMAL GLOMERULUS

Capillary open — blood flow

MILD GLOMERULONEPHRITIS

Swollen endothelial cell and membrane
Narrow capillary lumen — GFR decreases
Immune complex deposits — inflammation
RBC and protein leaks into filtrate — hematuria and proteinuria

SEVERE GLOMERULONEPHRITIS

Swollen cells
Immune complex deposits — severe inflammation
Cell proliferation
Little blood flow — oliguria

= RBC
P = PROTEIN
Inflammatory Disorders: Nephrotic Syndrome

- Abnormality in glomerular capillaries, increased permeability, large amounts of plasma proteins escape into filtrate
- May be idiopathic in children 2 to 6 years old
- May be secondary to SLE, exposure to nephrotoxins or drugs
Nephrotic Syndrome: Pathophysiology

- Hypoalbuminemia with decreased plasma osmotic pressure
  - Subsequent generalized edema
- Blood pressure remains low or normal.
  - May be elevated depending on angiotensin II levels
- Increased aldosterone secretion in response to reduced blood volume
  - More severe edema
- High blood cholesterol, lipoprotein in urine, lipiduria with milky appearance to the urine
Inflammatory Disorders:
Nephrotic Syndrome (Cont.)

● Signs and symptoms
  - Proteinuria, lipiduria, cast
  - Massive edema
  - Sudden increase in girth

● Treatment
  - Glucocorticoids
    - To reduce inflammation
  - ACE inhibitors
    - May decrease protein loss in urine
  - Antihypertensives
  - Sodium intake may be restricted.
Urinary Tract Obstructions
Urolithiasis (Calculi)

- Can develop anywhere in urinary tract
- Stones may be small or very large.
- Tend to form with:
  - Excessive amounts of solutes in filtrate
  - Insufficient fluid intake—major factor for calculi formation
  - Urinary tract infection
- Manifestations only occur with obstruction of urine flow.
  - May lead to infection
  - Hydronephrosis with dilation of calyces
  - If located in kidney or ureter and atrophy of renal tissue
Hydronephrosis
Urolithiasis (Calculi) (Cont.)

- Calculi composed of calcium salts
  - High urine calcium levels
  - Form readily with highly alkaline urine
- Uric acid stones
  - Hyperuricemia
    - Gout, high-purine diets, cancer chemotherapy
    - Especially with acidic urine
- Struvite and cystine stones
- Stone formation depends on predisposing factor.
Stones in kidney or bladder often asymptomatic
  - Frequent infections may lead to investigation.
  - Flank pain possible caused by distention of renal capsule

Renal colic caused by obstruction of the ureter
  - Intense spasms of pain in flank area
    - Radiating into groin area
    - Lasts until stone passes or is removed
  - Possible nausea and vomiting, cool moist skin, rapid pulse
  - Radiological examination confirms location of calculi.
Urolithiasis (Calculi) (Cont.)

- **Treatment**
  - Small stones will be passed eventually.
  - Extracorporeal shock wave lithotripsy (ESWL)
  - Laser lithotripsy
  - Drugs may be used to dissolve stones partially.
  - Surgery

- **Prevention**
  - Treatment of underlying condition
  - Adjustment of urine pH through dietary modifications
  - Consistent increased fluid intake
Hydronephrosis

- Secondary problem caused by:
  - Complication of calculi
  - Tumors, scar tissue in kidney or ureter
  - Untreated prostatic enlargement
  - Developmental abnormalities restricting urine flow
- Frequently asymptomatic in early stages
- Can be diagnosed with ultrasonography, radionucleotide imaging, CT, or renal scan
- If cause is not removed—chronic renal failure
Tumors: Renal Cell Carcinoma

- Primary tumor arising from the tubule epithelium
  - More often in renal cortex
- Tends to symptomatic in early stages
- Often has metastasized to liver, lung, bone, or central nervous system at time of diagnosis
- Occurs more frequently in men and smokers
- Treatment is removal of kidney.
- Immunotherapy may be used in some cases.
- Tumor is radioresistant, and chemotherapy is not used in most cases.
Tumors: Renal Cell Carcinoma (Cont.)

- Manifestations
  - Painless hematuria initially
    - Gross or microscopic
  - Dull, aching flank pain
  - Palpable mass
  - Unexplained weight loss
  - Anemia or erythrocytosis
  - Paraneoplastic syndromes
    - Hypercalcemia or Cushing’s syndrome
Tumors: Bladder Cancer

- Most bladder tumors are malignant and commonly arise from transitional epithelium of the bladder.
- Often develops as multiple tumors
- Diagnosed by urine cytology and biopsy
- Early signs
  - Hematuria, dysuria
  - Infection common
- Tumor is invasive through wall to adjacent structures.
  - Metastasizes to pelvic lymph nodes, liver, and bone
Tumors: Bladder Cancer (Cont.)

- Predisposing factors
  - Working with chemicals in laboratories and industry
    - Particularly aniline dyes, rubber, aluminum
  - Cigarette smoking
  - Recurrent infections
  - Heavy intake of analgesics

- Treatment
  - Surgical resection of tumor
  - Chemotherapy and radiation
  - Photoradiation successful in some early cases
Vascular Disorders: Nephrosclerosis

- Involves vascular changes in the kidney
  - Some occur normally with aging.
- Thickening and hardening of the walls of arterioles and small arteries
- Narrowing of the blood vessel lumen
  - Reduction of blood supply to kidney
  - Stimulation of renin
    - Increased blood pressure
  - Continued ischemia
    - Destruction of renal tissue
    - Chronic renal failure
Hypertension and the Kidney
Nephrosclerosis (Cont.)

- Can be primary lesion developed in kidney
- May be secondary to essential hypertension

**Treatment**
- Antihypertensive agents
- Diuretics
- Beta blockers
- Sodium intake should be reduced.
Congenital Disorders

- Vesicoureteral reflux
- Agenesis
  - Failure of one kidney to develop
- Hypoplasia
  - Failure to develop to normal size
- Ectopic kidney
  - Kidney and ureter displaced out of normal position
- “Horseshoe” kidney
  - Fusion of the two kidneys
Adult Polycystic Kidney

- Autosomal dominant gene on chromosome 16
- No indications in child and young adults
- First manifestations usually around age 40 years
- Multiple cysts develop in both kidneys.
  - Enlargement of kidneys
  - Compression and destruction of kidney tissue
  - Chronic renal failure
- Diagnosis by abdominal CT scanning or MRI
Polycystic Kidney

- Figure 18-15, A—external surface of enlarged kidney, showing cysts.
- Figure 18-15, B—bisected, shows large interior cysts.
Wilms’ Tumor

- Most common tumor in children
- Defects in tumor suppressor genes on chromosome 11
  - May occur in conjunction with other congenital disorders
- Usually unilateral
  - Large encapsulated mass
- Pulmonary metastases may be present at diagnosis.
Renal Failure
Acute Renal Failure

**Causes**

- Acute bilateral kidney diseases
- Severe, prolonged circulatory shock or heart failure
- Nephrotoxins
  - Drugs, chemicals, or toxins
- Mechanical obstruction (occasionally)
  - Calculi, blood clots, tumors
    - Block urine flow beyond kidneys
Acute Renal Failure (Cont.)

- Sudden onset
- Blood tests
  - Elevated serum urea nitrogen and creatinine levels
  - Metabolic acidosis and hyperkalemia
- Treatment
  - Identify and remove or treat primary problem.
    - To minimize risk of necrosis and permanent kidney damage
  - Dialysis
    - To normalize body fluids and maintain homeostasis
Causes of Renal Failure: Nephrotoxins

1. Filtrate becomes concentrated
2. Concentrated nephrotoxin → tubule wall becomes swollen and necrotic
3. Normal lumen → Obstructed lumen
4. Filtrate: high back pressure
5. Decreased GFR
6. OLIGURIA

NPHROTOXINS


Causes of Renal Failure: Ischemia

1. GLOMERULUS
   - Severe shock
   - Vasoconstriction
   - Decreased blood flow

2. TUBULE
   - Ischemia
   - Swelling
   - Necrosis
   - Obstruction

3. FILTRATE: High back pressure

4. OLIGURIA

Causes of Renal Failure:
Pyelonephritis
Chronic Renal Failure

- Gradual irreversible destruction of the kidneys over a long period of time
- Asymptomatic in early stages
- May result from
  - Chronic kidney disease
  - Congenital polycystic kidney disease
  - Systemic disorders
  - Low-level exposure to nephrotoxins over sustained period of time
Chronic Renal Failure: Stages

- **Decreased renal reserve**
  - Decrease in GFR
  - Higher than normal serum creatinine levels
  - No apparent clinical symptoms

- **Renal insufficiency**
  - Decreased GFR to about 20% of normal
  - Significant retention of nitrogen wastes
  - Excretion of large volumes of dilute urine
  - Decreased erythropoiesis
  - Elevated blood pressure
Chronic Renal Failure: Stages (Cont.)

- End-stage renal failure
  - Negligible GFR
  - Fluid, electrolytes, and wastes retained in body
  - Azotemia, anemia, and acidosis (three As)
  - All body systems affected
  - Marked oliguria or anuria
  - Regular dialysis or kidney transplantation
    - To maintain patient’s life
Development of Chronic Renal Failure

- Normal kidneys
- Nonfunctional area
- Fibrotic area
- Extensive damage
- Fibrotic kidneys shrink

No. of NEPHRONS

Function 100% → Decreasing renal reserve (asymptomatic) → Renal insufficiency → End-stage failure (uremia)

TIME

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Chronic Renal Failure (Cont.)

- Early signs
  - Increased urinary output
  - General signs
    - Anorexia
    - Nausea
    - Anemia
    - Fatigue
    - Unintended weight loss
    - Exercise intolerance
  - Bone marrow depression and impaired cell function
    - Caused by increased wastes and altered blood chemistry
  - Elevated blood pressure
Chronic Renal Failure (Cont.)

- Complete failure
  - Oliguria
  - Dry, pruritic, hyperpigmented skin, easy bruising
  - Peripheral neuropathy
  - Impotence in men, menstrual irregularities in women
  - Encephalopathy
  - Congestive heart failure, dysrhythmias
  - Failure to activate vitamin D
  - Possible uremic frost on the skin
  - Systemic infections
Chronic Renal Failure (Cont.)

- Diagnostic tests
  - Anemia, acidosis, and azotemia are the key indicators of chronic renal failure.

- Treatment—all body systems are affected.
  - Difficult to maintain homeostasis of fluids, electrolytes, and acid-base balance
  - Drugs to stimulate erythropoiesis
  - Drugs to treat cardiovascular problems
  - Intake of fluid, electrolytes, protein must be restricted
  - Dialysis or transplantation
Comparison of Acute and Chronic Renal Failure

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Acute Renal Failure</th>
<th>Chronic Renal Failure</th>
</tr>
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<tbody>
<tr>
<td>Causes</td>
<td>Severe shock, Burns, Nephrotoxins, massive exposure, Acute bilateral kidney infection or inflammation</td>
<td>Nephrosclerosis, Diabetes mellitus, Nephrotoxins, long-term exposure, Chronic bilateral kidney inflammation or infection, Polycystic disease</td>
</tr>
<tr>
<td>Onset</td>
<td>Sudden, acute</td>
<td>Slow, insidious</td>
</tr>
<tr>
<td>Early signs</td>
<td>Oliguria, increased serum urea</td>
<td>Polyuria with dilute urine, Anemia, fatigue, hypertension</td>
</tr>
<tr>
<td>Progressive signs</td>
<td>Recovery—increasing urine output</td>
<td>End-stage failure or uremia</td>
</tr>
<tr>
<td></td>
<td>If prolonged failure—uremia</td>
<td>Oliguria, acidosis, azotemia</td>
</tr>
</tbody>
</table>