CHAPTER 25
Diagnostic Tests

KEY TERMS

Arteriography (ar-TEER-ee-AWG-ruh-fee)
Barium enema (BA-ree-um EN-e-muh)
Bone marrow aspiration (BOWN MA-roh ASS-pi-RAY-shun)
Chest x-ray (CHEST EKS-ray)
Colonoscopy (KOH-lun-AWS-kuh-pee)
Complete blood cell count (kom-PLEET BLUHD SELL KOWNT)
Complete metabolic panel (kom-PLEET MET-uh-BAH-lik PAN-uhl)
Computed tomography (kom-PEW-ted toh-MAWG-ruh-fee)
Differential (dif-uh-REN-shul)
Echocardiogram (EK-oh-KAR-dee-oh-GRAM)
Electrocardiography (ee-LEK-troh-KAR-dee-AWG-ruh-fee)
Electroencephalography (ee-LEK-troh-en-SEF-uh-LAWG-ruh-fee)
Esophagogastroduodenoscopy (eh-SOF-ah-goh-GAS-troh-doo-AW-den-AWS-kuh-pee)
Glomerular filtration rate (gloh-MER-yoo-ler fill-TRAY-shun RAYT)
Glycosylated hemoglobin (GLY-koh-sye-LAYT-uhd HEE-muh-GLOW-bin)
Intravenous pyelogram (IN-trah-VEE-nus PIE-eh-loh-GRAM)
KUB
Left shift (LEFT SHIFT)
Lumbar puncture (LUM-bar PUNK-chur)
Magnetic resonance imaging (mag-NET-ik REZ-uh-nanss IM-uh-jing)
Oral glucose tolerance test (OR-uhl GLOO-kohss TALL-er-ens TEST)
Paracentesis (PAR-ah-sen-TEE-siss)
Right shift (RIGHT SHIFT)
Thoracentesis (THOR-uh-sen-TEE-siss)
Ultrasonography (UHL-truh-son-AWG-ruh-fee)
Venography (vee-NAWG-ruh-fee)

CHAPTER CONCEPTS

Patient-Centered Care

LEARNING OUTCOMES

1. Define various terms associated with diagnostic tests, as well as the five types of diagnostic tests.
2. Explain the nurse's role and responsibilities regarding preparation for tests and posttest nursing care.
3. Discuss all the components of a complete blood cell count, including normal ranges for each.
4. Identify the components of a white cell count with differential, including possible causes for abnormal values.
5. Explain components of blood chemistry testing and their significance.
6. Determine the purposes of testing cardiac enzymes, B-type natriuretic peptide, lipase, and glycosylated hemoglobin.
7. Contrast the normal and abnormal findings of a urinalysis and their significance.
8. Explain how the glomerular filtration rate is determined, along with its significance.
9. Describe radiology and imaging tests, including computed tomography and magnetic resonance imaging, along with the nursing care of each.
10. Discuss arteriography, venography, computed tomography angiography, and magnetic resonance angiography, as well as the nursing care for each.
11. Explain the preparation for, purpose of, and nursing care after endoscopic exams.
12. Identify allergies for which the nurse should assess prior to procedures and tests requiring use of contrast medium.
13. Discuss the purposes of graphic recording tests, including telemetry, and the nursing care required.
14. Explain the purposes for lumbar puncture, bone marrow aspiration, paracentesis, and thoracentesis, including how to position a patient for each procedure.
15. Discuss information found in the Connection features in this chapter.
16. Identify specific safety information.
17. Answer questions about the skills in this chapter.

SKILLS

25.1 Assisting With Aspiration Procedures: Bone Marrow, Lumbar Puncture, Paracentesis, and Thoracentesis
25.2 Performing a 12-Lead Electrocardiogram

CRITICAL THINKING CONNECTION

Clinical Assignment

You are caring for a 37-year-old female who has been hospitalized with abdominal pain, nausea, and vomiting of an unknown origin. The health-care provider has ordered an esophagogastroduodenoscopy; an ultrasound of the gallbladder and pancreas; and blood work to include a blood chemistry, electrolyte panel, alkaline phosphatase, glomerular filtration rate, and creatinine. Your patient tells you that she hopes they do it all quickly because she hates needles and has no idea what the other tests are like.

Critical Thinking Questions:

1. How will you prepare your patient for her tests?
2. What will you assess for after the tests are completed?
3. Why is it important for you to know normal ranges for diagnostic tests?

It is important that you know the purpose of each test and the normal findings so that you can notify the health-care provider of abnormal results.

Diagnostic tests are those tests and examinations that help to make a medical diagnosis by ruling out other possible diagnoses or by specifically pinpointing the disease process or injury afflicting the patient. This chapter will assist you to identify your role as a nurse in relation to diagnostic tests and to familiarize you with some of the more commonly used examinations.

Please note that this chapter does not provide a comprehensive review of diagnostic testing; rather, the focus is on routine tests that you will likely see on a daily basis. As you will find out throughout the course of your schooling and even as you start your career, the number of diagnostic tests available to health-care professionals cannot be covered in a single chapter. We encourage you to utilize books dedicated solely to this specialized subject to further your knowledge.

NURSING'S ROLE IN DIAGNOSTIC TESTING

As the nurse, you will not be performing many of the tests discussed in this chapter, but you will have numerous responsibilities relating to health-care provider–ordered diagnostic tests and procedures. Depending on the test, your responsibilities before the test may include the following:

- Noting the health-care provider's order.
- Occasionally scheduling the test or procedure.
- Educating the patient regarding the process.
- ***Safety: Determine that the patient is not allergic to any dyes or preparations that may be used for the test, including allergies to iodine, shellfish, and contrast medium.***
- Administering laxatives or enemas to remove fecal material from the intestinal tract, which allows for better visualization of the intestine for various imaging tests.
- Making certain written consent is obtained, if the procedure requires it; the health-care provider is responsible for explaining the diagnostic tests and answering the patient's questions prior to the consent being signed.
- Knowing when to withhold food and fluids (Box 25.1).
- Preparing the patient.
- Assisting the examiner with performance of the test or procedure.

Your responsibilities after the diagnostic tests may include the following:

- Obtaining specimens or delivering specimens to the laboratory.
- Monitoring and assessing the patient's condition after the test.
- Reassuring or supporting the patient as needed.
- Notifying the health-care provider of significant abnormal results.
- Monitoring for complications.
- Providing necessary postprocedure nursing care.
- Being able to relate the significance of the test findings to the patient's condition.

With all of these responsibilities, you can easily see that understanding the purposes, preparation for, and processes of commonly administered diagnostic tests is paramount to your role as a nurse. Table 25.1 details the preparation and posttest nursing care for selected tests.

Settings Connection: Medical Office

Diagnostic Testing and Results

Many times licensed practical/vocational nurses working in medical offices or clinics will be the staff member who sees the results of diagnostic tests first. Or they may be the person who gets the telephone call about abnormal blood tests. It is very important that you recognize values that are severely abnormal and let the health-care provider know about them right away.

If you are working in an office or clinic, you may also be responsible for scheduling diagnostic testing for your patients, as well as giving them preparation instructions. Your knowledge about the diagnostic tests, their purposes, preparation, and normal results will be very important in this setting.

Patient Teaching Connection

Diagnostic Tests

Prepare the patient for upcoming tests or procedures to alleviate the patient's anxiety and increase compliance. Using terminology that the patient will understand, explain the purpose of the test or procedure, as well as the test's benefits and dangers. The physician will explain the purpose and risks for the procedure. Describe what will occur, including any preparatory steps that must be performed prior to the test. If a specimen such as urine or sputum is required, explain how to correctly obtain the specimen. Avoid using acronyms for the name of the test or procedure; instead, use the complete name; for example, use "white blood cell count" rather than "WBC." Remember that the average patient is not familiar with medical terminology. However, this does not mean that you should talk down to the patient as if he or she is ignorant.

It is generally helpful to provide the patient with a written pamphlet or brochure about the procedure. Some patients prefer to read about it before you verbally explain it, while others would rather discuss it with you first and then relax and read the pamphlet to reinforce your teaching. If written consent must be obtained to perform the procedure, be certain that all patient teaching is completed before the consent is signed.

KNOWLEDGE CONNECTION

Discuss at least eight responsibilities you will have regarding diagnostic testing. What types of preparations are common prior to diagnostic procedures?

Box 25.1

When to Withhold Food and Fluids

Withholding food and fluids, or permitting "nothing by mouth," is known as keeping the patient NPO. Many tests require that the patient be kept NPO prior to the test, but there are no hard and fast rules for which tests require this. Each facility will have its own policies for diagnostic tests and whether or not preparation includes being kept NPO. Which blood chemistry tests include being kept NPO vary in different facilities. Some of the tests that commonly require the patient to be kept NPO for 6 to 8 hours include the following:

- Any type of endoscopy, such as EGD and colonoscopy
- Cardiac catheterization
- Any CT with contrast medium or dye
- Any test reflecting glucose levels, such as the glucose tolerance test and fasting blood glucose
- Lung and brain scans if contrast medium is used
- Cholesterol and lipid tests

CATEGORIES OF DIAGNOSTIC TESTS

There are five general categories of diagnostic tests that we will discuss in this chapter:

1. Laboratory tests
2. Radiology and imaging tests and procedures
3. Ultrasonography
4. Endoscopic examinations
5. Graphic recording tests

Laboratory Tests

Laboratory test is a broad classification for numerous types of examinations performed on some type of body fluid, such as whole blood or the serum portion of the blood, spinal fluid, sputum, urine, gastric contents, feces, and bone marrow.

Anatomy and Physiology Connection

Blood

Let's briefly review the production of blood cells. In adults, *red blood cells* (RBCs) are produced by the bone marrow within the sternum, vertebrae, ribs, and pelvis. The kidneys release a protein known as erythropoietin, which acts on stem cells in the bone marrow to produce more RBCs. The RBC has a relatively short life span of approximately 120 days, after which it is destroyed by the reticuloendothelial system. *White blood cells* (WBCs) are mostly produced in the bone marrow, with limited production in the lymphoid tissues. *Platelets* (PLTs) are produced from large bone marrow cells known as *megakaryocytes.*

Hematology

Hematology is the study of blood cells and the blood-forming tissues (the bone marrow). It includes different types of blood counts.

COMPLETE BLOOD COUNT. The most common test ordered is the **complete blood cell count** (CBC), which measures the number of leukocytes, or WBCs; erythrocytes, or RBCs; and thrombocytes, also called platelets and abbreviated as PLTs. It also differentiates the percentages of the five types of WBCs (lymphocytes, neutrophils, eosinophils, basophils, and monocytes); measures the *hemoglobin* (Hgb), or iron pigment; and the *hematocrit* (Hct), which is the measurement of the percentage of packed RBCs compared to the whole blood

• WORD • BUILDING •

radiology: radio – radiant energy + logy – study of

ultrasonography: ultra – extreme + sono – sound + graphy – writing

hematology: hemato – blood + logy – study of

Table 25.1
Preparation and Posttest Nursing Care for Selected Tests

Test	*Description*	*Purpose*	*Preparation*	*Posttest Nursing Care*
Barium enema	Rectal instillation of barium (a contrast medium) provides for radiographic visualization of the large intestine, to see its shape and any abnormalities that might be present.	To detect cancerous tumors, obstructions, polyps, inflammatory disease, or diverticula in the colon.	Explain the procedure. Offer assurance and support. The day before, perform bowel prep of laxatives and enemas according to facility or physician orders. Clear liquid diet. NPO after midnight.	Administer milk of magnesia or laxative of choice to remove barium before it hardens. Monitor for constipation. Explain that stools will be white until barium is eliminated. Provide fluids and physician-ordered diet.
Bone marrow aspiration (See Skill 25.1, page 517, for more information on assisting with bone marrow aspiration.)	Under local anesthetic, a sample of marrow is removed from the sternum, tibia, or iliac crest by needle aspiration for evaluation of blood cell production.	To diagnose some serious anemias, thrombocytopenia, and cancerous tumors, and to stage Hodgkin's disease.	Describe the procedure and explain that it only takes 10 to 20 minutes to perform. Assess for allergy to local anesthetic to be used. Explain there will be a feeling of pressure and a brief period of discomfort when the marrow is actually aspirated. Offer reassurance and support. Make certain written consent has been obtained. Administer sedative or analgesic 60 to 90 minutes prior to test. Assess vital signs for baseline.	Hold pressure to puncture site and observe for bleeding at site. Apply dressing. Monitor vital signs for shock: ↓BP, ↑P. Monitor for signs of infection: ↑T, ↑P.
Intravenous pyelogram (also known as excretory urogram)	An iodine-based contrast dye is injected intravenously. X-rays are taken for visualization of the kidney parenchyma, pelvis, calyces, ureters, and bladder.	Evaluation of renal structure and function; aids in detection of kidney stones, obstruction, tumors, urinary tract disease, and trauma.	Explain the procedure. Assess for allergy to iodine, shellfish, and contrast medium dyes. Keep the patient NPO for 8 hours prior to test. Make certain a consent form has been signed.	Observe for hematoma at the injection site. Observe for delayed reaction to the contrast dye. Assess for adequate urination. Encourage PO fluids to rehydrate the patient and flush dye from body. Provide physician-ordered diet.
Lumbar puncture (See Skill 25.1, page 517, for more information on	A spinal needle is inserted between vertebral spinous processes into the lumbar section of the arachnoid space to obtain a cerebrospinal fluid (CSF)	To diagnose meningitis, subarachnoid hemorrhage, tumors, and other infections of the	Explain the procedure and that it takes 10 to 15 minutes. Make certain written consent has been obtained. Assess allergy to iodine prep and local anesthetic.	Keep the patient flat in bed for 8 hours. May turn from side to side but may not raise head. Encourage plenty of PO fluids to reduce risk of spinal headache.

assisting with lumbar puncture.)	sample to culture for organisms and measure CSF pressure.	central nervous system.	When ready for the procedure, position the patient on his or her side at the edge of the bed. Have the patient draw knees up to abdomen and tuck chin down to chest to flex the spine for ease of needle insertion. Help to hold the patient in this position for duration of test.	Provide a flexible straw for drinking. Monitor needle insertion site for bleeding or drainage of CSF hourly for 4 hours and then every 4 hours for a period of 24 hours. Perform neurological status checks as ordered by physician. Assess for numbness and tingling of extremities, fever, neck rigidity, change in level of consciousness, BP changes, widening pulse pressure, ↓P, or irregular respirations for the first 24 hours.
Oral glucose tolerance test	Patient drinks concentrated glucose syrup to stimulate pancreatic production of insulin. Blood and urine samples are collected at five to six intervals over a 3- to 6-hour span to evaluate glucose levels.	To diagnose diabetes mellitus or hypoglycemia.	Explain the procedure. Keep the patient NPO for 12 hours, except for water, which must be drunk for production of urine samples.	Provide physician-ordered diet and fluids. Observe for hypoglycemia and hyperglycemia.
Paracentesis (See Skill 25.1, page 517, for more information on assisting with paracentesis.)	Under local anesthetic, a needle is inserted through the abdominal wall into the peritoneal cavity to remove free fluid from within the cavity (ascites).	To relieve discomfort of the pressure of ascites, common in abdominal organ cancers and liver disease.	Explain the procedure. Assess for allergy to local anesthetic to be used. Offer assurance and support. Make certain written consent has been obtained. Weigh the patient. Measure abdominal girth. Have the patient empty bladder. Assess baseline vital signs.	Document amount of fluid removed. Monitor vital signs. Assess for *syncope* (fainting). Encourage rest for several hours. Observe the needle insertion site for hematoma. Weigh the patient and compare to pretest weight. Measure abdominal girth and compare to pretest girth.
Thoracentesis (See Skill 25.1, page 517, for more information on assisting with thoracentesis.)	Under local anesthetic, a needle is inserted through the chest wall into the pleural space to remove excess fluid.	To remove fluid for diagnostic purposes or to decrease respiratory distress resulting from excess fluid because of lung disease or cancer.	Explain the procedure. Assess for allergy to local anesthetic to be used. Offer assurance and support. Make certain written consent has been obtained. Weigh the patient. Assess vital signs. Apply cardiac monitor and supplemental O_2.	Document amount of fluid removed. Monitor vital signs, especially SpO_2. Auscultate breath sounds. Assess for dyspnea and arrhythmias. Encourage rest for several hours. Observe needle insertion site for hematoma. Weigh the patient and compare to pretest weight.

volume. Each of these tests may be ordered as a stand-alone test as well as components of a CBC. *Even as a new nursing student attending clinical experiences, it is important to comprehend the different components of a CBC because it is performed on every patient upon admission to a hospital.* Table 25.2 lists the normal CBC values.

WHITE CELL COUNT AND DIFFERENTIAL. When the WBC count is elevated above normal, it is termed *leukocytosis;* when it is below normal, it is called *leukopenia.* WBCs, especially the neutrophils, function primarily to protect the body from infection. Once a bacterial infection begins, the bone marrow increases the production of WBCs, specifically the neutrophils, monocytes, and a few lymphocytes. The lymph tissue produces the majority of lymphocytes. A **differential** is the breakdown of the total WBC into percentages of the five types of white cells, each of which becomes elevated in response to different situations:

- *Neutrophils elevate* with infection. Slightly immature neutrophils are called *bands.* When their level is elevated, as opposed to the more mature segmented neutrophils, it is known as a **left shift**, which generally indicates bacterial infection.
- *Eosinophils* elevate in response to allergic reactions and parasites.
- *Basophils* contain large amounts of histamine and elevate in hypersensitivity reactions, such as reactions to stings, iodine, or medications. These reactions, known as *anaphylactic reactions,* are life-threatening allergic reactions.
- *Monocyte* levels rise as a second line of defense against bacterial infections.
- *Lymphocytes* increase with viral infections and allergic conditions. When their level is elevated, it is known as a **right shift,** a typical indicator of viral infection.

As shown above, a differential can help to discern whether there is a bacterial or viral infection, an allergic or hypersensitivity reaction, a parasitic invasion, or a disease of the blood-forming organs.

RED BLOOD CELL COUNT, HEMOGLOBIN, AND HEMATOCRIT LEVELS. An RBC count provides the number of RBCs in a cubic millimeter (mm^3) of whole blood, whose function is to carry the Hgb, which binds with oxygen to be delivered to cells throughout the body. When the RBC count is lower than normal, it is known as *erythropenia* or *erythrocytopenia.* A lower-than-normal level of RBCs can help to diagnose hemorrhage beyond 24 hours, fluid overload, or anemia. *Anemia* is a condition in which there is a reduction in the delivery of oxygen to the tissues; it is usually indicated by depressed RBC and Hgb levels. *Polycythemia* describes an elevated RBC count.

Closely related to the RBC count—and part of a CBC—is the Hgb test. This test helps to determine the presence and severity of the different types of anemia. When Hgb is decreased, the body's oxygen-carrying capacity is reduced, which interferes with the ability of different body tissues and systems to function at optimal level.

The RBC, Hgb, and Hct levels are closely related and are useful in diagnosing dehydration, anemia, and polycythemia. As well as being ordered as a stand-alone Hct or as part of a CBC, the Hgb and Hct are often ordered as an *H&H.*

PLATELET COUNT. PLTs are the blood cells that aid in the blood *clotting* process to prevent hemorrhage and help to protect vascular surfaces. If a patient has too many PLTs, the patient has *thrombocytosis,* which can result in abnormal clotting. If a patient has too few PLTs, *thrombocytopenia* develops, which hinders the body's hemostatic ability, or the ability to stop bleeding.

Table 25.2
Complete Blood Count Normal Values

Blood Component	*Normal Range*
WBC, total	Adults older than 10 years: 4.5–11.1 mm^3
WBC, differential	40%-75% of total WBC
total neutrophils (Bands)*	(3%–5%)
Lymphocytes†	12%-44% of total WBC
Monocytes	4%–9% of total WBC
Eosinophils	0%–5.5% of total WBC
Basophils	0%–1% of total WBC
RBCs	Adult males: 4.21–5.81 mm^3 Adult females: 3.61–5.11 mm^3
Hemoglobin	Adult males: 14–17.3 g/dL Adult females: 11.7–15.5 g/dL
Hematocrit	Adult males: 42%–52% Adult females: 36%–48%
PLTs	140,000–400,000/mm^3

*When bands elevate to higher percentage levels, called a left shift, this indicates bacterial infection.

†When lymphocytes elevate to higher percentage levels, called a right shift, this indicates viral infection.

KNOWLEDGE CONNECTION

Differentiate between the five types of WBCs, including possible etiologies of their elevations. What are the medical terms for the different types of blood cells, including RBCs, WBCs, and PLTs? Describe the components of a complete WBC count. List three ways an Hgb level may be ordered. Describe what is meant by a *left shift.*

• WORD • BUILDING •

leukocytosis: leuko – white + cyt – cell + osis – condition

leukopenia: leuko – white + pen – lack + ia – condition

Blood Chemistry Tests

Blood chemistry tests may be performed on whole blood, plasma, or serum. They are generally performed to detect changes in the biological chemical reactions in the body. They may be used to rule out certain conditions as well as to diagnose a disease or syndrome. The following are some of the more common chemistry tests:

- **Blood glucose:** When carbohydrates are digested by the body, they are broken down to glucose (see Chapter 23). Elevated blood glucose levels can be indicative of diabetes mellitus, which is a disorder of carbohydrate digestion and insulin production and use. Blood glucose is also known to elevate when an individual is under stress, such as with hospitalization. Some health-care providers routinely monitor glucose levels of patients admitted to the hospital, even if they are not diagnosed with diabetes mellitus.
- **Electrolyte levels:** Potassium (K^+), chloride (Cl^-), sodium (Na^+), magnesium (Mg^{2+}), calcium (Ca^{2+}), and phosphate (PO_4^-) levels are obtained to evaluate fluid and electrolyte balance and acid-base balance, which you will learn more about in Chapter 29.
- **Enzymes and isoenzymes:** These substances are released into the blood from specific tissue cells when those cells are injured; the enzymes and isoenzymes present help identify damage to specific organs. Cardiac cells release troponin, creatine kinase-MB, and lactate dehydrogenase types 1 and 2. Damaged liver cells release aspartate aminotransferase, alanine aminotransferase, and alkaline phosphatase.
- **Blood urea nitrogen:** Nitrogen is an end product of protein breakdown, excreted by the kidneys into the urine. Some common medications can cause elevation of the blood urea nitrogen (BUN) level, such as aspirin and certain antibiotics, as well as a high protein diet. Elevated blood levels occur with dehydration, heart failure, urinary tract obstruction, recent heart attack, or gastrointestinal bleeding. For these reasons, BUN alone is not indicative of kidney damage, but is considered along with creatinine and the *estimated glomerular filtration rate* (eGFR) in evaluating kidney function.
- **Serum creatinine:** Creatinine is a product of metabolism, removed from blood by the kidneys. Elevated levels indicate impairment of kidney function.
- **Total protein:** Total protein is used to evaluate many conditions, such as malnutrition, dehydration, severe burns, gastrointestinal disease, renal disease, liver disease, and diabetes mellitus. It measures serum levels of albumin and globulins, which are vital to numerous body functions. These proteins:
  - Serve as a buffer in the acid-base balance;
  - Help to maintain osmolarity of body fluids;
  - Act as carrier transporters of iron, copper, and other ions;
  - Perform as enzymes and antibodies;
  - Help to bind and detoxify medications; and
  - Serve as a resource for tissue nutrition.
- **Total bilirubin:** Total bilirubin measures the blood level of *bilirubin*, which is an orange pigment that is released during the destruction or breakdown of Hgb. Once an RBC's normal life span is over, the RBC is destroyed, releasing the Hgb and, eventually, the bilirubin. Normally, Kupffer cells in the liver transform the bilirubin into bile, which aids in digestion and is excreted in the feces. Certain disease processes can interfere with this process, resulting in excessive blood levels of bilirubin that stain the skin and tissues a yellowish-orange color, a condition known as *jaundice*. The bilirubin test is performed to evaluate liver function and to help in the diagnosis of certain anemias and biliary obstruction.

Most facilities have designated names for specific clusters or groups of blood chemistry tests. For example, some facilities use terms such as *basic metabolic panel* or **complete metabolic panel,** each representing a specific grouping of tests in which 8 or 14 respective tests are to be done. Box 25.2 provides a list of the tests included in a complete metabolic panel.

Box 25.2

Complete Metabolic Panel

A complete, or comprehensive, metabolic panel (CMP) is the name for a group of 14 separate tests that provide an overview of some of the functions of the liver, kidneys, and pancreas. The following are the tests included in a CMP:

- **Albumin:** a protein produced by the liver
- **Alkaline phosphatase (ALP):** an enzyme produced by the liver
- **Alanine aminotransferase (ALT),** also known as **SGPT:** an enzyme produced by the liver
- **Aspartate aminotransferase (AST),** also known as **SGOT:** an enzyme produced by the liver
- **Bilirubin:** a waste product remaining after the liver destroys old RBCs
- **Blood urea nitrogen:** a waste product filtered from the blood by the kidneys
- **Calcium:** an electrolyte; excess levels are removed from the blood by the kidneys
- **Chloride:** an electrolyte; excess levels are removed from the blood by the kidneys
- **Creatinine:** a waste product filtered from the blood by the kidneys
- **Glucose:** a simple sugar fuel source for cellular energy; needs insulin (from the pancreas) to transport glucose into the cells
- **Potassium:** an electrolyte; excess levels are removed from the blood by the kidneys
- **Sodium:** an electrolyte; excess levels are removed from the blood by the kidneys
- **Total protein:** measures all serum proteins, including albumin and globulins
- **Total serum CO_2:** measures serum level of bicarbonate (HCO_3^-), which provides data about serum CO_2 level because 95% of serum CO_2 is carried as part of HCO_3^-

Other Blood Tests

- **B-type natriuretic peptide**: The B-type natriuretic peptide (BNP) is secreted by the heart ventricles. When the pressure and blood volume in the ventricles rise, as occurs with congestive heart failure, production of BNP increases. This makes the BNP a valuable tool to diagnose congestive heart failure.
- **Cardiac enzymes:** Tests for three enzymes called *myoglobin*, *troponin*, and *creatine kinase* (CK) are done to determine if a myocardial infarction (heart attack) has occurred. You may hear these terms often when patients experience chest pain or are admitted with chest pain. Myoglobin is released with any muscle damage; however, if the patient has chest pain and no other muscle injury, this test is very helpful because myoglobin levels elevate within 30 minutes after an injury. Troponin actually includes two enzymes: troponin 1 and troponin T, which are released 3 to 4 hours after a myocardial infarction and will remain elevated for 10 days. CK includes three isoenzymes. However, the MB fraction is the one released with myocardial injury. The CK level begins to rise 3 to 4 hours after a myocardial infarction and stays elevated for 3 to 4 days.
- **Lipase:** Lipase is a group of digestive enzymes that are secreted by the pancreas into the duodenum. Elevated levels of lipase in the bloodstream are generally indicative of pancreatic disease, such as pancreatitis or pancreatic cancer. Although elevated lipase levels are most helpful in diagnosing pancreatic disease, they also may be elevated with acute inflammation of the biliary tract and during kidney failure, which is due to impaired renal excretion of the enzyme.
- **Glycosylated or glycated hemoglobin (Hbg A_{1c}):** **Glycosylated hemoglobin** is the measurement of the Hgb that has become bound with glucose. It provides a method of calculating the average blood glucose for the previous 3-month period of time, giving the health-care provider a picture of how well controlled the patient's diabetes is. Normally an A_{1c} should range from 4.0% to 5.5%. If the A_{1c} is between 5.7% and 6.4%, it is considered *prediabetes*. The American Diabetes Association recommends that diabetic patients be maintained at 6.5% or less for optimal disease control. There is no preparation for this test. The patient does not have to be NPO.

NURSING CARE FOR BLOOD TESTS. The patient should be informed that a blood sample will have to be drawn for any of the tests mentioned above. Most laboratories do not place restrictions on food or fluid for the tests listed here. However, many other tests do require the patient be kept NPO. Please refer to a laboratory diagnostic text book as you learn more about other diagnostic tests during your nurse's training and actual patient care. It will be your responsibility to know when to keep a patient NPO.

KNOWLEDGE CONNECTION

Describe at least four common laboratory tests and their purposes. Name two tests that evaluate renal function. Identify three diagnostic tests that would provide you with information relating to nutrition. Name three diagnostic tests that would be useful in evaluating liver function. Name three enzymes that would be used to diagnose myocardial infarction. Identify a test useful in diagnosing congestive heart failure. What blood test provides a 90-day average of the patient's blood glucose level?

Urine Tests

Urine tests may be performed on voided or catheterized urine specimens; urine also may be collected over 24 hours for examination (see Chapter 31). Analysis of the urine and its contents provides you with much useful information.

URINALYSIS. Routine urinalysis tests are ordered frequently in medical clinics and are routinely ordered on admission to hospitals. Normal findings in a routine urinalysis include the following:

- **Color:** straw to dark yellow
- **Odor:** slightly aromatic
- **Appearance:** clear
- **Specific gravity:** 1.001 to 1.029
- **pH:** 5 to 9
- **Glucose:** none
- **Protein:** less than 20 mg/dL
- **Ketones:** none
- **Nitrites:** none
- **Bilirubin:** none
- **Urobilinogen**: up to 1 mg/dL
- **RBCs:** less than 5 per high-power field
- **WBCs:** less than 5 per high-power field
- **Transitional/epithelial cells:** none
- **Casts:** none
- **Bacteria:** none
- **Yeast:** none
- **Parasites:** none

A basic urinalysis is simple to perform but can provide you with valuable information about the patient's health status, not just about the renal system. For example, the urine of a dehydrated patient may be a darker color, even amber. Color changes and abnormal pH values can be due to different diseases, medications, or dietary habits. The appearance may be cloudy due to the presence of bacteria or WBCs, often indicating infection of the urinary system. The specific gravity, which is the weight of the urine, will increase as dehydration increases the urine's ratio of solutes to water; it also may cause the odor to become stronger, even to the point that it smells like ammonia. Other systemic diseases and conditions that can affect the specific

gravity are diabetes insipidus, congestive heart failure, and shock. Protein in the urine, known as *proteinuria,* usually is related to some type of renal disease. The presence of ketones in the urine, known as *ketonuria,* is generally related to diabetes mellitus, indicating that adequate blood glucose is not being delivered to individual cells throughout the body. Therefore, it is to your benefit, as well as important to your patients' well-being, to become familiar with the components normally present in the urine and the significance of elevated or decreased amounts. It also is important to know the significance of abnormal components present in the urine.

Glomerular Filtration Rate

Now considered the most accurate test for evaluating kidney function, the **glomerular filtration rate** (GFR) measures the volume of urine, in milliliters, that is filtered by the kidney in 1 minute. The test involves a 24-hour collection of urine and determination of a blood creatinine level; however, more commonly an eGFR is performed. Using a formula and the creatinine results, the eGFR is calculated without waiting to collect a 24-hour urine sample. Anything below 60 mL/min is considered to be significant renal impairment (Table 25.3).

Radiology and Imaging Tests

Radiography or *x-ray* provides an image of the bones without any preparation and is the most common test performed on the skeletal system. It is useful in detecting bone fractures and displacement of bone structures.

Table 25.3
Glomerular Filtration Rate

Glomerular Filtration Rate (mL/min)	*Level of Kidney Impairment*	*Description*
100–120	None	Normal function
90–99	1	Slight kidney impairment with adequate glomerular filtration rate
60–89	2	Mild kidney impairment
30–59	3	Moderate kidney impairment
15–29	4	Severe kidney impairment
Less than 15	5	Complete kidney failure

Chest X-Ray

Chest x-ray (CXR) not only will allow you to see the bony structures of the thorax; it also will allow you to visualize the following:

- The heart's position and size
- The lungs and whether they are fully expanded or have collapsed lobes (known as *atelectasis*) and whether they are clear or congested
- Densities that may indicate malignant tumors or tuberculosis

Flat Plate of Abdomen or KUB X-Ray

A flat plate or **KUB** (which stands for kidneys, ureters, and bladder) is an x-ray of the abdomen that shows the structures and positions of the abdominal organs. It can provide information such as obstruction of, or excessive gas accumulation in, the intestines, tumors, kidney stones, or fluid collection in the peritoneal cavity, known as *ascites.* The abdominal flat plate or KUB is often the initial diagnostic tool used when an abdominal organ disease is suspected.

NURSING CARE FOR CHEST X-RAY OR KUB. Little nursing care is necessary for a CXR. Explain to the patient that painless x-ray pictures will be taken, requiring removal of jewelry, bras, and shirts or blouses with buttons, zippers, or snaps. A hospital gown will be used to protect modesty.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is a form of radiology that uses a magnetic scanner to detect the magnetic properties of atoms, usually hydrogen, while radiofrequency energy produces images of body tissues. It produces slices of the site, similar to computed tomography scans, allowing the examiner to view organs and tissues at all depths. MRI is useful in evaluation of the brain, spinal cord, bone, organs, and vessels in motion, as well as other fluid-filled soft tissues. It aids in diagnosing hemorrhagic and embolic cerebrovascular accidents, more commonly known as strokes; tumors; multiple sclerosis; spinal cord aberrations; and other fluid-filled soft tissue disorders. MRI can be done with or without contrast medium or dye.

The patient is placed in a tunnel opening within the scanner, which is not very large. Some patients become claustrophobic and require sedation, while others are unable to tolerate the procedure. These patients usually are better able to tolerate the procedure if it is performed in an open-style MRI machine.

NURSING CARE FOR MAGNETIC RESONANCE IMAGING. When an MRI is ordered, you will need to verify if contrast

• WORD • BUILDING •

proteinuria: protein – protein + ur – urine + ia – condition
ketonuria: keton – ketone + ur – urine + ia – condition
radiography: radio – radiant energy + graphy – writing

is to be used for enhanced visualization. The patient may need to be kept NPO depending on the organs to be scanned, whether or not contrast dye will be used, and the facility's policy. The contrast dye used in MRI is not iodine based as with computed tomography.

It is important to educate the patient regarding an impending MRI, making certain to inquire if the patient has claustrophobia. You should inform the patient of the limited space inside the scanner tunnel and of the loud knocking and clicking sounds that will be emitted from the scanner throughout the test. Ear plugs, music, and sound-reducing headphones are routinely used to muffle the noise. Inform the patient that even though the MRI is painless the noise can be annoying and that the scan generally takes from 30 to 90 minutes to complete. For patients with severe claustrophobia, a mild sedative or antianxiety medication may be ordered preprocedure. Most facilities require that a consent form be signed. ***Safety: Ask the patient if he or she has any metal implants, aneurysm clips, residual buckshot from gunshot wounds, or a pacemaker. MRI is contraindicated for patients with any type of internal ferrous metal due to the strong magnetic pull of the scanner. Also assist the patient to remove any ferrous metal from body piercings. If the patient is unsure what kind of metal is in the piercing jewelry, remove it to be safe.***

Computed Tomography

Computed tomography (CT), also known as computed axial tomography (CAT) scanning, is an x-ray procedure that takes many x-ray images of body parts from different angles. It then uses a computer to combine all the images to generate cross-sectional pictures and three-dimensional images of the internal organs and structures of the body. In other words, a CT scan helps to visualize slices of the organ or structure being imaged or scanned. This form of imaging can be used to detect normal and abnormal structures in the body, such as tumors. A contrast medium or dye may be ingested or injected prior to the procedure to better differentiate certain structures.

NURSING CARE FOR COMPUTED TOMOGRAPHY. As with an MRI, it is pertinent to assess whether or not the patient has claustrophobia and to explain the types of things that may be used to combat or decrease these feelings. ***Safety: Be certain to ask the patient if he or she is allergic to iodine, shellfish, radiopaque dye, or any contrast medium.*** Allergic reactions to iodine-based products may be more serious than just a "typical rash." This type of allergy can often result in systemic anaphylaxis, a life-threatening reaction causing bronchospasm, laryngeal edema, and peripheral vasodilation, which drops the blood pressure.

If contrast medium is to be administered, assess the patient's kidney function tests to confirm adequate kidney function to handle the contrast medium. This would include the creatinine, BUN, and GFR. An elevated creatinine or BUN should be reported to the health-care provider before proceeding with contrast medium administration. Poorly functioning kidneys are indicated by a lower GFR and should also be reported to the physician. ***Safety: If the patient is currently taking metformin (a drug for diabetes), it should be withheld the day of the CT scan and for an additional 2 days to prevent lactic acidosis problems.*** To assist with the elimination of contrast dye after the procedure, encourage fluids.

Arteriography and Venography

Arteriography, also known as *angiography,* and **venography** are forms of radiology that require a contrast medium be instilled into designated arteries in the case of arteriography or into veins in the case of venography. In arteriography, this contrast medium is instilled through a long catheter inserted into the artery and floated through the circulatory system to the desired organ or structure. This allows examination of the vessel to assess for abnormalities such as *thrombosis* (blood clots) or tumors. It will also show constrictions, occlusions, and *aneurysms,* which are areas of weakening or dilations in a vessel wall that are at risk for rupturing. These studies are commonly used to examine vessels in the heart, brain, lungs, and lower extremities.

NURSING CARE FOR ARTERIOGRAPHY AND VENOGRAPHY. Nursing care is dependent on the vessels accessed during the procedure. For example, when arterial access is performed, such as on the femoral artery, written consent must be obtained and allergy to the dye must be assessed. ***Safety: You must assess whether the patient has been taking anticoagulants, and you must monitor bleeding and coagulation test results prior to the test and make certain they are within normal ranges. An IV line is established prior to the procedure for administration of any needed sedatives or emergency drugs.*** Vital signs are monitored prior to, during, and after the procedure. After completion of the femoral arteriogram, pressure must be maintained on the needle insertion site. A vascular closure device, or plug, is used to prevent bleeding from the puncture site, along with a pressure dressing. The patient must be kept on bedrest for 6 to 8 hours, keeping the involved leg straight. Distal pulses, capillary refill, color, and temperature of the lower extremity must be assessed hourly. The radial artery is sometimes used for cardiac arteriography. An inflated band is placed over the radial artery to maintain pressure after the catheter is removed. This approach does not require bedrest after the procedure.

Computed Tomography Angiography and Magnetic Resonance Angiography

CTA and MRA are noninvasive imaging studies of the arteries and veins, but they do involve the injection of contrast

• WORD • BUILDING •

angiography: angio - lymph or blood vessels + graphy – writing

media. They show information about blood vessels in great detail, including blood flow through the vessels and the connections of the vessels to other organs. This testing shows a three-dimensional view of diseased blood vessels. ***Safety: As with an MRI, any implanted metal is contraindicated for the MRA, such as pacemakers, implanted defibrillators, spinal stimulators, and insulin pumps. Ferrous metal in piercings should be removed before an MRA.***

NURSING CARE AFTER CTA AND MRA. Assess for any allergic reaction to the contrast media used. If the patient has kidney disease or is pregnant, the tests are usually done without contrast.

KNOWLEDGE CONNECTION

Name three purposes for performing a CXR. Why would femoral arteriography require more assessment than the radial approach after the catheter is removed? What safety concern must you address with a patient prior to an MRI?

Ultrasonography

In **ultrasonography,** ultrasound waves are used to produce images of organs and tissues that can be recorded and printed. It is painless and easy to use, and it can show motion of the organ. Some situations in which ultrasound has been found beneficial include determining the size and position of the fetus or placenta, determining function of cardiac valves, identifying arterial blockages, detecting abscesses and cancerous tumors, and visualizing female reproductive organs. Generally, there is no preparation for ultrasound except for obstetrics, when the patient may be required to drink several glasses of water to provide a full urinary bladder for the test. However, it is important to educate the patient regarding the ease of the test to decrease anxiety and increase patient compliance.

Ultrasonography of the heart is known as an **echocardiogram** and is commonly used because it is noninvasive, quick, easy, and reliable. It can detect problems in heart wall motion, defective heart valves, volume of blood that is pumped from the heart with each heartbeat, and enlargement of the heart wall muscles, which happens with heart failure.

Endoscopic Examinations

Endoscopic examinations use a flexible scope with optical capability that allows visualization of body cavities and hollow organs, such as the colon or urinary bladder. Most endoscopies are performed using light sedation to alleviate patient discomfort during the procedure. Some of the more common endoscopies include esophagogastroduodenoscopy and colonoscopy.

Esophagogastroduodenoscopy

In **esophagogastroduodenoscopy** (EGD), the mouth and throat are sprayed with a local anesthetic and mild sedation is administered. Then a flexible scope is inserted through the mouth, down the esophagus, through the stomach, and into the upper duodenum, allowing visualization of the lining of each. It is useful in detection and biopsy of polyps, ulcers, tumors, gastric reflux, and constrictions, as well as evaluation of chemical burns after ingestion of poisons.

NURSING CARE FOR ESOPHAGOGASTRODUODENOSCOPY. The only preparation for EGD is placing the patient on NPO status for 8 to 12 hours prior to the test or as ordered by the health-care provider. The patient needs to be educated regarding the procedure and that there is minimal or no discomfort associated with the test. Assess vital signs prior to the procedure for a baseline, during the procedure, every 15 minutes for 1 hour, and then every hour for 4 hours after the procedure. Cardiac, neurological, respiratory, and gastrointestinal assessments should be performed on arrival back to the floor to make certain the patient is stable. Be certain the patient's gag reflex has returned postprocedure prior to giving fluids and food. ***Safety: Observe the patient for possible perforation.*** Signs of perforation might include severe pain or difficulty swallowing; epigastric, abdominal, shoulder, or back pain that increases with torso movement; and dyspnea or cyanosis. ***Safety: Check for the gag reflex to return after an EGD before allowing the patient to eat or drink anything, usually 2 to 4 hours after the procedure.***

Colonoscopy

In **colonoscopy,** once the patient is sedated, a flexible endoscope is inserted via the rectum into the colon and terminal ileum, allowing the physician to visualize the lining for abnormalities such as polyps, ulcerations, and tumors and to biopsy tissue as needed. The patient usually feels no discomfort during the examination and is unable to remember anything about the procedure after awakening. This examination should be performed at least every 5 to 10 years after the age of 50 years, and more often if there is a familial history of colon cancer. This exam helps detect cancerous and precancerous lesions early so they can be removed before spreading in the colon.

NURSING CARE FOR COLONOSCOPY. The colon must be prepared so that it is empty and clean for visualization. This preparation begins with limiting the patient's intake to clear liquids for 24 hours before the examination, with avoidance of ingestion of anything "red" such as red Jell-O, popsicles, or soda. Laxatives of the physician's choice are administered, usually beginning about 2 p.m. the day before the examination to evacuate the bowel. This may or may not be followed by

• WORD • BUILDING •

esophagogastroduodenoscopy: esophago – esophagus + gastro – stomach + duodeno – duodenum + scopy – examination

one to three enemas the evening before the test to completely clean out the bowel. Again, it is important to explain to the patient that there is minimal or no discomfort with the procedure. Often, the patient is concerned about the embarrassment of being exposed. Explain that the patient will be covered with drapes. Establish an IV line to be used to administer the conscious sedation medication. Assess vital signs prior to the procedure for a baseline, during the procedure, and every 15 minutes for 1 hour and then every hour for 4 hours after the procedure. Cardiac, neurological, respiratory, and gastrointestinal assessments should be performed on arrival back to the floor to make certain the patient is stable. ***Safety: Observe the patient for signs of possible bowel perforation, such as abdominal distention and rigidity or rectal bleeding.*** Remember to reassure the patient that sedation will be administered, causing him or her to sleep during the procedure.

Capsule Endoscopy

For this procedure, the patient swallows a tiny capsule that contains a camera. The patient also wears a recorder on a belt around his or her waist. The camera takes thousands of pictures of the digestive tract as it travels through it and transmits them to the recorder.

This test is used for several reasons:

- To determine the location of gastrointestinal bleeding
- To visualize the small intestine, which cannot be seen by EGD or colonoscopy
- To diagnose cancer, celiac disease, irritable bowel disorder, and Crohn's disease

After the capsule travels throughout the entire GI system, the pictures are downloaded from the recorder and examined for abnormalities in the digestive tract.

NURSING CARE FOR CAPSULE ENDOSCOPY. The patient will be NPO for 12 hours prior to the test and may have to take a laxative the night before the procedure. The nurse should ensure that medications are given 2 hours before or 2 hours after swallowing the camera capsule. The patient can have clear liquids 2 hours after swallowing the camera capsule and then a light meal 4 hours after swallowing it. The patient and the nurse need to watch for the camera capsule to be expelled in the toilet, which occurs 8 or more hours after it was swallowed. ***Safety: It is important to know that it has been expelled. Rarely a capsule remains in the body, but when it does, it must be removed surgically.***

KNOWLEDGE CONNECTION

Why would it be pertinent to have the large intestine clean and free of feces prior to a colonoscopy? What preparation is required for an EGD? What type of problems might be detected during an EGD? Name one major risk of EGD and colonoscopy. What type of problems could be discerned during a colonoscopy? What signs and symptoms would you observe for after an EGD? Why might a capsule endoscopy be ordered?

Graphic Recording Tests

Numerous graphic recording tests are performed to detect abnormalities in the electrical activity of the heart, skeletal muscles, and brain. Two of the more common are electrocardiography and electroencephalography.

Electrocardiography

Electrocardiography (ECG) uses six electrodes applied to specific locations on the chest wall and four electrodes applied to the four extremities to graphically record the electrical activity through the heart's electrical conduction pathway. It analyzes the heart's electrical activity from 12 different angles or views, detecting any abnormalities. The printout indicates how long it takes for the electrical impulse to travel from the sinoatrial node through the intraatrial pathways to the atrioventricular node, and then through the bundle of His and the Purkinje fibers. This time span is demonstrated by deflections of the baseline known as P waves, QRS complexes, and T waves, as well as the P-R interval and the S-T interval (Fig. 25.1). Aberrations from normal time spans and complexes that are altered in shape indicate injury or malfunction of the heart. Skill 25.2 (page 518) provides more information on performing a 12-lead ECG.

Although an ECG can be beneficial in diagnosing heart attacks and *myocardial ischemia,* which is a lack of adequate blood flow and oxygen to the heart muscle itself, a normal ECG does not always rule out a heart problem. If you work in a cardiac unit, clinic, or hospital setting where you perform or view ECGs regularly, you will acquire a better working knowledge of how to interpret ECG waveforms.

NURSING CARE FOR ELECTROCARDIOGRAPHY. Inform the patient that an ECG helps to assess cardiac function and takes about 10 to 15 minutes. Describe the procedure and inform the patient that there should be no discomfort related to the ECG. Obtain a list of medications that the patient is currently taking, as well as a history of the patient's cardiovascular system symptoms if they have not already been documented in the medical record. Ask the patient to remove any jewelry that may interfere with electrode placement. Preserve the patient's modesty as much as possible while attaching the chest electrodes and during the procedure. Ask the patient to lie as still as possible during the actual ECG.

• WORD • BUILDING •

electrocardiography: electro – electricity + cardio – heart + graphy – writing

electroencephalography: electro – electricity + encephalo – brain + graphy – writing

Real-World Connection

ECG Imperfection

A 44-year-old female had not been feeling well for 3 to 4 weeks. She visited her family practitioner on several occasions, but her complaints were vague and hard to describe. She said that she was tired and "just did not feel right." Various blood tests were run, producing normal results. After discussing her case with her physician during one of her visits, they mutually decided she should start taking a good multiple vitamin, pay more attention to her eating habits, drink plenty of water, and get plenty of rest and regular exercise.

The physician ran a routine ECG before increasing the patient's exercise level. The ECG was the first one the patient had ever had, and the results appeared normal with no areas of concern. However, a couple days later she was at work when she suddenly stood up and grabbed her chest. Before she could utter a word, she fell to the floor, unresponsive and without pulse or respiration. One of her employees called 911, and an ambulance was dispatched. She was pronounced dead on arrival at the local hospital emergency room. Autopsy results indicated that she had died of a massive myocardial infarction (MI) and that she had experienced numerous MIs previously that had gone undetected.

This real-life example demonstrates the fact that ECGs *cannot* rule out heart disease or a past or current MI. Although an ECG *may* be helpful and sometimes does detect *cardiac ischemia,* which is a lack of blood to the heart muscle, and an active MI, it is not 100% assured that a patient is not having heart problems, especially in women, whose cardiac signs and symptoms present differently than they do in men.

Exercise Stress Test

Because a regular ECG cannot conclusively rule out cardiac problems, it is sometimes feasible to perform an exercise stress test to assist in the detection of reduced blood flow to the heart. The heart function is monitored by continuous ECG while the patient exercises on a treadmill. The patient is also monitored for blood pressure changes, chest pain, and shortness of breath. The patient exercises until the heart rate is 80% to 90% of the maximum rate for age and gender. If symptoms develop, the test is stopped before the symptoms become too extreme.

To be of even further value, this test may also be done in conjunction with a tiny amount of radioactive tracer that is injected intravenously. Scans are then done to provide imaging of the coronary vessels to detect narrowing, known as *radionuclide scanning.*

Chemical Stress Test

A chemical stress test may be ordered if the patient is unable to physically exercise while the heart is tested during exertion. The patient must refrain from eating or drinking anything containing caffeine for 24 hours prior to the test. For this test, the patient is attached to an ECG monitor while he or she is given an IV medication that causes the coronary arteries to dilate quickly, which is what happens in exercise. The ECG is monitored for changes that would indicate narrowing of the coronary arteries and lack of blood flow to the left ventricle. The patient may experience shortness of breath or chest discomfort during the test. This test may also be done in conjunction with a nuclear scan of the heart.

TELEMETRY MONITORING. A telemetry monitor is a portable heart monitor. Wires (also called leads) attached to the battery pack connect to electrodes placed on the patient's chest. The electrodes are disposable foam circles with a connection in the middle that transmit the electrical activity of the heart as a waveform. The patient can then get up and move around without being hardwired to a bedside monitor while his or her heart rhythm is being continuously monitored. At a remote monitoring station, monitor technicians will watch the continuous waveform on a screen. Any abnormalities in the heart's activity are detected by the computerized equipment and printed out as an ECG strip. The monitor technician notifies the nurse caring for the patient of any abnormal rhythms. (Refer to Fig. 25.2 for a sample electronic documentation of a patient with a telemetry monitor.)

You may get a call to check the telemetry unit on a patient if the monitor technician is not able to clearly see the waveform. Go to the patient's room promptly and check each wire to be sure it is firmly inserted in the battery pack as well as firmly attached to the electrode. Check each electrode to be sure it is firmly stuck to the chest wall. If you need to change the battery, open the sliding cover at the bottom of the battery pack, replace the old battery with a fresh one, and close the cover. Telephone the monitor station from the patient's room to verify that a clearer picture has been obtained.

Safety: When you remove a telemetry unit for any reason, such as to give a bath or shower, you MUST first call the monitor station and tell the technician that you are going to remove the unit. The monitor technician will flag the patient's display with the reason the telemetry unit is off. Replace the unit immediately after completing the bath or shower and then telephone the monitor station from the patient's room to be sure the display is clear. It is also important to call the monitor technician prior to removing the unit when the health-care provider has discontinued the order for it.

The disposable electrodes usually are changed after the bath or when they no longer stick to the chest well. Replace the electrodes according to your facility's policy. Return the battery pack to the gown pocket or pouch. Be sure the pouch is clean and comfortable for the patient.

The electrodes and wires may be placed on the chest in a variety of patterns to transmit the heart's electrical activity. The right and left upper chest near the shoulders are used for the arm lead placements. The lower limb leads usually are placed on the lower ribs toward the patient's sides. A ground wire may

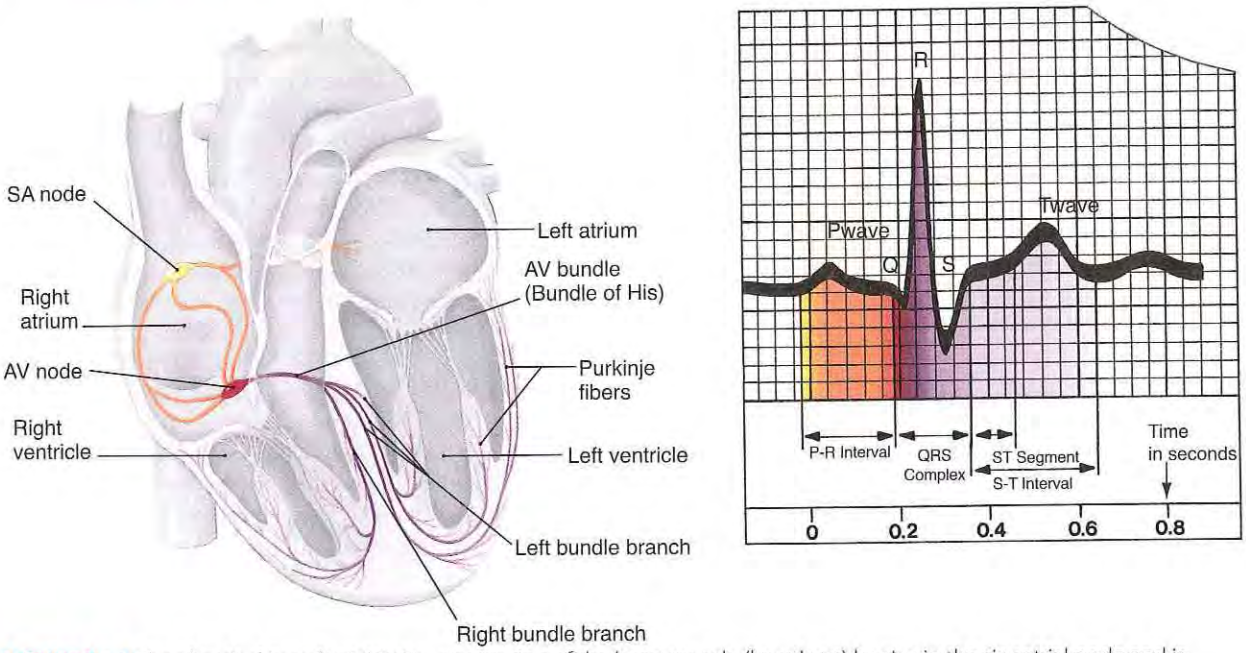


FIGURE 25.1 The electrical impulse initiating contraction of the heart muscle (heartbeat) begins in the sinoatrial node and is conveyed through the rest of the electrical conduction pathway. The P wave represents the depolarization of the atria, the result of which is contraction of the atria. The QRS complex represents the depolarization of the ventricles, resulting in contraction of the ventricles. The T wave represents the repolarization of the ventricles, during which the ventricles relax in preparation for the next depolarization. Each of the boxes on the ECG strip represents the length of time that it takes for the impulse to travel through the designated sections of the conduction pathway (from Scanlon V, Sanders T. *Essentials of Anatomy and Physiology.* 7th ed. Philadelphia, PA: FA Davis; 2015).

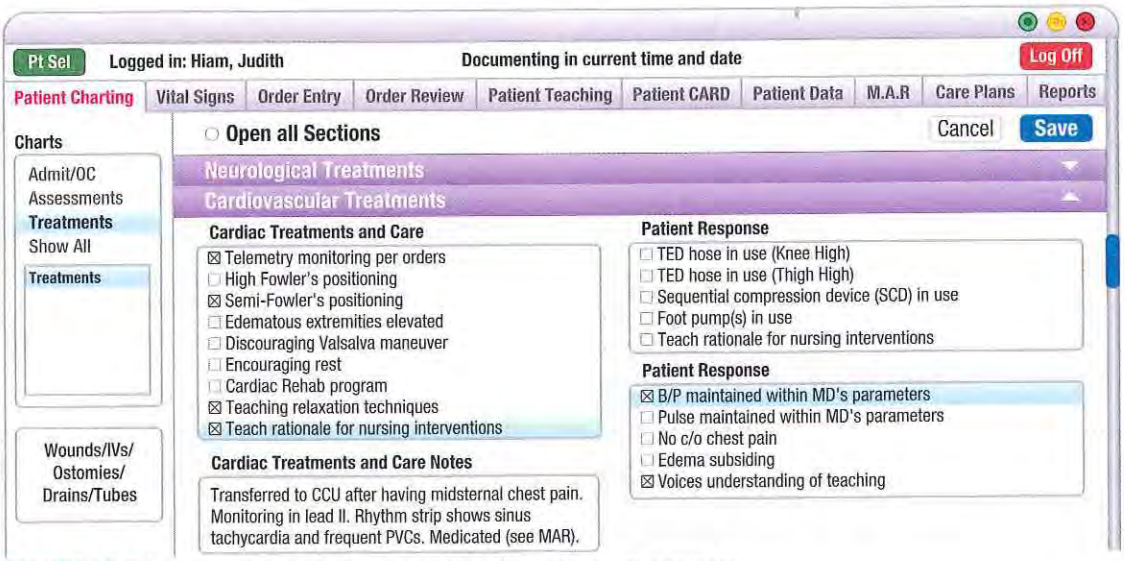


FIGURE 25.2 A sample electronic documentation of a patient with telemetry.

be placed on the center of the chest when five wires are used. The wires are color-coded for placement. For example, the white wire is placed on the right upper chest to represent the right arm. Follow your facility's policy for electrode placement.

One way to remember electrode placement is to follow this guide:

- **White to the right:** White goes on right upper chest
- **Clouds over grass:** White on right upper chest, green on right lower chest
- **Smoke over fire:** Black on left upper chest, red on left lower chest
- **Brown is ground:** Brown goes in the middle of the chest

HOLTER MONITORS. A Holter monitor is an even more portable electrocardiograph than the telemetry unit. This type of monitoring device can be worn by the patient at home. It usually is ordered for a 24- to 48-hour period. It weighs about 2 pounds and is placed in a harness that the patient wears on his or her back. Again, electrodes are placed on the patient's

chest with lead wires attached. The Holter monitor records the patient's ECG for the entire period that the monitor is worn. The patient is asked to keep a diary of his or her activities during the 24- to 48-hour period. If the patient feels symptoms, such as chest discomfort, pain, or palpitations, he or she will push the "event" button, which marks the ECG recording for later analysis by the physician. This type of monitoring works well for patients who have cardiac symptoms that occur with activity or at widely spaced intervals.

Electroencephalography

In **electroencephalography** (EEG), electrodes are placed strategically on the scalp and record the electrical activity of the brain, known as *brain waves.* This study is beneficial in detecting epilepsy, diseases of the central nervous system, and tumors, as well as to confirm brain death.

NURSING CARE FOR ELECTROENCEPHALOGRAPHY. Explain the procedure to the patient and family, being careful to include that the test is painless. Wash the patient's hair to remove all hair spray and styling products. After the patient returns to his or her room, it may be necessary to shampoo the hair to remove the electrode paste. If the EEG confirms brain death, be prepared to support the family in this difficult time. It may be helpful to offer to telephone a spiritual advisor or other support person for the family if they wish.

KNOWLEDGE CONNECTION

What is the purpose of an ECG? Does a normal ECG always prove that the patient does not have heart problems? Give three purposes for which an EEG might be performed.

Skill 25.1 Assisting With Aspiration Procedures: Bone Marrow, Lumbar Puncture, Paracentesis, and Thoracentesis

Assessment Steps

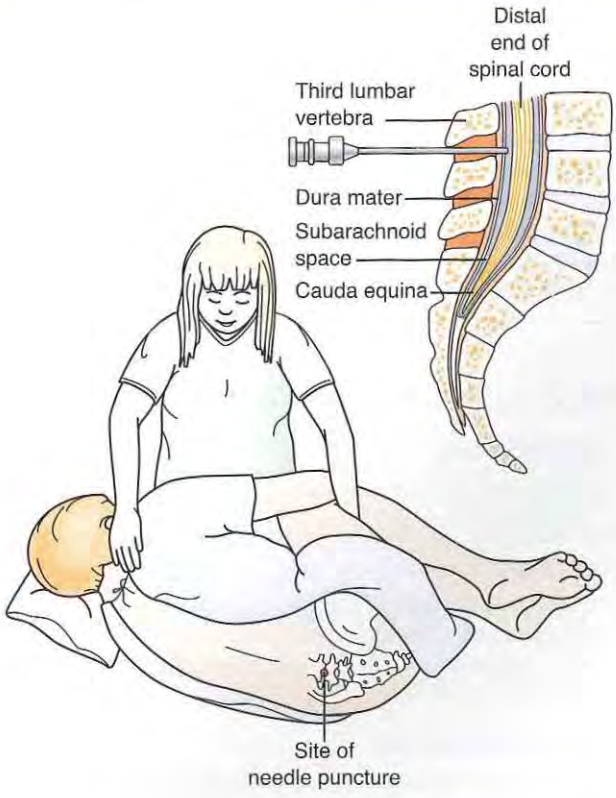
1. Verify the patient's understanding of preprocedure teaching.
2. Verify that written consent has been obtained for the procedure.
3. *Safety: Assess for patient allergies to local anesthetic, as well as iodine and shellfish, if an iodine-based cleanser is to be used for the preparation.*

Planning Steps

1. Gather needed equipment and supplies:
   - **Bone marrow aspiration:** Bone marrow aspiration tray, sterile gloves, local anesthetic, prep cleansing solution, labels for laboratory specimens, and dressing supplies (sterile gauze and tape or bandage)
   - **Lumbar puncture:** Lumbar puncture tray, extra spinal needle, sterile gloves, local anesthetic, prep cleansing solution, labels for laboratory specimens, vital sign equipment, and dressing supplies (sterile gauze and tape, bandage, or small occlusive pressure dressing)
   - **Paracentesis:** Paracentesis tray, sterile gloves, large calibrated container, local anesthetic, prep cleansing solution, labels for laboratory specimens, vital sign equipment, and dressing supplies (sterile gauze and tape or bandage)
   - **Thoracentesis:** Thoracentesis tray, sterile gloves, large calibrated container, local anesthetic, prep cleansing solution, labels for laboratory specimens, vital sign equipment, and dressing supplies (sterile gauze and tape or bandage)

Implementation Steps

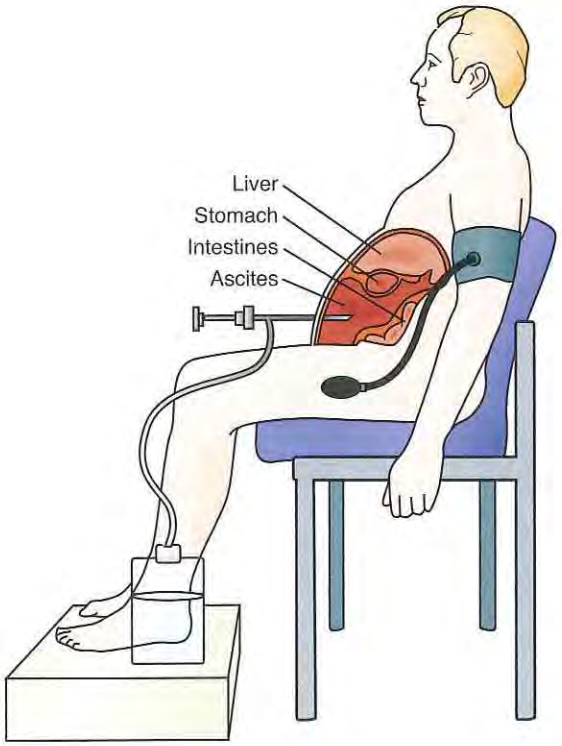
1. Follow the Initial Implementation Steps located on the inside back cover.
2. **Paracentesis:** Weigh the patient. Have the patient empty his or her bladder. Measure abdominal girth. Assess vital signs. **Thoracentesis:** Weigh the patient. Assess vital signs. Auscultate breath sounds. Apply supplemental O_2 and cardiac monitor.
3. Set up the sterile field ***to prevent contamination.***
4. Position the patient for the procedure:
   - **Bone marrow aspiration:** Supine for tibial or sternal aspiration, side-lying for iliac crest aspiration
   - **Lumbar puncture:** Side-lying with knees flexed onto abdomen and chin tucked against chest, close to the edge of the bed



(skill continues on page 518)

Skill 25.1 (continued)

- **Paracentesis:** Semi-Fowler's position or sitting, as directed by physician



- **Thoracentesis:** Orthopneic position (sitting upright with head and raised arms resting on over-bed table)

5. Assist the physician as needed with cleansing prep of injection site and drawing up of local anesthetic.
6. Reassure the patient and assist him or her to remain in the proper position throughout the procedure.
7. After completion of the procedure, hold pressure on the puncture site for at least 5 minutes ***to prevent bleeding.*** Once you are certain that bleeding has stopped, apply a bandage, small dressing, or occlusive pressure dressing as appropriate.
8. Apply labels to specimens before sending them to the laboratory.
9. Follow the Ending Implementation Steps located on the inside back cover.
10. Document the procedure and the patient's tolerance of it.

Evaluation Steps

1. Assess vital signs, noting any signs of hypotension or shock.
   Paracentesis: Weigh patient. Measure abdominal girth and compare to previous measurement.
   Thoracentesis: Weigh patient. Assess vital signs. Observe for dyspnea, arrhythmias.
2. Assess the puncture site for bleeding or drainage.
3. Position the patient for comfort.
4. Send laboratory specimens to the laboratory.

Sample Documentation

12/01/22 0900 Procedure explained to patient by Dr. Evans; permit signed. Weight 189 lbs. Voided. Placed in supine position. Baseline VS: BP - 132/68, T - 98.6, P - 68 reg & strong, R - 14 reg & even, SpO_2 - 95%. Denies pain. Abdominal girth 49 inches. Abdomen cleansing prep performed using Betadine. 1% lidocaine injected at intended puncture site just above the umbilicus. Paracentesis performed by Dr. Holsted with 750 mL cloudy, yellow fluid returned. Pressure held on injection site for 5 minutes. No signs of bleeding noted. Abdominal girth now 45 inches. Postprocedure weight 186.5 lbs. No problems noted during procedure. No complaints of discomfort. _____

_____ *Nurse's signature and credentials*

0925 VS: BP - 138/74, P - 74 reg & strong, R - 17 reg & even, SpO_2 96%. Denies pain. No bleeding at injection site.

_____ *Nurse's signature and credentials*

Skill 25.2 Performing a 12-Lead Electrocardiogram

Assessment Step

1. Review the ECG machine manual for the specifics of operating that particular model.

Planning Step

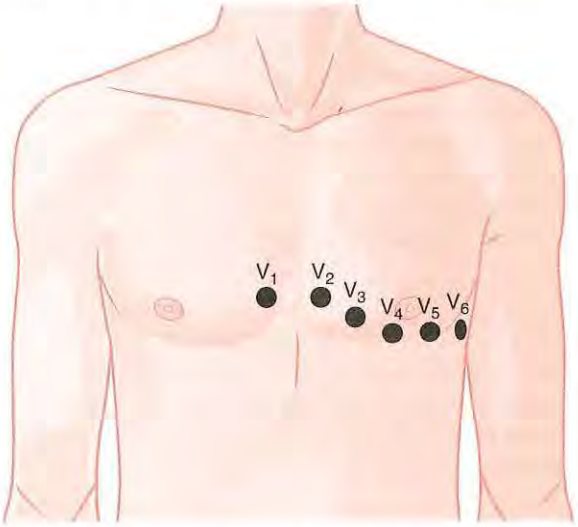
1. Gather needed equipment and supplies: ECG machine with 10 lead wires, 10 new pre-gelled electrodes or 10 non-gelled electrodes with a bottle of conduction gel, alcohol sponges, razor, and washcloth.

Implementation Steps

1. Follow the Initial Implementation Steps located on the inside back cover.
2. Position the patient in the semi-Fowler's or supine position, making him or her as comfortable as possible. Remove the patient's shirt or blouse and bra. Cover with a patient gown that opens in the front ***to help preserve modesty.*** Remove necklaces, bracelets, and watches ***to prevent interference with the electrical tracing.***
3. If necessary, shave small areas on the chest at the sites for application of electrodes. If shaving is not necessary, remove body oil at the sites using alcohol sponges ***so that electrodes will make good contact with the skin.***
4. Enter appropriate data into the ECG machine ***to allow for proper identification and interpretation of results on the ECG printout.***

Skill 25.2 (continued)

5. Apply 10 electrodes. Either the electrodes will be pre-gelled, or you may have to apply a small amount of conduction gel ***to ensure adequate conduction of electrical impulses.*** Apply four electrodes to the medial or inner aspects of both wrists and ankles, ensuring good contact with skin. Then apply six electrodes to the chest:
   - V_1 at the right sternal border in the fourth intercostal space
   - V_2 at the left sternal border in the fourth intercostal space
   - V_4 in the fifth intercostal space in the midclavicular line
   - V_3 halfway between V_2 and V_4
   - V_5 to the left of the V_4 electrode in the anterior axillary line
   - V_6 to the left of the V_5 electrode in the midaxillary line



   Ensure good contact with skin. ***If the electrodes are not placed correctly, the tracing will not be reliable.***
6. Attach the lead wires to the electrodes. The six chest lead wires will be marked V_1, V_2, V_3, V_4, V_5, and V_6. Attach the lead wires to the electrodes at the corresponding sites on the patient's chest.

7. Request that the patient hold completely still ***to prevent interference during the ECG.***
8. Following the manual instructions, press the run button.
9. After reviewing the ECG printout for correct appearance, turn off the machine.
10. Remove the electrodes and clean the skin with alcohol wipes or a damp cloth ***to remove any residue from the conduction gel.*** Assist the patient to dress if necessary.
11. Follow the Ending Implementation Steps located on the inside back cover.

Evaluation Step

1. Review the ECG printout and notify the physician of pertinent findings.

Sample Documentation

03/12/22 1415 12-lead ECG performed without difficulty. Results phoned to Dr. Heart. _____
_____ *Nurse's signature and credentials*

POST CONFERENCE

When you enter the conference room for post conference, another student says, "I bet you had an easy day. Your patient was just having tests, right?" You respond, "She had quite a time of it. She was terrified of having her blood drawn, vomited while she was in the radiology department, and had abdominal pains during the ultrasound." Your patient benefited from your teaching and was relieved to know that although four vials of blood were drawn, the technician only had to stick her once with the needle, not once for each test. She knew what to expect when she was sedated for the EGD, and she was glad you were there when she had the ultrasound, which turned out to be painful because of her extreme abdominal tenderness. By the end of your shift, the physician was feeling confident about a diagnosis of pancreatitis. And you would never have the attitude that a patient was "just having tests," having seen firsthand what was involved in her care.

Key Points

- Nurses have key responsibilities in preparing patients for diagnostic tests and caring for them after the tests.
- The five categories of diagnostic tests are laboratory tests, radiology and imaging tests, ultrasonography, endoscopic examinations, and graphic recording tests.
- Hematology tests include the CBC, WBC count with differential, RBC count with Hgb and Hct, and PLT count.
- A WBC count with differential involves the number and type of cells: neutrophils, eosinophils, basophils, monocytes, and lymphocytes. An elevation of young neutrophils, called bands, causes a left shift which indicates bacterial infection. An elevation of lymphocytes causes a right shift which indicates viral infection.
- A blood chemistry test includes a number of components including electrolytes, enzymes and isoenzymes, BUN, serum creatinine, protein, and bilirubin.
- Blood testing to diagnose and monitor specific illnesses include BNP, cardiac enzymes, lipase, and A_{1c}.
- Urine testing provides information about the patient's overall health status, not just the condition of the urinary system.
- The eGFR and GFR indicate kidney function and are measured by creatinine level in the blood and other calculations. The GFR requires 24-hour urine collection. The eGFR is calculated using a formula. If either one is below 60, it indicates significant renal impairment.
- Radiology and imaging testing, including MRI and CT, give information about structures in the body without having to invade the body. Arteriography, venography, MRA, and CTA give information about blood vessels and circulation to various organs.
- Ultrasonography is used to visualize a number of internal structures such as a fetus, placenta, female pelvic organs, and function of the heart valves and wall movement.
- Endoscopy is used to look inside the digestive system. An EGD allows the physician to see the esophagus, stomach, and duodenum, as well as the sphincters between each structure. Colonoscopy provides visual examination of the full colon. The small intestine can be visualized by using camera capsule endoscopy. Nursing care is needed after each of these tests.
- Assess your patients for allergies to iodine, shellfish, radiopaque dye, or any previous reactions to contrast medium before they undergo tests using contrast media.
- Graphic recording tests include ECG and EEG. An exercise stress test involves recording heart activity during the stress of exercise or after injection of a medication to mimic the effect of exercise on the heart. Telemetry is a portable heart monitor that allows ECG tracings at all times while still allowing the patient to be mobile in the hospital.

Review Questions

Select the answer that is most appropriate for each of the following questions. Some questions may have more than one correct answer. Select all that apply.

1. Which of the following urinalysis findings would you need to report to the physician?
   1. Protein: 30 mg/dL
   2. Bacteria: 0
   3. WBCs: 3 to 4 per high-power field
   4. pH: 4.1
   5. Specific gravity: 1.025
   6. RBCs: 10 per high-power field

2. Which of the following preparatory steps would you be likely to perform prior to a barium enema?
   1. Start an IV line the day prior to the test
   2. Keep the patient NPO 48 hours prior to the test
   3. Administer a laxative the day before the test
   4. Place the patient on a clear liquid diet for 24 hours prior to the test
   5. Administer an enema the evening before the test

3. Which of the following tests would be helpful for evaluating the large intestine?
   1. Colonoscopy
   2. EGD
   3. Barium enema
   4. ECG
   5. Intravenous pyelogram
   6. Hgb and Hct

4. Which of the following findings indicate a left shift and bacterial infection in an adult?
   1. WBC: 13,900/mm^3; total neutrophils: 76% (bands: 30%, segmented: 46%); eosinophils: 2.5%; basophils: 0.5%; monocytes: 4%; lymphocytes: 17%
   2. WBC: 4,600/mm^3; total neutrophils: 59% (bands: 3%, segmented: 56%); eosinophils: 4%; basophils: 1%; monocytes: 6%; lymphocytes: 30%
   3. WBC: 11,350/mm^3; total neutrophils: 55% (bands: 3%, segmented: 52%); eosinophils: 12 %; basophils: 2%; monocytes: 8%; lymphocytes: 23%
   4. WBC: 9,450/mm^3; total neutrophils: 61% (bands: 5%, segmented: 65%); eosinophils: 4%; basophils: 1%; monocytes: 3%; lymphocytes: 28%

5. Which of the following tests or procedures is (are) beneficial in evaluation of the kidneys?
   1. IV pyelogram
   2. 24-hour urine
   3. Oral glucose tolerance test
   4. Urinalysis
   5. Glomerular filtration rate
   6. Creatinine

6. You are to provide nursing care for a patient who just had a femoral arteriogram. Which of the following actions would take priority?
   1. Assessment of vital signs
   2. Assessment of puncture site for bleeding
   3. Assessment of temperature of lower extremity on the affected side
   4. Keeping the affected leg straight
   5. Assessment of ability to void
   6. Providing PO fluids

7. You should measure the abdominal girth and weight of a patient who is about to undergo:
   1. a glucose tolerance test.
   2. a CT scan of the cerebrum.
   3. an alkaline phosphatase test.
   4. a paracentesis.
   5. a lumbar puncture.

8. When performing a 12-lead ECG, you know that you will apply:
   1. 12 lead wires.
   2. 10 lead wires.
   3. 6 lead wires.
   4. 4 lead wires.

ANSWERS 1. 1, 4, 6, 2. 3, 4, 5, 3. 1, 3, 4. 1, 5. 1, 2, 4, 5, 6, 6. 2, 7. 4, 8. 2

Critical Thinking Exercises

Answers available online.

1. You are assigned to provide nursing care for a patient who is scheduled for a colonoscopy tomorrow morning. In report, you are told that she is extremely nervous and frightened regarding the procedure. What can you do to help this patient?

2. Why is it so important that you provide thorough patient teaching regarding any upcoming tests or procedures?

Additional Resources

DAVIS edge **Use the scratch off code on the inside front cover of your book to access online quizzes that will help you to improve your scores on course exams and prepare for the NCLEX-PN®.**

Study Guide