Chapter 10

Diseases and Disorders of the Urinary System

Learning Objectives

After studying this chapter, you should be able to

- Describe the anatomy and the functions of kidneys, nephrons, ureters, urinary bladder, and urethra
- Identify the etiology, signs and symptoms, diagnostic tests, and treatment for acute kidney injury and other acute and inflammatory diseases of the urinary system
- Know the etiology, and describe the signs and symptoms, diagnostic tests, and treatment of urinary tract infections
- Identify the etiology, signs and symptoms, diagnostic tests, and treatment for chronic kidney disease, hypertensive kidney disease, diabetic nephropathy, nephrotic syndrome, end-stage renal disease, and other chronic diseases of the urinary system
- Describe kidney dialysis
- Recognize the etiology, signs and symptoms, and modes of treatment for renal cell carcinoma, Wilm’s tumor, and bladder cancer
- Describe common congenital disorders of the urinary system
- Describe common age-related diseases of the urinary system

Fact or Fiction?

Kidney stones occur only in the kidneys.

Fiction: Kidney stones may form anywhere within the urinary system, but they usually form in the renal pelvis or calyces of the kidney and they can lodge in the ureters.

Histopathology of kidney showing nodular glomerulosclerosis characteristic of diabetes mellitus. (Courtesy of the Centers for Disease Control and Prevention/Dr. Edwin P. Wing, Jr., 1974)
Disease Chronicle

What’s in a Name?

Many anatomical structures once bore the names of the scientists who first discovered them. Recently anatomists have revised anatomical nomenclature and we no longer formally name organs after scientists. Instead, we apply descriptive anatomical terminology to structures. The glomerulus or renal corpuscle was formerly known as the malpighian corpuscle, named for Italian anatomist Marcello Malpighi (1628–1694) who first published a description of the glomerulus. One of the microscopic filtration tubules now called the renal loop was for many years named the loop of Henle, for Friedrich Gustav Jakob Henle, who described it in 1862.
Anatomy and Physiology Review

The organs of the urinary system filter the blood, form and store urine, and excrete urine from the body. The urinary system is comprised of two kidneys and ureters, a urinary bladder, and a urethra. The two kidneys are retroperitoneal, located behind the peritoneum of the posterior abdominopelvic cavity. Leading from each kidney is a ureter that drains urine to the urinary bladder, located on the floor of the pelvic cavity. The urethra drains urine from the urinary bladder to the outside.

The kidneys are critical for homeostasis. Kidneys continually remove waste and toxins from the blood, regulate water and electrolyte levels, and control pH and blood pressure. Kidneys also produce renin, which regulates blood pressure, and erythropoietin, which stimulates red blood cell production. Kidneys produce approximately 1 milliliter of urine per minute. In doing so, 20–25% of the body’s blood volume flows within the kidneys at any given time.

Diagnostic Tests and Procedures

History and Physical Exam

Diagnosis of urinary system diseases requires assessing patient history. Important factors include the presence of other diseases, especially diabetes, hypertension, and urinary tract infections. A history should also determine exposure to medicines, antibiotics, and kidney toxins or abuse of analgesics such as acetaminophen. Diagnostic information can be gathered from patient reports about fever, pain, and urine volume, frequency, or color. Family history of renal diseases can indicate a genetic predisposition for certain diseases.

A physical exam can reveal renal disease because the entire body is affected. For example, edema can be detected in skin, around the eyes, and on the ankles. As toxins accumulate in the blood, neurologic abnormalities arise, including disorientation and changes in consciousness and response to stimuli. Changes in electrolyte levels occur with renal disease, causing hypotension and a strong, irregular pulse. Alterations in pH levels result in acidosis, which triggers hyperventilation.

The Nephron

The functional unit of the kidney is the nephron. Approximately a million nephrons reside within each kidney. As blood passes through the nephrons, metabolic waste products are filtered from the blood plasma. At the same time, most of the water (99%) is reabsorbed, along with nutrients such as glucose and amino acids. Extra water, excess ions, acid, some drugs, and metabolic wastes such as urea and creatinine are excreted. The hormones aldosterone and antidiuretic hormone (ADH) play important roles in the regulation of the nephron’s ability to reabsorb salt and water.

Each nephron consists of an afferent arteriole, an efferent arteriole, a glomerulus, a glomerular capsule, a proximal convoluted tubule, a renal loop (loop of Henle), and a distal convoluted tubule that leads to a collecting duct. The components of the nephron are shown in Figure 10–1. The afferent arteriole carries blood into the nephron and enters the glomerulus, a network of specialized selectively permeable capillaries, where blood is filtered into the surrounding glomerular capsule. This filtrate contains fluid from plasma and some of its constituents. As the filtrate continues on through the proximal renal tubule, renal loop, and distal renal tubule, its composition is altered. Much water is retained (reabsorbed into nearby capillaries), as are glucose and electrolytes. Acid and urea are not reabsorbed. Instead, these are excreted and move with the filtrate to the collecting ducts, forming urine. Normal urine does not contain blood cells, plasma proteins, or glucose.

Urine from the collecting ducts of the nephrons eventually empties into the renal calyces and renal pelvis at the junction of the kidneys with the ureters, and moves down the ureters to the urinary bladder. Neural signals governing micturition stimulate the bladder to empty urine into the urethra, which leads outside the body. Figure 10–2 illustrates the urinary system.
Figure 10–1 ▶ The kidney with an expanded view of the nephron.
Urinalysis and Laboratory Tests
Renal disease can be detected through analysis of blood for creatinine, uric acid, and blood urea nitrogen. Significant diagnostic information can be obtained by urinalysis, in which a urine specimen is studied physically, chemically, and microscopically. Physical factors include urine color, clarity, odor, pH, and specific gravity. The color of normal urine ranges from pale yellow to amber.

The color and volume of urine may indicate disease. For example, diabetics produce large volumes of pale and dilute urine. In chronic kidney diseases, the ability of the renal tubules to concentrate urine is absent. As a result, the urine is dilute and pale, and the specific gravity is low. The presence of red blood cells imparts a reddish-brown color to urine.

Chemical tests may employ a urine dipstick to detect a variety of chemicals. For example, albumin in the urine (albuminuria) can indicate inflammation of the urinary tract, particularly of the glomeruli. The presence of glucose in the urine is one of the signs of diabetes mellitus.

Urine is centrifuged and examined microscopically for red blood cells, white blood cells, bacteria, crystals, and casts. Casts form within kidney tubules from which the casts take their cylindrical forms. Casts consist of coagulated protein, blood cells, and epithelial cells.

Imaging Techniques
Ultrasound and CT allow visualization of the kidneys, ureters, and bladder. A cystoscopic examination enables visualization of the inside of the bladder and urethra. The cystoscope is a long, lighted instrument resembling a narrow hollow tube inserted through the urethra into the bladder.

Acute Diseases and Disorders
Acute Kidney Injury
Acute kidney injury is the sudden onset of impaired renal function. Acute kidney injury has three main causes. One is shock, which
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interrupts blood flow to the kidneys. Second is tubular necrosis, which results in a number of diseases such as systemic lupus erythematosus, sickle cell disease, renal vein thrombosis, acute poststreptococcal glomerulonephritis, or exposure to toxins. Third is obstructed urine flow, a condition arising with kidney stones, an inflamed prostate, or tumors.

Significant signs of acute kidney injury include oliguria (low urine output), a sudden drop in urine volume, and rarely a complete cessation of urine production, a condition called anuria. Systemic symptoms arise as the body fails to clear toxins and acid from the blood. Symptoms include nausea, vomiting, diarrhea, and the odor of ammonia on the breath caused by accumulation in the blood of nitrogen-containing compounds. Headache, drowsiness, confusion, neuropathy, seizures, and coma may occur if untreated. At first low blood pressure occurs, then hypertension and heart failure and respiratory edema. Hyperkalemia, a condition of elevated blood potassium, can cause cardiac arrest.

Diagnosis includes a history to determine the presence of other diseases or exposure to toxins or medicines that are known to trigger acute kidney injury. Blood tests will reveal elevated blood urea nitrogen, serum creatinine, potassium, and low pH, all of which are signs of the kidneys’ failure to clear these substances and acid from the blood. Urinalysis will reveal casts, low specific gravity, and possibly proteinuria. An ultrasound may be used to visualize renal damage.

Treatment includes a diet low in protein, sodium, and potassium, restricted fluid intake, and dialysis if needed. Hyperkalemia requires dialysis and IV medications that remove potassium. The prognosis is favorable if treatment begins early. Acute kidney injury can be prevented by treating the causative diseases and by avoiding known kidney toxins.

Urinary Tract Infections

Urinary tract infections (UTIs) are caused primarily by bacteria from the skin or colon. Bacteria that colonize the urethra usually become dislodged by regular flow of urine. If not cleared from the urethra, bacteria can ascend the urethra and infect the urinary bladder and the kidneys. UTIs can occur when urine flow is reduced, during catheterization, or following poor hygiene. Because females have a shorter urethra, the prevalence of UTIs is greater in females than in males.

**Lower UTIs: Urethritis and Cystitis**

**Urethritis** and **cystitis** are fairly common UTIs. Urethritis is inflammation of the urethra and cystitis is inflammation of the urinary bladder. Risk factors include being female, having multiple sex partners, and having sexually transmitted infectious diseases. The symptoms of urethritis include a discharge from the urethra, an itching sensation at the opening of the urethra, and a burning sensation during urination. Cystitis is characterized by urinary frequency, a sense of urinary urgency, and dysuria, a painful, burning sensation during urination. Other symptoms include low fever and pressure with pain in the lower back. The primary cause of lower UTIs is a bacterial infection. Treatment includes antibiotics. Lower UTIs can be prevented by staying hydrated to promote urine flow, practicing front-to-back wiping after urinating, and safe sex.

**Upper UTIs Pyelonephritis** is inflammation of the kidney. Risk factors include being female, kidney stones, having a urinary catheter, or immunodeficiency. In pyelonephritis, infected abscesses form and rupture, draining pus into urine. Pus in the urine is called pyuria, which makes the urine sample turbid or cloudy. Symptoms of pyelonephritis include chills, high fever, sudden back pain that spreads over the abdomen, dysuria, and hematuria. Microscopic examination of the urine reveals numerous pus cells and bacteria. The abscesses can fuse, filling the entire kidney with pus. Figure 10–3 shows how pyelonephritis develops. Pyelonephritis is often caused by pyogenic (pus-forming) bacteria, such as *Escherichia coli*, streptococci, and staphylococci.

Left untreated, pyelonephritis may lead to uremia and renal failure. Less severe infections heal and form scar tissue. Treatment includes antibiotics. Prevention relies on prompt treatment of infections in the bladder and lower urinary tract.

**Inflammatory Kidney Diseases**

Immune system–mediated inflammation of the kidney may occur in the absence of infection.
immunoglobulin A (IgA) deposition in the glomeruli. IgA nephropathy is more common in men, especially those in their late teens to early 30s, although it affects all age groups. IgA nephropathy is a common cause of glomerulonephritis. Because it takes years to become recognized and cause complications, younger people seldom display symptoms. The most common early symptoms are blood in the urine and later swelling of the hands and feet.

Diagnosis involves tests for blood urea nitrogen, urinalysis, and renal biopsy. No treatment is recommended for mild cases with normal blood pressure and proteinuria, but elevated blood pressure requires hypertension medications. Prevention is not possible.

**Glomerulonephritis**

Glomerulonephritis (GN) is an inflammatory disease of the glomeruli. GN is a condition that arises from a variety of underlying diseases and disorders, and its prevalence is not well known. However, GN is the second leading cause of renal failure. In GN, most glomerular injury results from inflammatory conditions. Acute GN usually affects children 1–4 weeks following a streptococcal infection of the skin or throat. In contrast, chronic GN usually follows chronic kidney disease. Risk factors for GN include diabetes, hypertension, and streptococcal infection.

**Acute Poststreptococcal Glomerulonephritis**

Acute poststreptococcal GN is an inflammatory condition of the kidney. Nephritis occurs in about 45% of those with systemic lupus erythematosus. Symptoms and signs include hematuria, hypertension, and joint pain.

Diagnosis of lupus nephritis begins with a patient history, physical exam, and evaluation of symptoms. Lab tests include urinalysis, blood tests, ultrasound, and might include kidney biopsy to determine the type of kidney injury. Treatment involves anti-inflammatory drugs and immune-suppressants. Hypertension must be treated with statins or ACE inhibitors and a reduced-fat and low-salt diet. Renal transplant may be performed if the kidney function does not recover. Prevention is not possible, but risk can be reduced by adequate treatment of systemic lupus erythematosus.

**IgA Nephropathy**

IgA nephropathy is an inflammatory disease of the kidney resulting from
States. Men are four times more likely than women to produce renal calculi, with the first episodes occurring between ages 20 and 40.

Urinary calculi may cause no symptoms, even when passed through the urinary tract, unless they are larger than a quarter inch in diameter, in which case they become lodged in the ureter. The lodged stones cause intense pain that radiates from the kidney to the groin area. In addition to intense pain, other signs and symptoms include hematuria, nausea, vomiting, and diarrhea.

Kidney stones may cause urinary tract infections by blocking urine flow and permitting bacterial growth in the urinary tract. A large kidney stone is illustrated in Figure 10–6. Stones can also form in the urinary bladder. The presence of bladder stones causes urinary tract infections because they frequently obstruct the flow of urine.

Diagnosis relies on CT and renal ultrasound. Urinary calculi may be treated with medication that partially dissolves the stone, permitting it to be passed in the urine. Lithotripsy, the crushing of kidney stones, is particularly effective for the 20% of kidney stones that do not pass on their own. In lithotripsy, sonic vibrations are applied externally, and focused internally, to

Kidney Stones

Kidney stones are deposits of minerals within the kidney. The stones, called urinary calculi or uroliths, occur in 9% of adults in the United States.
but there may be some bruising, and the patient might require a hospital stay.

Prognosis is good, although recurrence of stones is not uncommon. To prevent recurrence, fluid intake should be increased to keep the urine dilute, and dietary calcium and protein should be reduced.

crush the stones. If performed while the patient is immersed in a tank of water, the procedure is called hydrolithotripsy (Figure 10–7). In this technique, the partially submerged patient is subjected to the sonic waves that shatter the hard stones into sand-sized particles that can be eliminated with the urine. Recovery is rapid,
Renal Failure

Renal failure is the progressive loss of kidney function over time. Renal failure has many underlying causes, so its prevalence is not known. Risk factors include diabetes, glomerulonephritis, or other chronic kidney diseases. Ischemia, hemorrhage, shock, toxins, and large kidney stones or tumors may cause renal failure. In renal failure the kidneys are unable to clear the blood of urea and creatinine, which are nitrogen-containing waste products of protein metabolism. These metabolic products are toxic if they accumulate in the blood, a condition known as uremia. Uremia signifies the terminal stage of renal failure (Figure 10–8). Diagnostic tests include blood tests for blood urea nitrogen, and tests of the glomerular filtration rate (GFR). GFR determines the ability of the kidney to clear creatinine. When GFR is impaired, the serum creatinine level rises and the creatinine clearance rate falls. Treatment depends on the underlying cause of renal failure but usually includes renal dialysis.

Chronic Diseases and Disorders

Diabetic Nephropathy

Today diabetic nephropathy is recognized as the most common cause of chronic kidney disease and end-stage renal disease in the United States. Diabetic nephropathy is due to inflammation of the glomerulus, which leaks high levels of albumin and other plasma proteins. After years of diabetes mellitus, mature adults have a risk for developing diabetic nephropathy. The best way to reduce the risk for diabetic nephropathy is to manage diabetes mellitus from the first day it is diagnosed. The kidney damage of diabetic nephropathy is cumulative and irreversible, so it is much better to prevent this disease than to deal with its consequences.
Nephrotic Syndrome Nephrotic syndrome (NS) is a chronic disease with proteinuria, hypoalbuminemia (low plasma albumin), hyperlipidemia (high plasma lipids), and edema. NS occurs in several forms that affect different populations and differ somewhat in signs, symptoms, and prognosis. Nephrotic syndrome results from glomerular injury that occurs in the course of other kidney diseases. Most cases of NS are due to glomerulonephritis and diabetes.

A chief sign of NS is edema of the ankles and around the eyes, and pleural and genital edema. Symptoms include low blood pressure, lethargy, and anorexia. High lipid levels can lead to premature atherosclerosis and associated complications. NS also raises the risk for infection and blood clots.

Diagnosis involves urinalysis that shows high protein levels and casts. Blood tests show high lipids and low albumin. A kidney biopsy may be performed to determine the presence of lesions characteristic of NS.

Treatment of NS requires addressing the underlying cause. NS can be treated with hypertension medications, diuretics, immune-suppressants, cholesterol-lowering drugs, and blood-thinning medications. The prognosis varies and depends on the form of NS. NS cannot be prevented, but the risk can be reduced by treating diabetes or glomerulonephritis.

Hypertensive Kidney Disease Hypertensive kidney disease is caused by kidney injury. Also called renovascular hypertension, hypertensive kidney disease is found in about 1 in 10 people with systemic hypertension. Hypertensive kidney disease occurs mainly in people over age 50.

Hypertensive kidney disease is caused by atherosclerosis of renal arteries and their small branches within the kidneys. As these vessels narrow, systemic blood pressure increases. The decreased blood to kidneys causes them to release renin, which converts the plasma protein angiotensin into angiotensin I. In the liver and lungs, angiotensin I is converted to angiotensin II, which triggers vasoconstriction and aldosterone secretion, resulting in hypertension.

Signs and symptoms include typical features of systemic hypertension, such as headache, heart palpitations and tachycardia (rapid heart rate), light-headedness, and anxiety. Damage to the retina can be observed. Sustained hypertension elevates the risk for heart failure, myocardial infarction, and stroke.

Diagnosis begins with a patient history. Because surgery might be able to help, the kidneys are examined to determine which kidney is affected and where the problems lie. Ultrasound and renal arteriography permit visualization of blood flow and obstruction. The blood in the renal veins can be tested for elevated renin to determine which kidney is affected.

Treatment includes surgery to correct the underlying renal vascular problems. The surgery can include renal artery bypass, endarterectomy, or angioplasty. Symptoms can be managed with antihypertension medication and diuretics and by controlling sodium intake. Renal hypertension may not be easily prevented, but the risk can be lowered by regular exercise, a low-fat diet, not smoking, and by treating hypertension, all of which help prevent atherosclerosis.

Treatment of Chronic Kidney Disease Chronic kidney disease is treated with antihypertensives, diuretics, and kidney dialysis. Controlling weight, blood lipids, sodium intake, sugar levels, and engaging in regular exercise may help control progression of renal disease.

Renal dialysis is commonly used to treat renal failure before considering kidney transplant. Renal dialysis removes toxic substances from the blood. In hemodialysis, blood is removed from the body and passed through dialysis membranes where toxic substances are removed from the blood, and the blood is returned to the body (Figure 10–9). For hemodialysis, a patient typically must visit a clinic or hospital for dialysis treatment and stay for 3–6 hours during the process. However, residential dialysis units allow patients more convenient and private treatment. Small portable dialysis units have further reduced cost and have increased availability for many patients.
In peritoneal dialysis (PD), dialyzing fluid is introduced into the abdominal cavity, where the peritoneum or cavity lining acts as a dialysis filter membrane. The fluid draws toxic materials out of capillaries surrounding the body cavity, and after a suitable amount of time, the peritoneal fluid is removed, along with its dissolved toxins. A bag may be attached externally to collect the fluid, permitting the patient to remain mobile and providing more freedom and flexibility during treatment. Dialysis may be required for years but may not be sufficient in advanced chronic kidney disease.

Kidney function can decline to a point that dialysis is no longer an effective treatment option. A kidney transplant may be viable for some of these people. One transplanted kidney can replace the function of two nonfunctional kidneys, but the procedure is not for everyone. The candidate must be healthy enough to endure the risks of surgery, a long recovery, and a lifetime of antirejection drugs. Available tissue-matched kidneys are uncommon, and long wait lists have developed, resulting in waiting a year or more before a potential donor kidney is identified. Kidneys can be transplanted by living donors or from deceased donors. In either case, the transplant requires antirejection drugs for life. Partly because of such drugs, about 90% of live kidney recipients survive at least 5 years after the transplant (Figure 10–10 ▶).

**End-Stage Renal Disease**

End-stage renal disease (ESRD) is a complete failure of kidney functioning and ends in death. ESRD follows the final stages of chronic kidney disease when dialysis or kidney transplantation have not succeeded. The risk for ESRD can be reduced by taking the following measures.

1. Control blood pressure and blood sugar levels.
2. If diabetic or hypertensive, monitor total urine protein levels.
3. If at high risk for ESRD, reduce dietary protein.
4. Do not smoke.
**Prevention PLUS!**

**Chronic Kidney Disease**

Chronic kidney disease is life-threatening and potentially preventable. A number of lifestyle choices reduce the risk for developing CKD. Notice that these behaviors reduce the risk for atherosclerosis and heart disease.

- Do not smoke.
- Reduce or eliminate alcohol use.
- Control weight.
- Reduce dietary fat, sodium, and sugar.
- Control blood pressure.
- Control diabetes.

**Think Critically**

1. How does atherosclerosis contribute to kidney disease?
2. Why do dietary factors affect kidney health?

**Other Chronic Kidney Disorders**

**Hydronephrosis**  
Hydronephrosis is a condition of urine retention within dilated kidney tubules. Hydronephrosis occurs in about 1 of 100 individuals, primarily affecting one kidney (Figure 10–11 ▶). This condition results from urinary calculi, a congenital defect, a tumor, an enlarged prostate gland, or other obstruction of the renal pelvis or ureter. The ureters may also dilate above an obstruction in a condition called **hydroureters** (Figure 10–12 ▶). Signs and symptoms include hematuria and pain. Pyuria and fever occur if an infection develops because of reduced urine flow.

Hydronephrosis is diagnosed with physical exam, CT, or ultrasound. Treatment includes antibiotics, analgesics, catheterization, and surgery. Prevention is not possible, but risk can be reduced by treating stones or tumors that obstruct urine flow.

**Chronic Glomerulonephritis**  
Chronic glomerulonephritis (GN) is a slowly progressing inflammation of the glomeruli that leads to glomerular necrosis, chronic kidney disease, and renal failure. Chronic GN is caused by a number of different chronic kidney and glomerular diseases, systemic lupus erythematosus, renal autoimmunity, and hemolytic uremic syndrome. Signs and symptoms develop gradually, eventually lead to nephrotic syndrome, and include typical features of chronic kidney disease and renal failure. Diagnosis is based on history, urinalysis, blood urea nitrogen, and serum creatinine levels. Ultrasound or CT reveals small kidneys and

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**Figure 10–11 ▶** Hydronephrosis: bilateral (left), unilateral (right).
diseases, tumors, and spinal injuries also cause incontinence.

Signs and symptoms range from small leaks of urine—"dribbles"—to complete loss of control over urine flow. Stress incontinence is unexpected flow of urine that occurs with coughing, sneezing, laughing, or lifting. Others experience a sense of urinary urgency followed by flow of urine. Others experience overflow incontinence, in which the inability to empty the bladder results in continued leaking following urination.

Diagnosis requires a history, physical exam, and laboratory blood tests. Patients may be asked to maintain a diary of their incontinence to help identify associated patterns and triggers. Ultrasound and cystoscopy may be used to inspect the bladder.

Treatment depends on the type of incontinence and the nature of underlying causes. Treatments may involve behavioral changes, pelvic exercises, medication, catheterization surgery, or other interventions. Prevention requires treatment of the underlying diseases and disorders.

Malignancies

Renal Cell Carcinoma Renal cell carcinoma is a relatively rare type of cancer, comprising only 3% of all adult cancers. The prevalence of kidney cancer in men is twice that for women, and it normally occurs between ages 50 and 60. Smokers are twice as likely as nonsmokers to develop kidney cancer. The American Cancer Society projected nearly 65,000 new cases of kidney cancer in 2012. Major risk factors are smoking, obesity, and heredity.

The tumor grows slowly for several years. Painless hematuria eventually becomes the chief sign. When the tumor becomes large, an abdominal mass may be felt. This mass can then be detected on an x-ray as a tumor of the kidney. The malignancy frequently spreads to the lungs, liver, bones, and brain. Metastasis to other organs often occurs before the presence of the kidney tumor is known.

Besides pain, typical signs include loss of appetite, weight loss, anemia, and an elevated white blood cell count or leukocytosis. Surgical removal of the kidney or the tumor is an effective treatment.
Wilm’s Tumor  
Wilm’s tumor is a malignant tumor of the kidney pelvis that develops in children, usually diagnosed between ages 2 and 5. A fast-growing adenosarcoma, it metastasizes through the blood and lymph vessels. Symptoms and signs include hematuria, pain, vomiting, and hypertension similar to symptoms of renal carcinoma in an adult.

Wilm’s tumor, found 1 in 10,000 individuals, has a genetic basis. At least three different genes influence the occurrence of this disease. The Wilm’s tumor gene 1 (WT-1) has been identified as an important genetic marker for Wilm’s tumor. When this gene is missing or mutated, congenital defects appear, and this abnormal tissue later becomes the site of cancer.

Diagnosis is done by CT and ultrasound and confirmed by kidney biopsy. Early diagnosis and treatment have improved the prognosis for Wilm’s tumor. Prevention is not possible.

Carcinoma of the Bladder  
Carcinoma of the bladder is a malignant tumor originating in the urinary bladder. Bladder cancer accounts for more than 3% of cancers in men and more than 1% of cancer cases for women in the United States. Smokers have a risk 2½ times higher than non-smokers for developing bladder cancer. Symptoms are bleeding, burning pain, cramping, and inability to urinate. Diagnosis is done through physical exam, urinalysis procedures, biopsy, and blood analysis. The carcinoma can be detected with a cystoscope and removed surgically. If the urinary bladder must be surgically removed, an ileal conduit (Figure 10–13) may be constructed surgically to store and evacuate urine. Prevention is not possible.

SIDE by SIDE  
Polycystic Kidney

A  
Normal kidney. (© Logical Images/Custom Medical Stock Photo)

B  
Polycystic kidney. (Courtesy of the Centers for Disease Control and Prevention/Dr. Edwin P. Ewing, Jr., 1972)
Congenital Disorders

Polycystic Kidney Disease

Polycystic kidney disease (PKD) is the development of numerous fluid-filled pockets of tissue within the kidney. Cysts may also form in other organs such as the liver. Two genetic forms of PKD occur. About 90% of cases are autosomal dominant and affect adults. The autosomal recessive form affects children. In the United States about 600,000 individuals have PKD.

Signs and symptoms arise as the cysts fuse and enlarge, compressing surrounding tissue and impairing kidney function. Cysts may number in the hundreds or thousands, and they can cause the kidney to weigh 20–30 pounds. The accompanying Side by Side illustrates the polycystic kidney of an adult. Chief problems are pain, hypertension, and hematuria. PKD is diagnosed with a combination of a physical exam and a renal ultrasound or CT.

There is no cure for PKD. Treatment is aimed at controlling high blood pressure, pain, and infections that tend to arise in cysts. Surgery may be used to drain cysts, which can relieve pain temporarily. Eventually dialysis and kidney transplant may be needed. Prevention is not possible because of the genetic nature of PKD.

Other Congenital Disorders

Medullary Sponge Kidney Medullary sponge kidney is named for the appearance of the inner part (medulla) of an affected kidney. Affecting about 1 in 5,000–20,000 people in the United States, medullary sponge kidney is present at birth, but is usually asymptomatic until adulthood. In most cases, signs and symptoms include recurrent kidney stones, sometimes accompanied by hematuria, and pain. It can be diagnosed with ultrasound or intravenous pyelogram. No specific treatment is available, except for increasing fluids to reduce risks of forming stones and their complications. Medullary sponge kidney cannot be prevented, but its complications can be managed by reducing risks for kidney stones.

Congenital Disorders of the Ureters, Urinary Bladder, and Urethra Congenital abnormalities of the ureters, bladder, and urethra are relatively common, occurring in about 5% of births. Many of these disorders are immediately detected, whereas others are found when signs and symptoms arise later. Ureter disorders include duplication, abnormal position, abnormal location of openings, abnormal dilation, or constrictions. Urinary bladder abnormalities include a malformed wall or pouches. Congenital abnormalities of the urethra include epispadias, in which the urethral opening develops on the dorsal side of the penis, and hypospadias, in which the urethral opening occurs on the ventral surface of the penis. Many of these can be detected through assessment of urinary function at birth. Most require surgical repair to obtain normal function.

Age-Related Diseases

Several changes accompany the aging urinary system. With age comes less control over urination as urethral sphincter muscles lose tone.

The total number of functioning nephron units declines with age. As much as 30–40% of the nephrons may degenerate between ages 25 and 85. In addition, the kidney loses sensitivity to ADH. Reduction of rennin, and therefore aldosterone activity, causes a lack of salt and water retention, allowing more urine to be released by the kidney.

Urinary retention may also occur because the urinary bladder loses muscle tone and cannot empty completely. Obstruction exacerbates urine retention and is common in men because of prostate enlargement. Urinary retention, in turn, increases the risk for urinary tract infections and stone development. Kidney cancer increases significantly after age 60, and the incidence of bladder cancer increases after age 70.

Resource

# Diseases at a Glance

## Urinary System

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<td>Patient history, blood tests, and urinalysis</td>
<td>Restricted sodium and protein diet, restrict fluid intake, dialysis for hyperkalemia</td>
<td>Treat kidney diseases and avoid kidney toxins</td>
</tr>
<tr>
<td>Urinalysis, pus and blood in urine</td>
<td>Antibiotics</td>
<td>Treat lower urinary tract infections and kidney stones</td>
</tr>
<tr>
<td>Microscopic exam of urine, patient history</td>
<td>Antibiotics</td>
<td>Maintain regular urination habits, good hygiene</td>
</tr>
<tr>
<td>Patient history, urinalysis, blood tests, kidney biopsy</td>
<td>Anti-inflammatories, immune-suppressants, antihypertensives, reduced salt and fat diet</td>
<td>Reduce risk by treating systemic lupus erythematosus</td>
</tr>
<tr>
<td>Blood tests, urinalysis, renal biopsy</td>
<td>None for mild cases; treat hypertension</td>
<td>None</td>
</tr>
<tr>
<td>Urinalysis, patient history</td>
<td>Anti-inflammatories, immune-suppressants, treat hypertension</td>
<td>Reduce risk by treating streptococcal infections</td>
</tr>
<tr>
<td>Patient history, blood and urinalysis, CT ultrasound</td>
<td>Lithotripsy, surgery</td>
<td>Prevent dehydration</td>
</tr>
<tr>
<td>Patient history, kidney biopsy</td>
<td>Antihypertensives, dialysis</td>
<td>Control diabetes</td>
</tr>
<tr>
<td>Patient history, ultrasound, renal arteriography, renin levels in renal veins</td>
<td>Endarterectomy, angioplasty, renal artery bypass, manage hypertension</td>
<td>Low lipid and sodium diet, not smoking, exercise</td>
</tr>
<tr>
<td>Patient history, urinalysis, blood analysis, kidney biopsy</td>
<td>Treat underlying disease, manage symptoms</td>
<td>Treat glomerulonephritis and diabetes</td>
</tr>
<tr>
<td>Urinalysis, blood tests, ultrasound, CT</td>
<td>Treat hypertension, dialysis, transplantation</td>
<td>Treat acute kidney injuries, lupus</td>
</tr>
<tr>
<td>Disease</td>
<td>Etiology</td>
<td>Signs and Symptoms</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------------------------------------------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>Hydronephrosis</td>
<td>Renal obstruction or congenital defect</td>
<td>Pain, hematuria</td>
</tr>
<tr>
<td>Urinary incontinence</td>
<td>Behavior, childbirth, pregnancy, aging, diet, neurologic damage</td>
<td>Urgency, dribbling urine, or complete lack of urine control</td>
</tr>
<tr>
<td>Congenital disorders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polycystic kidney</td>
<td>Genetic</td>
<td>Pain, hypertension, hematuria</td>
</tr>
<tr>
<td>Medullary sponge kidney</td>
<td>Congenital</td>
<td>Few; recurrent kidney stones, hematuria, pain</td>
</tr>
<tr>
<td>Congenital disorders of urinary bladder, ureters, and urethra</td>
<td>Various malformations apparent at birth or soon after</td>
<td>Various symptoms associated with malformed organs</td>
</tr>
<tr>
<td>Malignancies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal cell carcinoma</td>
<td>Idiopathic, risk elevated for smokers</td>
<td>Painless hematuria, later pain, loss of appetite, weight loss, anemia, elevated white blood count</td>
</tr>
<tr>
<td>Wilm's tumor</td>
<td>Idiopathic, probably genetic</td>
<td>In young children, signs and symptoms similar to renal cell carcinoma in adults</td>
</tr>
<tr>
<td>Bladder cancer</td>
<td>Idiopathic, smoking, hazardous chemicals</td>
<td>Hematuria, dysuria, fatigue, anorexia</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Treatment</td>
<td>Prevention</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Urinalysis, CT, ultrasound</td>
<td>Analgesics, catheterization surgery</td>
<td>Treat or prevent kidney stones</td>
</tr>
<tr>
<td>Patient history, cystoscopy</td>
<td>Behavior and diet modification, pelvic exercise, surgery</td>
<td>Reduce risk factors when possible</td>
</tr>
<tr>
<td>Ultrasound, CT</td>
<td>Treat symptoms, transplantation</td>
<td>None</td>
</tr>
<tr>
<td>Patient history, ultrasound, CT</td>
<td>Treat symptoms, hydration</td>
<td>None</td>
</tr>
<tr>
<td>Physical exam, ultrasound</td>
<td>Surgery</td>
<td></td>
</tr>
<tr>
<td>CT, ultrasound</td>
<td>Surgery</td>
<td>Uncertain</td>
</tr>
<tr>
<td>CT, ultrasound</td>
<td>Surgery, sometimes radiation</td>
<td>None</td>
</tr>
<tr>
<td>Cystoscope, biopsy, CT</td>
<td>Radiation, surgery</td>
<td>Uncertain; do not smoke</td>
</tr>
</tbody>
</table>
Interactive Exercises

Cases for Critical Thinking

1. Jane, a college sophomore, experienced painful urination and noticed blood in the urine. What can explain her symptoms and hematuria?

2. Britany, a thin fourth grader, experienced a significant weight gain within 2 weeks' time. Just before holiday break, she had a bad sore throat, but after a visit to the doctor, those symptoms subsided. Her abdomen was distended and she had edema of the extremities. She complained of abdominal discomfort and general aches. Urinalysis indicated proteinuria and hematuria. A follow-up blood screen found antibodies to streptococci. What may explain Britany's symptoms?

3. A mother of a 4-month-old infant, while giving a bath, noticed and palpated a mass on the right side of the child's abdomen. The child was irritable and somewhat lethargic. What might explain this mass, and what diagnostic techniques can help determine the nature of the disease?

4. A 52-year-old grandfather's urinalysis revealed blood (hematuria). The x-ray showed a renal mass on the right side. What is the probable cause for the hematuria, and what treatment would be recommended?

Multiple Choice

1. Which describes anuria?
   a. blood in the urine
   b. uncontrolled passage of urine
   c. painful urination
   d. complete lack of urine production

2. Which condition is an inflammatory disease of the kidney?
   a. pyelonephritis
   b. polycystic kidney disease
   c. hydronephrosis
   d. hypertensive kidney disease

3. Which inflammatory disease occurs 1–4 weeks following a streptococcal infection?
   a. nephrotic syndrome
   b. acute glomerulonephritis
   c. cystitis
   d. polycystic kidney

4. Which term describes high levels of ammonia in the blood?
   a. glomerulonephritis
   b. pyelonephritis
   c. tuberculosis
   d. uremia

5. Which of the following is true about urinary tract infections?
   a. more common in males
   b. symptoms include dysuria and urgency
   c. commonly caused by a virus
   d. do not respond to antibiotics

6. Which form of kidney dialysis permits a patient to retain mobility?
   a. peritoneal dialysis
   b. hemodialysis
   c. hemolysis
   d. ileal shunt

7. Painful urination is described as
   a. micturition
   b. dysuria
   c. anuria
   d. hematuria

8. What is a common cause of chronic kidney disease?
   a. diabetic nephropathy
   b. bacterial infection
   c. autoimmune disease
   d. kidney stones
9. What causes hypertensive kidney disease?
   a. bacterial infection
   b. hyperalbuminuria
   c. renal artery atherosclerosis
   d. lower GFR

10. Bacteria cause all of the following except:
    a. pyelonephritis
    b. cystitis
    c. urethritis
    d. chronic glomerulonephritis

True or False

_____ 1. A sudden drop in urine volume indicates acute kidney disease.

_____ 2. Cystitis is often caused by bacteria.


_____ 4. Albuminuria is a condition of low protein in the urine.

_____ 5. Wilm’s tumor occurs mainly in adults.

_____ 6. Bacteria do not cause acute glomerulonephritis

_____ 7. Pyelonephritis is a pus-forming bacterial infection.

_____ 8. Diabetic nephropathy is a common cause of chronic kidney disease.

_____ 9. Leukocytes in urine indicate bacterial infection.


Fill-Ins

1. ________________ is pus in the urine.

2. ________________ is a kidney disease resulting from diabetes mellitus.

3. Urinary calculi, or ________________, may be present and cause no symptoms until they become lodged in the ureter.

4. ________________, the external crushing of kidney stones, is now the preferable procedure to remove kidney stones, replacing the need for surgery.

5. ________________ is a congenital anomaly and tumor that usually involves both kidneys.

6. Scanty urine or ________________ is low urine volume (or formation).

7. Uncontrolled passage of urine is called ________________.

8. Retention of urine within dilated ureters is known as ________________.

9. In adults polycystic kidney is a genetic disease caused specifically by an autosomal ________________ gene.

10. ________________ describes the presence of blood in urine.