Laboratory Tests 11

The icon ✦ denotes content of special importance for NCLEX®.

✦ Table 11-1 ROUTINE BLOOD CHEMISTRY TESTS*

Test	Purpose	Normal Values
Erythrocytes		
Red blood cell count (RBC or erythrocytes)	Determines actual number of formed blood elements in relation to volume. Identifies abnormalities; monitors RBC count.	Males: 4.5–6.2 million/mm^3 (Females: 4.0–5.5 million/mm^3) Children: 3.2–5.2 million/mm^3
Hematocrit (HCT)	Measures percentage of red blood cells per fluid volume of whole blood.	Males: 40–54/100 mL Females: 37–47/100 mL Children: 29–54/100 mL
Hemoglobin (Hgb)	Measures amount of hemoglobin/100 mL blood to determine oxygen-carrying capacity; assists in diagnosing anemia.	Males: above 13–18 g/100 mL Females: above 12–16 g/100 mL
Platelet count	Determines number of platelets.	Adults: 150,000–450,000/mm^3
Prothrombin time (PT) (see pages 516 and 517 for INR)	Evaluates thrombin generation or how long it takes for a fibrin clot to form. Detects deficiencies in extrinsic clotting mechanism; monitors anticoagulant therapy.	10–13 seconds Prolonged values seen in liver disease, vitamin K deficiency, specific drugs, etc.
Activated partial thromboplastin time (APTT)	Evaluates adequacy of plasma-clotting factors—intrinsic clotting mechanism.	20–38 seconds Prolonged values indicate coagulation factor deficiency, cirrhosis, vitamin K deficiency
Thrombin time	Screening test to detect abnormalities in thrombin fibrinogen reaction. (Conversion to fibrin in stage 3 of clotting sequence.)	10–15 seconds.
Leukocytes		
White blood cell count (WBC or leukocytes)	Establishes quantity and maturity of white blood cell elements. If WBC is abnormal, it is important to learn which of five types is increased or decreased. Tests of five WBC types is called a differential.	Adults: 4500–11,000/mm^3 Children: 5000–13,000/mm^3 Neutrophils: 3000–7500/mm^3 Band neutrophils: 150–700/mm^3 Basophils: 25–150/mm^3 Eosinophils: 50–450/mm^3 Lymphocytes: 1500–4500/mm^3 Monocytes: 100–800/mm^3
Erythrocyte sedimentation rate (ESR)	Measures rate of red blood cells settling from plasma—reflects inflammatory conditions.	*Wintrobe Method* Males: 0–9 mm/hr. Children: 0–13 mm/hr Females: 0–15 mm/hr *Westergren Method* Males: 0–15 mm/hr Females: (under 50 years) 0–20 mm/hr (over 50 years) 0–30 mm/hr; Children: 0–20 mm/hr

*Blood chemistry–renal tests change with age—see Gerontological Nursing, Chapter 15.

SERUM ELECTROLYTE LEVELS

(See **Table 11-1**)

Potassium

A. Normal adult range 3.5–5.0 mEq/L. Child range 3.5–5.0 mEq/L.
   Critical values:
   Adults > 16 years < 2.8 mEq/L > 6.2 mEq/L.
   Pediatric (0–15 years) < 3.0 mEq/L > 6.5 mEq/L.
B. Purpose—Evaluates potassium levels that aids in diagnosing disorders such as acidosis, renal failure, and dehydration. Used to monitor the effectiveness of therapeutic interventions implemented.
C. Indications.
   1. Increased potassium K^+—acute renal disease, burns, crushing injuries, adrenal insufficiency, dehydration, anorexia nervosa, excessive intake caused by specific drugs (potassium penicillin), salt substitute, or, the most common, too-rapid infusion of intravenous (IV) solution containing potassium.
   2. Decreased K+—renal loss (due to diuretics), loss from the gastrointestinal (GI) tract via nasogastric (NG) tube, vomiting or diarrhea,

reduced potassium intake, hypomagnesemia, endocrine causes.

D. Treatment implications.
   1. Critical values may lead to fatal cardiac arrhythmias.
   2. Assess for signs and symptoms of potassium excess or loss (see below).

✦ E. **Hyperkalemia.**
   1. Removal of excess potassium per physician's orders.
      a. Administer diuretics if kidney function is adequate.
      b. Administer exchange resins through NG tube or via sodium Kayexalate (polystyrene sulfonate) enema.
      c. Administer hypertonic IV glucose with insulin as ordered—moves potassium back into cells.
      d. Administer sodium bicarbonate—shifts potassium back into cells.
      e. Hemodialysis or peritoneal dialysis.
   2. Nursing considerations.
      a. Restrict potassium intake.
      b. Calcium will counteract negative effects of potassium on the heart.
      c. Frequently check cardiac monitor placed on client with hyperkalemia.
      d. Penicillin in form of potassium should not be administered to clients with hyperkalemia.

✦ F. **Hypokalemia.**
   1. Replacement of lost potassium.
      a. Administer oral potassium, monitor IV infusion of potassium.
      b. Replace no more than 20 mEq of KCl (potassium chloride) in 1 hour.
   2. Nursing considerations.
      a. Observe electrocardiogram (ECG) monitor if possible to observe for cardiac effect of KCl.
      b. Give foods rich in potassium—bananas, molasses, oranges, raisins, seafood.
      c. Assess for hypokalemia in clients who require frequent NG suctioning.

Sodium

A. Normal adult range 135–145 mEq/L. Child range 135–145 mEq/L.
   Critical values:

Sodium	< 120 mEq/L	> 160 mEq/L.

B. Purpose—test for deficiency or excess of electrolyte seen in some endocrine disorders and monitor fluid balance in IV electrolyte therapy.

C. Indications.
   1. Increased level is a very high concentration of sodium in the extracellular fluid—dehydration, severe vomiting or diarrhea, decreased water intake, fever, renal failure, and ingestion of sodium chloride (NaCl).
   2. Decreased level is a very low concentration of sodium in the extracellular fluid—diuretics, excessive perspiration, GI loss (vomiting, diarrhea), lack of sodium in diet, Addison's disease or adrenal insufficiency, burns, and excessive IV solutions without NaCl replacement.

D. Treatment implications.
   1. Assess for signs and symptoms of sodium excess or loss.
   2. Assess for critical levels (< 120 mEq/L or > 155 mEq/L).

✦ E. **Hypernatremia.**
   1. Removal of excess sodium.
      a. Administer salt-free IV solutions (dextrose), monitor for hyponatremia, and administer 0.45% NaCl to prevent hyponatremia.
      b. Restrict sodium in diet.
      c. Discontinue drugs that cause sodium retention.
   2. Nursing considerations.
      a. Weigh daily and record intake and output (I&O).
      b. Assess blood pressure level in terms of fluid retention.

✦ F. **Hyponatremia.**
   1. Replacement of lost sodium.
      a. Administer IV fluids with sodium (3% or 5% saline)—monitor venous pressure to prevent circulatory overload.
      b. Restrict water intake—monitor intake and output.
   2. Nursing considerations.
      a. Clients who excrete excess sodium must be advised how to increase sodium intake.
      b. Assist client to identify symptoms of sodium depletion.

Calcium

A. Total serum level is 8.4–10.5 mEq/dL.
   Critical values:

Calcium	< 6.0 mg/dL	> 13.0 mg/dL.

B. Purpose—test for deficit or excess of calcium electrolyte.

C. Indications.
   1. Increased level—excess of calcium in the extracellular fluid. Excess of vitamin D (from milk), hyperparathyroidism, cancer (neoplasm of parathyroid, multiple myeloma), immobilization, Paget's disease, thyrotoxicosis, acromegaly, specific drugs (thiazide diuretics), and calcium supplements with inadequate assimilation.

2. Decreased level—deficit of calcium in the extracellular fluid. Vitamin D deficiency, magnesium deficiency, excessive laxatives, malabsorption syndrome, hypothyroidism, chronic renal insufficiency, burns, acute pancreatitis, removal of the parathyroid glands, blood transfusions (over 2000 mL) without calcium supplements, and specific drugs (anticonvulsant therapy).

D. Treatment implications.
1. Assess for signs and symptoms of excess or loss of calcium.
2. Assess for critical levels of calcium (< 7.0 or > 13.5 mg/100 mL). Notify physician immediately.
a. Assess for tetany and convulsions indicating hypocalcemia.
b. Excess calcium may lead to coma.

✦ E. **Hypercalcemia.**
1. Removal of excess calcium.
a. Increase fluid intake, which decreases tubular reabsorption of calcium and prevents stone formation.
b. Promote calcium excretion (sodium salts IV and diuretics).
2. Nursing considerations.
a. Limit dietary intake of calcium.
b. Avoid milk and milk products, which contain high levels of calcium.

✦ F. **Hypocalcemia.**
1. Replacement of low levels of calcium.
a. Administer calcium gluconate IV or serum albumin if low levels are due to low serum albumin concentration.
✦ b. Monitor for tetany—major symptom of hypocalcemia.
2. Nursing considerations.
a. Monitor by checking for positive Trousseau's test or Chvostek's sign.
b. Administer oral calcium supplements and a diet high in calcium (dairy products, bone meal, molasses, yogurt) with vitamin D. Instruct client to take supplements before bed with vitamin C for greater absorption.

Magnesium

A. Normal serum level is 1.5–2.5 mEq/L.

Critical values:

Magnesium	< 1.0 mg/dL	> 4.7 mg/dL.

B. Purpose—test for excess or deficit serum levels of magnesium to evaluate kidney function and metabolic disorders.

C. Indications.
1. Increased magnesium—renal insufficiency, severe dehydration, adrenal insufficiency, hypothyroidism, leukemia, overuse of antacids with magnesium (Gelusil), specific drugs.
2. Decreased magnesium—acute pancreatitis, chronic nephritis, diuretic phase of renal failure, gastric drainage, abnormal loss due to diarrhea, impaired absorption, specific drugs (diuretics), hypercalcemia, acute alcoholism and cirrhosis, prolonged IV (3 weeks) without magnesium.

D. Treatment implications.
1. Assess for signs and symptoms of magnesium excess or loss.
2. Assess for critical values indicating immediate interventions.
a. Increased level—above 2.5 mEq/L. The higher the level of magnesium, the more sedative the effect.
b. Assess for loss of deep tendon reflexes, respiratory decrease, and cardiac arrest.

✦ E. **Hypermagnesemia.**
1. Removal of excess magnesium.
a. Increase fluid intake—for magnesium intoxication, give IV calcium gluconate slowly in peripheral veins (do not use a central venous pressure [CVP] line) to promote excretion of excess magnesium.
b. Administer diuretics with possible renal dialysis if renal function is impaired.
2. Nursing considerations.
a. Monitor for increased levels, which potentiate cardiac effect of increased potassium.
b. Monitor for renal failure, often associated with high levels of magnesium.

✦ F. **Hypomagnesemia.**
1. Replacement of magnesium.
a. Assess for severe deficiency—muscle twitching indicates neurological signs; nausea and vomiting indicate GI signs.
b. Administer magnesium sulfate IV (10–40 mEq/L in IV fluid) or intramuscular (IM) slowly. Observe for urine output and keep antidote (calcium gluconate) available.
2. Nursing considerations.
a. Monitor daily ingestion of magnesium PO and promote diet high in magnesium—nuts, green vegetables, seafood.
b. Check for hidden conditions affecting magnesium levels such as alcoholism, GI malabsorption.

Chloride

A. Normal serum value is 100–106 mEq/L.

B. Purpose—test for excess or deficit levels.

C. Indications.
   1. Increased chloride—prolonged diarrhea leading to metabolic acidosis, acute renal failure, respiratory alkalosis (hyperventilation, central nervous system [CNS] damage), diabetes insipidus, dehydration, specific drugs (salicylate intoxication, steroids).
   2. Decreased chloride—prolonged vomiting or NG suction, loss of HCl (hydrogen chloride), diarrhea, metabolic acidosis, adrenocortical insufficiency, renal disease that loses salt, specific drugs.

D. Treatment implications.
   1. Assess for signs and symptoms of chloride excess and loss.
   2. Assess for critical values, below 70 mEq/L or above 120 mEq/L.
   3. Assess for conditions that cause increased sodium levels—may also cause increased chloride.

E. Nursing considerations.
   1. Record intake and output and daily weights to monitor electrolyte imbalances.
   2. Prolonged vomiting or uncontrollable diabetes may lead to abnormally low levels of chloride.

Phosphorus

A. Normal serum value is 2.3–4.7 mg/dL. Phosphorus (inorganic) < 1.0 mg/dL*.

B. Purpose—test for excess or deficit levels.

C. Indications.
   1. Increased phosphorus—hypocalcemia, tetany, hypoparathyroidism, headaches, GI irritation, kidney disease, specific drugs, and vitamin D excess.
   2. Decreased phosphorus—hypocalcemia, hypomagnesemia, hyperparathyroidism, vitamin D deficiency, alcohol intoxication, malabsorption.

D. Treatment implications.
   1. Assess for signs and symptoms of phosphorus excess and loss.
   2. Assess for critical values—hyperphosphatemia may occur with hypocalcemia and cardiac complications (arrhythmias).

E. Nursing considerations.
   1. Hyperphosphatemia.
      a. May require dialysis to lower serum phosphorus.
      b. Gastric lavage with potassium may lower level of phosphorus.
      c. Blood transfusions may be necessary.
   2. Hypophosphatemia.
      a. Administer phosphate salt tablets or foods high in phosphorus (eggs, fish, meat, poultry, grains, peas, peanuts, walnuts, whole wheat, rye, and chocolate).
      b. Administer IV potassium phosphate.

* Phosphorus (inorganic) values less than 1.0 mg/dL are treated as significant (not critical) values.

Chem 7

A. Measure serum levels of seven substances: electrolytes (potassium, sodium, and chloride), carbon dioxide, glucose, blood urea nitrogen (BUN), and creatinine.
   1. Tests fluid balance and renal function, as well as acid–base status.
   2. When combined with complete blood counts (CBC), these tests give a view of how the entire body is functioning.
   3. Chem 7 is also part of the preoperative workup.
   ✦ 4. Standard values of Chem 7 (may vary from lab to lab; check your own facility values).
      a. Potassium: 3.5–5.3 mEq/L.
      b. Sodium: 135–145 mEq/L.
      c. Chloride: 98–106 mEq/L.
      d. CO_2: 23–30 mmol/L.
      e. Glucose (fasting): 65–110 mg/dL.
      f. BUN: 7–18 mg/dL.
      g. Creatinine: 0.5–1.5 mg/dL.

B. How these values may be interpreted.
   1. Potassium: an electrolyte that helps maintain acid–base balance.
   2. Sodium: an electrolyte that helps maintain acid–base balance and osmotic pressure.
   3. Chloride: an electrolyte that helps maintain extra electrical neutrality; combines with sodium to form a salt.
   4. CO_2: reflects value of bicarbonate in arterial blood.
   5. Glucose: fasting blood glucose levels may identify diabetes.
   6. BUN: reflects liver's ability to make urea and the kidney's ability to excrete it. With renal disease, the BUN goes up.
   7. Serum creatinine: more specific test of renal function; elevated levels indicate renal disease.

CARDIAC FUNCTION TESTS

Serum Cardiac Markers

A. Enzyme activity evaluation denotes heart muscle damage.
   1. When the heart muscle is without oxygen for 30–60 minutes, the cells are damaged, which

results in necrosis. Intracellular enzymes leak out of cell membranes and are released into the bloodstream as the cells die.

2. Specific enzymes are released into the bloodstream at varying intervals; as myocardial cells die, they release chemicals that can be measured. The times of detection in the bloodstream, peak levels, and return to normal time vary greatly.

✦ a. Creatinine kinase (CK), formerly called creatinine phosphokinase (CPK)-isoenzymes (CPK-MB)—most valuable measurement; level rises within 4–6 hours of initial heart muscle damage, peaking at 18–24 hours. More than 6 times normal value with damage—returns to normal within 3–4 days.

b. Compare CK-MB with following two tests (serum glutamic oxaloacetic transaminase [SGOT] and lactate dehydrogenase [LDH]) to determine myocardial damage.

✦ c. Lactate dehydrogenase LDH_1, LDH_2-isoenzymes—level rises in 12–24–48 hours; persists longer, can be as long as 2 weeks. When the physician analyzes these two levels (LDH_1 and LDH_2), he or she will look for a *flipped ratio*—when LDH is the highest, it indicates a myocardial infarction (MI).

✦ d. SGOT+ or aspartate aminotransferase (AST). High levels peak following an acute MI or liver damage.

3. CK-MB: one of three isoenzymes that make up the total creatinine kinase (CK).
   a. Diagnostically cardiac specific.
   b. Present in bloodstream within 3–8 hours.
   c. Peaks within 24 hours.
   d. Returns to normal within 48–72 hours.
4. Normal cardiac enzyme ranges.
   a. Total creatinine kinase—15–99 units/L; CK-MB, 0–6% heart value.
   b. Total lactate dehydrogenase—either 100–190 units/L or 48–95 units/L; isoenzymes LDH_1, 14–26% and LDH_2, 27–37%.

✦ c. The greater the peak in enzymes and the longer the level remains, the more serious the heart damage.

B. Troponin test.
   1. Tested for myocardial injury; when infarction occurs, this substance is released in the bloodstream.
   2. Made up of three proteins found in striated muscle. Cardiac troponin T rises in 3–6 hours and remains up for 14–21 days; troponin 1 rises in 7–14 hours and remains up 5–7 days. Both are accurate assessments for myocardial damage.
   3. Normally values are low (troponin T 0.0–0.2 ng/mL and troponin 1 less than 0.6 ng/mL); any rise may indicate myocardial cell damage. Serial tests are important.

C. Myoglobin test.
   1. Oxygen-binding protein found in cardiac muscle (and skeletal muscle).
   2. Level rises shortly after cell dies; peaks in 4–6 hours and returns to normal in 24–36 hours.

B-Type Natriuretic Peptide

BNP—NT-proBNP (B-type natriuretic peptide; brain natriuretic peptide).

A. BNP is a hormone released from the ventricles in response to increased wall tension (stress) that occurs with heart failure.

B. A baseline BNP may be helpful in the diagnosis of acute congestive heart failure (CHF) and a repeat BNP at discharge may be helpful in management on an ambulatory basis.

C. BNP levels rise as wall stress increases and are useful in the rapid evaluation of heart failure.

D. In general, the higher the BNP levels, the worse the heart failure. BNP can identify clients at a higher risk for death, independent of kidney dysfunction.

E. Purpose: To assess for heart failure.
   Normal values:
   < 50 yrs: 0–450 pg/mL.
   50–75 yrs: 0–900 pg/mL.
   > 75 yrs: 0–1800 pg/mL.

Blood Lipid Tests

✦ A. **Normal values.**
   1. Cholesterol—below 200 mg/100 mL is desirable (teenager's level should be below 180 mg/100 mL). Levels over 239 mg/100 mL classified as high.
   2. Triglycerides—cluster of fatty acids formed from breakdown of dietary fat and simple sugar (40–150 mg/100 mL).
   3. Low-density lipoproteins (LDLs, the "bad" cholesterol)—60–180 mg/100 mL.
      a. LDLs burrow into the arterial walls to form plaque.
      b. Factors that lead to elevated LDL: diet (saturated fat and cholesterol); obesity; poorly controlled diabetes; genetic predisposition.

4. Very-low-density lipoproteins (VLDLs)—25–50% of total cholesterol.
5. High-density lipoproteins (HDLs, the "good" cholesterol)—male level, 30–70 mg/100 mL; female level, 30–80 mg/100 mL.
6. The "ideal" lipoprotein profile: high on high-density lipoprotein (HDL); low on low-density lipoprotein (LDL).
7. The greater amount of HDL cholesterol in proportion to total cholesterol value, the lower the risk for developing coronary artery disease.

B. Purpose—total cholesterol, lipoproteins, and triglycerides are screening tests to determine risk of atherosclerosis and heart disease.
1. High cholesterol—increased risk of heart disease.
2. High-density lipoprotein—lower risk of heart disease.
3. Low-density lipoprotein—higher risk of heart disease.
4. Hypercholesterolemia combined with low levels of high-density lipoprotein—increases risk of arteriosclerosis.
5. High triglycerides—higher risk of acute myocardial infarction.

C. Variations.
1. Serum cholesterol increased in biliary obstruction (cirrhosis), hypothyroidism, pancreatic disease, uncontrolled diabetes, and pregnancy.
2. Serum cholesterol decreased in liver disease, hyperthyroidism, malnutrition, anemias, malabsorption of cholesterol.
3. Triglycerides increased in hepatitis, pancreatitis, cirrhosis due to alcoholism, renal failure, acute myocardial infarction.
4. Triglycerides decreased in hyperparathyroidism, pulmonary disease, malnutrition.

Arterial Blood Studies

✦ A. **Arterial blood gases (ABGs).**
1. Assesses respiratory function.
✦ a. Oxygen (pO_2).
(1) Increased may indicate polycythemia.
(2) Decreased may indicate chronic obstructive pulmonary disease (COPD), lung cancer, sickle cell anemia, anemias, cystic fibrosis.
✦ b. Carbon dioxide (pCO_2).
(1) Increased may indicate COPD, emphysema, bronchitis, asthma attack, pneumonia, cerebral trauma, neurologic disorder.
(2) Decreased may indicate anxiety, hysteria, tetany, increased temperature, delirium tremens (DTs), hyperthyroidism, salicylate poisoning.
✦ c. pH—high is alkalotic, low is acidotic.
✦ d. Oxygen saturation and bicarbonate (HCO_3).
(1) Oxygen saturation should be viewed with hemoglobin value.
(2) Bicarbonate—if low (< 23) or high (> 27), indicates malfunction of metabolic process.
2. Determines state of acid–base balance.
3. Reveals adequacy of the lungs to provide oxygen and to remove carbon dioxide.
4. Assesses degree to which kidneys can maintain a normal pH.

✦ B. **Normal arterial values.**
1. Oxygen saturation—93–98%.
2. PaO_2—95 mm Hg.
3. Arterial pH—7.35–7.45 (7.4).
4. pCO_2—35–45 mm Hg (40).
5. HCO_3 content—22–26 mEq/L.
6. Base excess— –3 to +3 (0).

✦ C. **Acid–base imbalances.**
1. Respiratory acidosis.
a. pH— < 7.35.
b. pCO_2— < 45 mm Hg.
c. pO_2—90 mm Hg.
d. HCO_3—24 mEq/L.
2. Respiratory alkalosis.
a. pH— > 7.45.
b. pCO_2—35 mm Hg.
c. pO_2—95 mm Hg.
d. HCO_3— < 22 mEq/L.
3. Metabolic acidosis.
a. pH— < 7.35.
b. HCO_3— < 22 mEq/L.
c. pCO_2—38 mm Hg.
d. pO_2—95 mm Hg.
e. Cl—120 mEq/L.
f. K—5.5 mEq/L.
4. Metabolic alkalosis.
a. pH— > 7.45.
b. HCO_3— > 26 mEq/L.
c. pCO_2—38 mm Hg.
d. pO_2—95 mm Hg.
e. K—3.0 mEq/L.
f. Cl—88 mEq/L.

HEMATOLOGICAL TESTS

✦ Blood Grouping

A. Normal values summary of ABO blood grouping.
B. Purpose—to correctly match donated blood with recipients.

✦ C. Rh blood group.
1. Positive (85% of the population).
2. Negative (15% of the population).

Antigens and Antibodies

A. Based on type of antigens present in red blood cells as well as type of antibodies in the serum.
✦ B. A and B antigens.
1. Clients with type A blood have antigen A present; clients with type B blood have antigen B present.
2. Clients with type AB blood have both A and B antigens present.
3. Clients with type O blood have no antigens present.
✦ C. Anti-A and anti-B antibodies present.
1. Clients with type A blood do not have anti-A antibodies because the blood cells would be destroyed by agglutination; they have anti-B antibodies.
2. Type B blood has anti-A antibodies.

Blood Coagulation

A. Clotting takes place in three phases.
1. Phase I—prothrombin activator formed in response to ruptured vessel or damage to blood.
2. Phase II—prothrombin activator catalyzes conversion of prothrombin into thrombin.
3. Phase III—thrombin acts as an enzyme to convert fibrinogen into fibrin thread.
B. Types of clotting factors.
1. Calcium ions.
a. Cofactor in coagulation.
b. Does not enter into reaction.
c. If absent, neither extrinsic nor intrinsic system will operate.
2. Phospholipids.
a. Necessary for formation of final prothrombin activator.
b. Thromboplastin is phospholipid in extrinsic system.
c. Platelet factor III is phospholipid for intrinsic system.
3. Plasma protein—all clotting factors from V to XIII.
✦ C. Coagulation mechanisms.
1. Extrinsic mechanisms.
a. Extract from damaged tissue is mixed with blood.
b. Trauma occurs to tissue or endothelial surface of vascular wall, releasing thromboplastin.
2. Intrinsic mechanisms.
a. Blood itself comes into contact with roughened blood vessel wall.
b. Platelets adhere to vessel and disintegrate, which releases blood factor III containing thromboplastin.
D. Fibrinolytic system.
1. Adequate function is necessary to maintain hemostasis.
2. Dissolves clots through formation of plasmin.

Prothrombin Time

✦ A. Normal values—10–13 seconds (some labs use 11–16 seconds).
B. Purpose—prothrombin time provides data on thrombin generation or how long it takes for a fibrin clot to form after reagent tissue and calcium are added to citrated plasma.
1. It is a screening test to detect deficiencies in the extrinsic clotting mechanism.
2. Useful for control of long-term anticoagulant therapy.
C. Critical values.
1. If value is greater than 30 seconds, hemorrhage may occur—observe for bleeding.
2. Administer vitamin K as ordered.
D. Possible causes of prolonged clotting time.
1. Inadequate vitamin K in premature and newborn infants or in diet.
2. Poor fat absorption (obstructive jaundice).
3. Liver disease (cirrhosis, hepatitis).
4. Specific drugs (heparin, Coumadin [warfarin sodium], salicylates [aspirin]).

Anti-Factor Xa Activity

A. Used to determine the adequacy of anticoagulation in clients receiving agents that interfere with factor Xa activity (e.g., heparin, low-molecular-weight heparin, Xarelto [rivaroxaban], Eliquis [apixaban]).
1. The direct factor Xa inhibitors (e.g., Xarelto [rivaroxaban], Eliquis [apixaban]) do not require routine monitoring in practice.
2. Two relatively new anticoagulants, low-molecular-weight heparin (LMWH) and Orgaran (danaparoid), if present at therapeutic levels, usually do not significantly prolong the activated partial thromboplastin time (APTT). Therefore, when laboratory tests are used to monitor therapeutic anticoagulant levels of LMWH or Orgaran, anti-factor Xa assays are necessary.
B. Purpose: Determine if the client is at the desired level of anticoagulation with therapeutic doses of heparin, LMWH, or Orgaran.

C. Monitoring.
   1. Continuous intravenous administration of unfractionated heparin: *anti-factor Xa activity can be measured at any time (i.e., as a random level).*
   2. Low-molecular-weight heparin (LMWH): anti-factor Xa activity should be tested 4 hours after the dose is administered.
   3. Oral direct anti-Xa drugs can be monitored by anti-factor Xa activity in assays calibrated for the drug; however, *there is no established range as these drugs were approved for use without a monitoring requirement.*
   4. Results of anti-factor Xa assays may differ between laboratories due to variability in the type of assays used.

D. Normal values.
   1. Clients not on anticoagulants: 0 units/mL.
   2. Therapeutic range for *treatment* of existing deep venous thrombosis (DVT):
      a. Heparin 0.3–0.7 units/mL.
      b. LMWH: 0.4–1.1 units/mL for twice daily subcutaneous dosing.
      c. For once daily subcutaneous LMWH dosing, the therapeutic range is less certain but is approximately 1–2 units/mL.
      d. Orgaran: 0.5–0.8 units/mL.
   3. Target range for DVT prophylaxis (prevention): There is no defined target range for *prophylaxis* of DVT because such anticoagulation is not usually monitored. When anti-Xa levels have been measured, mean values have been < 0.45 units/mL.

Activated Partial Thromboplastin Time

✦ A. Normal values—20–38 seconds with standard technique; different activators will yield different values.

B. Purpose—best single screening test for coagulation disorders.
   1. Test evaluates adequacy of plasma clotting factors—intrinsic clotting mechanism.
   2. Test of choice for monitoring heparin therapy.
   3. Used for clients with hemophilia.

C. Arterial values—if activated partial thromboplastin time (APTT) is very prolonged (100 seconds), assess for spontaneous bleeding coagulant disorder.

D. Possible causes of prolonged clotting time.
   1. Vitamin K deficiency.
   2. Liver disease.
   3. Hemophilia.
   4. Specific drugs (heparin, Coumadin [warfarin], salicylates).

✦ E. When APTT is prolonged, MD may order protamine sulfate (or in severe cases, whole blood or plasma transfusion).

✦ International Normalized Ratio

A. Designed to standardize values and improve monitoring process. Test provides a more accurate assessment of client's anticoagulant; a uniform value in which client's PT is expressed as a ratio.

B. Standardizes PT ratio by allowing all thromboplastin reagents to be compared to an international standard thromboplastin (sensitivity index) provided by the World Health Organization (WHO).
   1. International normalized ratio (INR) is a mathematical correction to prothrombin time ratio (PTR).
   2. Value is calculated using client's PT divided by the mean normal PT. Target range is 2.5 to 3.5.
   3. INR is calculated by raising the observed PT ratio to the power of the sensitivity index, depending on the reagent used.

C. The INR is the best lab value for monitoring anticoagulation therapy; improves the effectiveness of the medication.

D. Should be used only after client has been stabilized on Coumadin (warfarin) (which takes at least a week).

E. Often, both PT and INR values are reported for monitoring Coumadin (warfarin) therapy.

Prostate-Specific Antigen Test

A. Values.
   1. Normal: 0 to 4–6 ng/mL.
   2. Benign prostatic hypertrophy: 4 to 9 ng/mL.
   3. Prostate cancer: 10 to 120 ng/mL.

B. Purpose—shows concentration of glycoprotein from prostate tissue.
   1. Increases with benign prostatic hypertrophy (BPH).
   2. Markedly increases with cancer of the prostate.
   3. Used to diagnose or to monitor effect of treatment with chemotherapy or radiation.
   4. Collect 5 mL of venous blood before rectal or prostate exam (exam irritates tissue).

Serum Protein Electrophoresis Test

A. Normal values:
   1. Total serum protein: 6.3 to 7.9 g/dL.
   2. Albumin: 3.5 to 5.0 g/dL.
   3. $Alpha_1$ globulin: 0.1 to 0.4 g/dL.
   4. $Alpha_2$ globulin: 0.4 to 1.0 g/dL.
   5. Beta globulin: 0.5 to 1.1 g/dL.
   6. Gamma globulin: 0.5 to 1.7 g/dL.

B. Purpose: To differentiate between protein fractions—serum proteins are made up of albumin and globulins. Test indicates the size, shape, and electrical charge of the major blood proteins (fractions) to diagnose certain diseases.

C. Abnormal results.
   1. Elevated levels.
      a. Albumin: dehydration, exercise.
      b. Alpha$_1$ and alpha$_2$, globulins: myocardial infarction, hepatic disease, myeloma, collagen diseases, and acute and chronic infections.
   2. Decreased levels: liver disease, malnutrition, leukemia, renal failure, emphysema, anemia.

RENAL FUNCTION TESTS

✦ A. Phenolsulfonphthalein (PSP) test indicates the functional ability of the kidney to
   1. Excrete waste products.
   2. Concentrate and dilute urine.
   3. Carry on absorption and excretion activities.
   4. Maintain body fluids and electrolytes.

✦ B. Renal concentration tests.
   1. Evaluate the ability of the kidney to concentrate urine.
   2. As kidney disease progresses, renal function decreases. Concentration tests evaluate this process.
   3. Renal concentration is measured by specific gravity readings.

✦ C. Specific gravity.
   1. Normal value—range is 1.003–1.030, usually 1.010–1.025.
   2. If specific gravity is 1.018 or greater, it may be assumed that the kidney is functioning within normal limits.
   3. Specific gravity that stabilizes at 1.010 indicates kidney has lost ability to concentrate or dilute urine.

✦ D. Blood urea nitrogen (BUN).
   1. Normal value—10–20 mg/100 dL.
   2. Purpose—tests for impaired kidney function by testing the body's urea production and urine flow.
   3. BUN level affected by protein intake and tissue breakdown.

✦ E. Serum creatinine.
   1. Normal value—male: 0.8–1.2 mg/dL; female: 0.6–0.9 mg/dL. If normal value doubles, overall renal function and glomerular filtration rate (GFR) have decreased by half.
      a. When elevated, suggests hypertension or drugs such as steroids.
      b. Decreased indicates mild to severe renal impairment, muscular dystrophy, or use of certain drugs.
   2. Purpose—tests renal function by evaluating the balance between production and filtration of glomeruli.
   3. This is the most sensitive of renal function tests.

✦ F. Concentration and dilution tests.
   1. Fishberg concentration test—high-protein dinner with 200 mL fluid is ordered. Next AM on arising, client voids q 1/hr. One specimen should have specific gravity more than 1.025.
   2. Dilution test—NPO after dinner. Morning voiding discarded. Client drinks 1000 mL in 30 to 45 minutes. Four specimens at 1-hour intervals are collected. Specific gravity of one specimen will fall below 1.003.
   3. Specific gravity—urine range 1.003 to 1.030. Increased solutes cause increased specific gravity (see above).

✦ G. Glomerular filtration rate (GFR) or endogenous creatinine clearance.
   1. Normal values—125 mL/min (male) and 110 mL/min (female).
   2. Purpose—kidney function is assessed by clearing a substance from the blood such as inulin, a polysaccharide found in plants (filtration in the glomerulus).
   3. Common test is the amount of blood cleared of urea per minute.
   4. Test done on 12- or 24-hour urine specimen.

H. Electrolyte tests.
   1. Kidney function is essential to maintain fluid and electrolyte balance.
   2. Tests for electrolytes (sodium, potassium, chloride, and bicarbonate) measure the ability of the kidney to filter, reabsorb, or excrete these substances.
   3. Impaired filtration leads to retention, and impaired reabsorption leads to loss of electrolytes.
   4. Tests are performed on blood serum, so venous blood is required.

Urine Analysis

✦ A. Normal values.
   1. Specific gravity—1.010–1.025.
   2. Urine pH—4.5–8.0.
   3. Color—straw.
   4. Odor—aromatic.
   5. Appearance—clear.
   6. Protein—negative or zero.
   7. Glucose—negative or zero.
   8. Ketones—negative or zero.
   9. Red blood cells—0–3.
   10. White blood cells—0–4.
   11. Casts—none; occasional.
   12. Crystals—negative.
   13. Yeast cells—none.
   14. Parasites—none.

B. Urinalysis is a critical test for total evaluation of the renal system and for indication of renal disease.

✦ C. Specific gravity shows the degree of concentration in urine.
1. Normal value—1.010–1.025.
2. Indicates the ability of the kidney to concentrate or dilute urine.
3. Change from normal range.
a. Elevated (greater than 1.030) indicates fluid depletion—diabetes mellitus, dehydration, vomiting/diarrhea, contrast media (1–2 days).
b. Low (less than 1.010) indicates fluid excess—diabetes insipidus, overhydration, renal disease.
4. Renal failure—specific gravity constant at 1.010.

D. Analysis of urine pH.
1. pH is the symbol for the logarithm of the reciprocal of the hydrogen ion concentration.
2. A measurement of hydrogen ion concentration is taken—the lower the number, the higher the acidity of urine.
✦ a. Normal value range—4.5 to 8.0 (normal pH is 6 to 7).
b. Lower than 6 is acidic urine, and higher than 7 is alkaline urine.
3. Regulation of urine pH is important for treatment of certain conditions.
a. When the pH is alkaline, it suggests urinary tract infection, metabolic or respiratory alkalosis, drug influence, a vegetarian or highly alkaline diet.
b. When the pH is acidic, it may reflect renal tuberculosis (TB), phenylketonuria (PKU), pyrexia, acidosis.
c. Acid urine may be desired when treating blood infections or phosphate stones.

✦ E. Chemical analysis of urine.
1. Protein or albumin—zero is normal for a 24-hour specimen.
a. Presence may indicate kidney dysfunction or renal disease, such as nephritis or nephrosis.
b. Inflammatory processes any place in the body may result in proteinuria.
c. Toxemia of pregnancy yields a finding of proteinuria.
d. Renal calculi indicate positive test results.
e. Appearance in urine may be due to dehydration, strenuous exercise, high-protein diet.
2. Glucose—normal range is zero.
a. Presence of glucose may indicate head injury, diabetes, Cushing's syndrome, hyperthyroidism.
b. Test is usually done by test strips or tablets; change in color indicates presence of glucose. (Urine testing for glucose has been primarily replaced by testing blood for glucose.)
3. Ketone bodies—normal range is zero. Positive is +1 to +3.
a. Ketonuria primarily indicates diabetic acidosis but is also present with starvation and pernicious vomiting.
b. Test is usually done by strip or powder mixed with urine; purple color indicates positive test.
4. Bilirubin—normal range is zero.
a. Presence in urine may indicate liver disease and may appear before the clinical symptom of jaundice.
b. Detected in the urine by qualitative methods, such as inspection of color.
5. Blood—normal range is zero.
a. If red blood cells are present, may indicate disease of kidney or urinary tract, and the source of hemorrhage must be determined.
b. Specific diagnosis is made by complete urine analysis for casts and epithelial cells.

F. Microscopic examination of urine.
1. Evaluation of urinary sediment is important for diagnostic purposes.
2. Test for cellular elements (epithelial cells, white and red blood cells).
3. Test for casts, fat bodies, and crystals.

G. Levels of albuminuria.
1. 30 mg/100 mL = 1+.
2. 100 mg/100 mL = 2+.
3. 300 mg/100 mL = 3+.
4. 1000 mg/100 mL = 4+.

Schilling Urine Test

A. Determines absorption of vitamin B_{12} necessary for erythropoiesis—definitive test for pernicious anemia and intestinal malabsorption syndrome.

B. 7% excretion of radioactive B_{12} in urine within 24 hours. (When less than 3 g is excreted, diagnosis is confirmed.)

ANALYSIS OF GI SECRETIONS

A. Contents of the GI tract may be examined for the presence or absence of digestive juices, bacteria, parasites, and malignant cells.

B. Stomach contents may be aspirated and analyzed for volume and free and total acid.

✦ Gastric Analysis

A. Performed by means of a nasogastric tube.
   1. Maintain NPO 6–8 hours prior to the test.
   2. Pass NG tube; verify its presence in the stomach; tape to client's nose.

B. Collect fasting specimens.
   1. Administer agents, such as alcohol, caffeine, histamine (0.2 mg subcutaneous), as ordered, to stimulate the flow of gastric acid.
      a. Watch for side effects of histamine, including flushing, headache, and hypotension.
      b. Do not give drug to clients with a history of asthma or other allergic conditions.
   2. Collect specimens as ordered, usually at 10- to 20-minute intervals.
   3. Label specimens and send to laboratory.
   4. Withdraw NG tube; offer oral hygiene; make client comfortable.
   5. Gastric acid is high in the presence of duodenal ulcers and is low in pernicious anemia.

✦ C. Gastric washings for acid-fast bacilli.
   1. Instruct client to fast 6–8 hours prior to the procedure.
   2. Insert nasogastric tube and secure gastric washings.
   3. Send specimens to the laboratory to determine the presence of acid-fast bacilli.
   4. Wash your hands carefully and protect yourself from direct contact with specimens.
   5. This procedure is performed on suspected cases of active pulmonary tuberculosis when it is difficult to secure sputum for analysis.

Stool Analysis

✦ A. Stool specimens are examined for amount, consistency, color, shape, blood, fecal urobilinogen, fat, nitrogen, parasites, food residue, and other substances.
   1. Stool cultures are also done for bacteria and viruses.
   2. Some foods and medicines can affect stool color—spinach, green; cocoa, dark red; senna, yellow; iron, black; upper GI bleeding, tarry black; lower GI bleeding, bright red.

B. Stool abnormalities.
   1. Steatorrhea—bulky, greasy and foamy, foul odor.
   2. Biliary obstruction—light gray or clay-colored.
   3. Ulcerative colitis—loose stools, with copious amounts of mucus or pus.
   4. Constipation or obstruction—small, hard masses.

C. Specimen collection.
   1. Specimens for detection of ova and parasites should be sent to the laboratory while the stool is still warm and fresh.
   2. Examinations for blood are performed on small samples. A tongue blade may be used to place a small amount of stool in a disposable waxed container, or place a drop on a commercial card, which will turn color if blood is present in the stool.
   3. Stools for chemical analysis are usually examined for the total quantity expelled, so the complete stool is sent to the laboratory.

LIVER FUNCTION TESTS

✦ A. Pigment studies.
   1. Serum bilirubin—abnormal in biliary and liver disease causing jaundice.
      a. Direct (conjugated)—normal: 0–0.3 mg/100 mL, soluble in H_2O.
      b. Indirect (unconjugated)—normal: 0.8–1.0 mg/100 mL, insoluble in H_2O.
      c. Total serum bilirubin—normal: 0–0.9 mg/100 mL.
   2. Urine bilirubin—normally none is found.
   3. Urine urobilinogen—0–4 mg/24 hours.
   4. Fecal urobilinogen—40–280 mg/24 hours.
   5. Serum cholesterol—150–250 mg/100 mL.

✦ B. Protein studies.
   1. Total protein—6–8 g/100 mL.
   2. Serum albumin—3.5–5.0 mg/100 mL.
   3. Serum globulin—1.5–3.0 mg/100 mL.
   4. Prothrombin time—11–15 seconds.
   5. Cephalin—0–1+.
   6. In liver damage, fewer plasma proteins are synthesized; thus albumin synthesis is reduced.
      a. Serum globulins produced by the plasma cells are increased.
      b. PT is reduced in liver cell damage.

C. Cholesterol (see page 514).

✦ D. Detoxification.
   1. Bromsulphalein excretion (BSP).
   2. Less than 5% dye retention after 1 hour.
      a. Dye is injected intravenously and removed by the liver cells, conjugated, and excreted.
      b. Blood specimen is obtained at 30-minute and 1-hour intervals after injection.
      c. Increased retention occurs in hepatic disorders.

✦ E. Enzyme (transaminase) indicators.
   1. Elevations reflect organ damage.
   2. Levels.
      a. AST (formerly SGOT)—10–40 units/mL.

b. Alanine transaminase (ALT) (formerly serum glutamic pyruvic transaminase [SGPT])—5–35 units/mL.
c. LDH—100–200 units/mL.
d. Gamma-glutamyl transpeptidase (GGT)—10–48 units/mL.

✦ F. Alkaline phosphatase.
1. 2–5 units (varies with method used).
2. Elevated in obstructive jaundice, liver disease, Paget's disease, and cancer with bone metastasis.

✦ G. Blood ammonia.
1. 20–120 μg/dL.
2. Ammonia level rises in liver failure because liver converts ammonia to urea.
3. Metabolic alkalosis increases the toxicity of NH_3.

THYROID FUNCTION TESTS

✦ Radioactive Iodine Uptake (Radioiodine ^{131}I)

A. Normal values—5–35% in 24 hours (recently lowered values in United States due to increased ingestion of iodine).
1. Elevated values indicate hyperthyroidism, thyrotoxicosis, hypofunctioning goiter, iodine lack, excessive hormonal losses.
2. Depressed values indicate low T_4, antithyroid drugs, thyroiditis, myxedema, or hypothyroidism.

B. Purpose—measures the absorption of the iodine isotope to determine how the thyroid gland is functioning.

C. Principles.
1. The use of ^{123}I rather than ^{131}I is now preferred because of its lower radiation hazard. (^{123}I can be used on pregnant women; ^{131}I is contraindicated.)
2. The amount of radioactivity is measured at 2, 6, and 24 hours after ingestion of the capsule.
3. ^{131}I (as does ^{123}I) evaluates the storage of iodine and gives a distribution pattern.

✦ Thyroid-Stimulating Hormone Ultrasensitive Assay

A. Normal values were 0.5–5.0 μU/mL—new, narrower thyroid-stimulating hormone (TSH) normal range of 0.3–3.0 μU/mL is a more accurate level and is recommended to become the standard of practice for therapeutic management.
1. Increased values, more than 20 μU/mL indicates hyperthyroidism, Addison's disease, goiter, and toxicity from certain drugs.
2. Decreased values: first-degree (secondary) hypothyroidism is less than 0.3 μU/mL, and second- to third-degree hypothyroidism is less than 0.1 μU/mL.

B. Test is an ultrasensitive indicator that has mostly replaced all other thyroid tests.
1. If assay is normal, no other test is indicated.
2. If test is abnormal, it should be validated by a T_4 assay.

✦ T_3 and T_4 Resin Uptake Tests

A. Normal values.
1. T_4—3.8–11.4%.
2. T_3—25–35%.
3. T_4.
a. Elevated—hyperthyroidism, early hepatitis, exogenous T_4.
b. Decreased—hypothyroidism, abnormal binding, exogenous T_4.
4. T_3.
a. Elevated—hyperthyroidism, T_3 toxicosis.
b. Decreased—advancing age.

B. Purpose—both of these in vitro tests are used as screening tests for diagnosis in thyroid disorders. T_4 is 90% accurate in diagnosing hyperthyroidism and hypothyroidism.

C. Decreased T_4 and normal or elevated TSH level can indicate thyroid disorder; decreased T_4 and decreased TSH level can indicate pituitary disorder.

D. Principles.
1. Levels of T_3 and T_4 in the blood regulate TSH.
2. These levels change according to a balancing system of negative feedback.
3. Venous blood sample is obtained to directly measure concentration of unsaturated thyroxine-binding globulin in the serum.
4. Thyroid function tests should be interpreted according to the clinical situation.

✦ TSH

A. Normal values 0–6 μU/mL or < 10 μU/mL (may vary with laboratory).
1. Increased values indicate primary hypothyroidism.
2. Decreased values indicate Hashimoto's thyroiditis, hyperthyroidism, large doses of glucocorticoids, secondary hypothyroidism.

B. Purpose—differentiates primary from secondary hypothyroidism and assesses level of thyroid gland activity.

C. Principles.
   1. Administration of IM TSH (thyrotropin) measures the responsiveness of the thyroid gland.
   2. Blood samples are obtained at intervals.

BLOOD GLUCOSE STUDIES

✦ Fasting Plasma Glucose

A. Normal fasting glucose is 70 to 100 mg/100 mL; indicates good metabolic control.
B. > 125 mg/dL can signify diabetes.
   1. This number is based on the most recent guidelines that lowered the threshold for diabetes.
   2. Fasting is defined as no calorie intake for 8 hours.
C. Fasting plasma glucose (FPG) is used to diagnose hypoglycemia, confirm a diagnosis of prediabetic state, confirm diabetes mellitus, or monitor blood glucose levels.

✦ Random (Casual) Plasma Glucose Levels

A. Levels of more than 200 mg/dL on more than one occasion are diagnostic of diabetes.
B. Casual is any time of day without regard to when the last meal was eaten.

✦ Glucose Tolerance Test

A. Normal values are between 70 and 105 mg fasting blood glucose and no sugar in the urine.
   1. Greater than 140 mg/dL fasting and 200 mg/dL 2 hours postprandial are diagnostic of diabetes.
   2. The oral glucose tolerance test and IV glucose are no longer recommended for routine clinical use.
B. Purpose—primary aim is to diagnose or rule out diabetes, but also important for unexplained hypoglycemia and malabsorption syndrome.
C. Principles.
   1. This test determines rate of removal of a concentrated dose of glucose from the bloodstream.
   2. Test is indicated when there is sugar in the urine or when fasting blood sugar is elevated.
   3. This is a timed test done in the morning after fasting for at least 12 hours. Blood and urine samples are taken at intervals up to 3 hours.
   4. This test is contraindicated for recent surgical clients or clients with history of myocardial infarctions.

IMMUNODIAGNOSTIC TESTS

HIV-1 Antibody Test

✦ A. The ELISA (enzyme-linked immunosorbent assay) test was developed to screen donor blood on a national scale.
   1. This test does not test for acquired immune deficiency syndrome (AIDS), but rather antibodies to the human immunodeficiency virus (HIV).
   2. Once exposed to a virus, it takes the body time to produce antibodies. A person may already be infected and if the body has not yet produced antibodies, the ELISA test will be negative.
   3. The test is not perfect because it may produce a false positive or false negative.
   4. When performed at least 12 weeks after infection, the test has a 99.5% sensitivity and will show a positive result.
B. All positive results must be retested.
C. The Western blot test is given for final confirmation; used to confirm seropositive blood as identified by ELISA.
D. The indirect immunofluorescence assay (IFA) is being used by some physicians rather than the Western blot to confirm positive HIV. This test is rapid and easy to complete.

✦ Coombs' Test

A. Normal values—negative.
B. Purpose—test to discover presence of antibodies present in Rh-negative mother's blood.
   1. Test also will confirm diagnosis of hemolytic disease in the newborn.
   2. Titration determines extent to which antibodies are present.
C. Types of test for Rh incompatibility.
   1. Indirect Coombs'—mother's blood reveals antibodies as result of previous transfusion or pregnancy.
   2. Direct Coombs'—tests newborn's cord blood: determines presence of maternal antibodies attached to baby's cells.

✦ Venereal Disease Research Laboratory Test

A. Normal values—serum is nonreactive.
B. Purpose—to screen for primary or secondary syphilis and for diagnosis.
C. Differential diagnosis.
   1. Biological false-positive tests may occur with hepatitis, mononucleosis, leprosy, malaria, rheumatoid arthritis, lupus erythematosus.

2. A nonreactive result does not rule out syphilis, as it takes up to 4 weeks after infection to cause an immunologic response.

D. The rapid plasma reagin circle card test (RPR-CT) is also used to screen for diabetes.
E. The fluorescent treponemal antibody absorption test (FTA-ABS) is used to verify the screening test and determine that it was not a false positive.

Epstein-Barr Virus Antibodies

A. Normal values—negative (antibodies appear within first 3 weeks, then decline rapidly).
B. Purpose—to diagnose infectious mononucleosis or to determine the antibody status of EBV-infected people.
C. Test—serum is tested for heterophile antibodies (Monospot test).
D. Differential diagnosis.
   1. Positive results may occur with infectious mononucleosis, hepatitis A and B, cancer of the pancreas.
   2. A negative Monospot does not always rule out acute or past EBV.

✦ Serologic Tests for Hepatitis A and B

A. Normal values—negative for hepatitis A, B, non-A, non-B, and D.
B. Purpose—serologic tests diagnose and differentiate different forms of hepatitis and detect presence in client's or donor's blood.
C. Test variations.
   1. Hepatitis A (HAV).
      a. Anti-HAV immunoglobulin M (IgM) presence confirms recent infection of hepatitis A—detectable for 3 to 12 weeks.
      b. Anti-HAV immunoglobulin G (IgG) indicates previous exposure to HAV, recovery, and immunity. Appears after acute infection and is detectable for life.
   2. Hepatitis B (HBV).
      a. Hepatitis B surface antigen—appears in 27 to 41 days and is the earliest indicator of HBV.
      b. Antibody to hepatitis B surface antigen indicates clinical recovery with subsequent immunity.
   3. Hepatitis C (non-A, non-B) has no serologic or laboratory test to establish diagnosis—usually made by excluding other causes of hepatitis.
   4. Hepatitis D or delta is associated with hepatitis B and depends on HBV for replication. It is found in the serum 7 to 14 days during acute infection.
   5. Hepatitis E virus—fecal–oral route; similar to HAV.
   6. Hepatitis G—also known as GB virus C.

✦ Rubella (German Measles) Viral Serologic Test

A. Normal values.
   1. Negative titer of less than 1.8 or 1.10 (depending on test)—no antibody detected, therefore not immune.
   2. Positive titer of more than 1.10—antibody detected, therefore immune.
B. Purpose—exposure to rubella is important to detect because exposure to this virus—if a woman is in the first trimester of pregnancy—may result in congenital abnormalities, abortion, or stillbirth.

✦ Papanicolaou Smear

A. Diagnosis to identify preinvasive and invasive cervical cancer.
B. Vaginal secretions and secretions from posterior fornix are swabbed and smeared on a glass slide.
C. Pathological classifications (early cellular changes may be detected before disease becomes clinically observable).
   1. Class I—no abnormal or atypical cells present.
   2. Class II—atypical or abnormal cells present but no malignancy found; repeat Papanicolaou (Pap) smear and follow up if necessary.
   3. Class III—cytology, suggestive of malignancy; additional procedures indicated (biopsy, dilation and curettage [D&C]).
   4. Class IV—cytology, strongly suggestive of malignancy; additional procedures indicated (biopsy, D&C).
   5. Class V—cytology results conclusive of malignancy.

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LABORATORY TESTS REVIEW QUESTIONS

1. A client has just had his anticoagulant therapy monitored via the international normalized ratio (INR). The rationale for using this laboratory value is

1. It is less expensive than doing a PT or PH test.
2. It is the only test available for anticoagulant therapy monitoring.
3. The client chooses the test and this test is easier for him to do.
4. It is the most efficient lab value for monitoring anticoagulant therapy.

2. A client with suspected HIV will receive which test(s) to verify the diagnosis?

1. Home Access HIV-1 Test System.
2. Enzyme-linked immunosorbent assay (ELISA) and Western blot assay.
3. Indirect immunofluorescence assay (IFA).
4. ELISA and DNA.

3. A 57-year-old, postmenopausal female client complaining of chest pain is admitted. She is suspected of having a myocardial infarction. Which of the following isoenzyme values would be indicative of specific myocardial damage?

1. CK (formerly CPK).
2. CK–MB band.
3. CK–MM band.
4. CK–BB band.

4. A client has been advised to take a bile acid sequestrant (Colestid [colestipol]) to lower his LDL. It comes in powder form or tablets. The nurse should inform the client that if he chooses tablet form, he should

1. Take milk with the medication.
2. Take up to 30 tablets per day for the medication to be effective.
3. Take the tablet every 6 hours.
4. Not take the medication with citric acid (orange juice).

5. A client with symptoms of nausea and vomiting is admitted to the emergency department. He states that before he came to the hospital, when he tried to lie down, his abdominal pain got worse and was not relieved by antacids. When questioned, he states that he had consumed a large meal and two glasses of wine. The tentative diagnosis is acute pancreatitis. The physician orders lab work. With this complaint picture and diagnosis, the nurse would expect lab results to include

1. Decreased white blood cells (WBC).
2. Elevated serum amylase and lipase.
3. No change in serum bilirubin level.
4. Elevated alkaline phosphatase.

6. When a physician orders ABGs on a client, which results will tell the nurse if an acid–base problem is present and whether it is respiratory or metabolic?

1. pH and CO_2.
2. CO_2 and HCO_3.
3. pH, CO_2, and HCO_3.
4. pH and $PaCO_2$.

7. Which group of cells is the first line of defense against bacterial infection working primarily through phagocytosis?

1. Monocytes.
2. Platelets.
3. Neutrophils.
4. Basophils.

8. Kayexalate is ordered for a client with a serum potassium level of 5.5 mEq/L. If this substance is effective, the nurse should expect to see an ECG with

1. Return of T-wave width and amplitude to normalcy.
2. Broad, flat P waves.
3. Absence of P waves.
4. Return of QRS to upright configuration.

9. A client is scheduled to take a serum creatinine test, and she asks the nurse what this test shows. The most appropriate response would be

1. "This test will tell your doctor how your kidneys are functioning."
2. "You'll have to ask your doctor."
3. "It will tell if you have severe renal impairment or a disease."
4. "Results will indicate if certain drugs, such as steroids, are interfering with kidney functioning."

10. The nurse is assigned to a male client who was admitted with flu symptoms of nausea and vomiting. He is receiving IV therapy. The lab has sent his early-morning blood results, which are: BUN 32, creatinine 1.1, hematocrit 50. The initial nursing intervention is to

1. Notify the physician STAT.
2. Do nothing because the results are within normal limits.
3. Decrease the IV rate and notify the physician, as lab results indicate overhydration.
4. Evaluate urine output for amount and specific gravity.

11. The nurse would expect to find an improvement in which of the blood values as a result of dialysis treatment?

1. High serum creatinine levels.
2. Low hemoglobin.
3. Hypocalcemia.
4. Hypokalemia.

12. Which of the following blood chemistry results would the nurse expect to find elevated in a client with right-sided congestive heart failure?

1. Ammonia.
2. Albumin.
3. LDH.
4. CK.

13. A client with a long-standing history of alcoholic cirrhosis with ascites is admitted to the hospital. His diagnosis is acute bleeding from esophageal varices secondary to cirrhosis with portal hypertension. Which of the following laboratory findings indicates that blood is being digested and absorbed by the GI tract?

1. Elevated BUN.
2. Elevated serum ammonia.
3. Decreased hemoglobin.
4. Elevated bilirubin.

14. An 80-year-old client has been admitted to the hospital with influenza and dehydration. Which of the following blood urea nitrogen (BUN) levels would indicate to the nurse that the client has received adequate fluid volume replacement?

1. 40 mg/dL.
2. 29 mg/dL.
3. 17 mg/dL.
4. 3 mg/dL.

15. A client who sustained head trauma in a motor vehicle accident has been diagnosed and treated for having syndrome of inappropriate antidiuretic hormone (SIADH) secretion. Which of the following urine specific gravity values would indicate that the situation had not resolved?

1. 1.005.
2. 1.018.
3. 1.025.
4. 1.035.

16. As part of an annual physical exam, a 60-year-old adult male has had lab work done. Which of the following serum creatinine levels would indicate that the client has a mild degree of renal insufficiency?

1. 4.0 mg/dL.
2. 3.3 mg/dL.
3. 1.7 mg/dL.
4. 0.8 mg/dL.

17. The nurse should explain to a client who takes Lasix (furosemide) and has a potassium level of 3.2 mEq/L that he should

1. Avoid apple juice, orange juice, and instant coffee.
2. Eat three servings daily of fruits and meat or fish.
3. Maintain a fluid intake of 2 L/day.
4. Avoid driving or operating electrical equipment.

18. Of the following blood gas values, the one the nurse would expect to see in the client with acute renal failure is

1. pH 7.49, HCO_3 24, pCO_2 46.
2. pH 7.49, HCO_3 14, pCO_2 30.
3. pH 7.26, HCO_3 24, pCO_2 46.
4. pH 7.26, HCO_3 14, pCO_2 30.

19. The premenstrual hemoglobin of a 24-year-old client with no history of trauma, recent surgery, or hemorrhage is 9.8 g/dL. The nurse interprets that this value is due to

1. Iron-deficiency anemia.
2. Hypovolemia.
3. Dehydration.
4. Cardiogenic shock.

20. A client is scheduled for a carotid endarterectomy in 3 days. Which of the following preadmission lab test results must be immediately reported to the physician?

1. Sodium of 151 mEq/L.
2. Chloride of 105 mEq/L.
3. Potassium of 3.8 mEq/L.
4. Bicarbonate of 23 mEq/L.

21. A client is admitted to the hospital for evaluation. His physician writes in the chart "rule out liver cancer" and schedules a liver biopsy. Before the procedure, the nurse reviews the PT results just back from the lab: 24—INR, 4.0. The nurse also notes that this client is not on an anticoagulant. The nursing intervention is to

1. Do nothing—the results of the PT are normal.
2. Notify the physician before the biopsy procedure.
3. Ask the lab to repeat the test tomorrow and notify the physician.
4. Ask the client if he has been eating foods high in vitamin K.

22. A 60-year-old client is admitted to the surgery unit for removal of fibroid tumors. When the nurse checks the lab results for routine blood chemistry, she notes that the sedimentation rate is 29 mm/dL. The appropriate intervention is to

1. Ask the client if she has been sick with a fever.
2. Do nothing—the value is normal.
3. Notify the physician.
4. Ask the lab to repeat the test.

23. A TSH ultrasensitive assay has been ordered for a client, and she asks the nurse the purpose of this test. The most appropriate reply is

1. "This test is a screening test to diagnose thyroid disorders."
2. "The doctor is testing whether you have Hashimoto's disease."
3. "This test measures the absorption of iodine and how it relates to the thyroid gland."
4. "The test indicates whether your thyroid gland is over- or underactive."

24. At the physician's office, the client has a random plasma glucose test. The results were 250 mg/dL. The client asked the office nurse why the doctor told him to come back the next day to repeat the test. The best answer is

1. "The doctor always repeats this test."
2. "You may have diabetes and the doctor wants to be sure."
3. "This test must be done at least twice for accurate results."
4. "It was a little high, so the doctor wants to check the results."

25. A client has a gastric analysis done and results showed that gastric acid was high. This test result would indicate to the nurse that the client may receive the diagnosis of

1. Pernicious anemia.
2. Peptic ulcer.
3. Tuberculosis.
4. Duodenal ulcer.

LABORATORY TESTS ANSWERS WITH RATIONALE

1. (4) INR is the most efficient lab value test to use because it provides a more accurate and standardized value and, therefore, improves the effectiveness of the medication. It is not less expensive (1); the client does not choose the test (3); and it is not the only test available (2).

   NP:P; CN:PH; CA:M; CL:C

2. (2) ELISA is the first test used to confirm the presence of antibody to HIV and indicates the person has been exposed to or infected by HIV. The Western blot assay is used to confirm seropositivity as identified by ELISA. The Home Access kit (1) has been approved by the FDA, but false-positive test results are possible and must be verified. The IFA (3) is an indirect test and must be confirmed by the Western blot. DNA (4) may be used to track HIV.

   NP:AN; CN:H; CA:M; CL:K

3. (2) CK is a cellular enzyme that is fractionated out into MB, MM, and BB bands. The MB bands are specific to cardiac muscle, the MM bands (3) relate to skeletal muscle, and the BB bands (4) relate to CK in the brain. Although an elevated CK (1) may indicate cardiac muscle damage, it is only the MB portion that is specific to cardiac muscle.

   NP:A; CN:PH; CA:M; CL:A

4. (2) If the client chooses to take the tablets rather than the powder, he will have to take up to 30 tablets per day. The powder can be taken with a beverage or cereal.

   NP:I; CN:PH; CA:M; CL:A

5. (2) These elevated serum levels (amylase and lipase) are the hallmark of acute pancreatitis. Increased WBC (1) and serum bilirubin level (3) are also seen with acute pancreatitis. Elevated alkaline phosphatase (4) is found in chronic pancreatitis.

   NP:AN; CN:PH; CA:M; CL:AN

6. (3) If an acid–base problem is present, the nurse will note it from the pH result (if blood pH is below 7.4, it is acid; if above 7.4, it is base). The matching component, CO_2, indicates whether the problem is respiratory; HCO_3, the other matching value, reflects a metabolic problem. $PaCO_2$ represents only the respiratory part of acid–base balance, but the CO_2 and HCO_3 values must be present. For example, if an acid–base problem is present, the nurse will note pH and either $PaCO_2$ (respiratory) or HCO_3 (metabolic).

   NP:AN; CN:PH; CA:M; CL:AN

7. (3) Neutrophils are the first line of defense against infection. They live in the circulation for about 6 hours after bacteria are ingested. The cells die and become the main component of pus. Monocytes (1) are the second group to defend the body. Platelets (2) are blood components that go to the site of injury and stem blood loss. Basophils (4) release heparin and histamine in areas that are invaded by antigens.

   NP:AN; CN:S; CA:M; CL:K

8. (1) The Kayexalate should bring the potassium level down. When this occurs, the effects on the T wave reverse and the ECG will return to normal.

   NP:E; CN:S; CA:M; CL:AN

9. (1) This response is preferred because it answers the question rather than avoiding it, as in answer (2). It does not give information that may frighten the client (3), nor does it suggest an outcome that will be negative (4).

   NP:I; CN:PH; CA:M; CL:A

10. (4) These lab results indicate that the client is dehydrated. Specific gravity and urine output are indicators used to support the laboratory findings. The higher the specific gravity, the more dehydrated the client.

    NP:I; CN:PH; CA:M; CL:AN

Coding for Questions/Answers Abbreviations: Nursing Process: NP, Assessment: A, Analysis: AN, Planning: P, Implementation: I, Evaluation: E; Client Needs: CN, Safe, Effective Care Environment: S, Health Promotion and Maintenance: H, Psychosocial Integrity: PS, Physiological Integrity: PH; Clinical Area: CA, Medical Nursing: M, Surgical Nursing: S, Maternal/Newborn Nursing: MA, Pediatric Nursing: P, Psychiatric Nursing: PS; Cognitive Level: CL, Knowledge: K, Comprehension: C, Application: A, Analysis: AN.

11. (1) High creatinine levels will be decreased as a result of dialysis. Anemia is a result of decreased production of erythropoietin by the kidney and is not affected by hemodialysis (2). Hyperkalemia and high base bicarbonate levels are present in renal failure clients.

    NP:E; CN:PH; CA:M; CL:A

12. (3) The liver becomes engorged with blood in right-sided congestive heart failure. Liver function studies, such as the LDH, an enzyme production test for the liver, will be abnormally elevated in 40% of these clients. Serum bilirubin is also frequently increased. Ammonia (1) and albumin (2), also liver tests, will not be elevated. CK isoenzymes (4) (CK–MB) are a valuable indicator of myocardial infarction.

    NP:AN; CN:PH; CA:M; CL:AN

13. (1) As blood is digested, the BUN rises rapidly. A result of bleeding may also be a lowered hemoglobin (3), but this does not indicate digestion and absorption of blood nitrogen. An elevation of serum ammonia (2) may ensue if the liver is unable to handle the protein load of digested blood.

    NP:AN; CN:PH; CA:M; CL:A

14. (3) The normal BUN is 10–20 mg/dL. Values of 40 mg/dL (1) and 29 mg/dL (2) indicate unresolved dehydration. A value of 3 mg/dL (4) is significantly lower than normal and may indicate fluid overload.

    NP:A; CN:PH; CA:M; CL:AN

15. (4) This value is above normal limits (the normal range of a urine specific gravity is 1.010–1.025). A value of 1.005 (1) may be seen when the client was in the diuretic phase of a head injury or insult. Values of 1.018 (2) and 1.025 (3) are within normal limits, but 1.025 is indicative of concentrated urine.

    NP:A; CN:PH; CA:M; CL:AN

16. (3) The normal serum creatinine level for a male is 0.6–0.9 mg/dL. A client with a mild degree of renal insufficiency would have a slightly elevated level, which in this case would be 1.7. Levels of 3.3 (2) and 4.0 (1) may be associated with acute or chronic renal failure.

    NP:A; CN:PH; CA:M; CL:A

17. (2) The normal potassium level is 3.5–5.0 mEq/L. The client's potassium level is low, and he needs to replenish what has been lost as a result of taking the Lasix. In addition to taking potassium supplements, the client should be given a list of the appropriate foods that have an average of 7 mEq potassium per serving. Fruit, meat, fish, instant coffee, and milk are high in potassium.

    NP:P; CN:PH; CA:M; CL:AN

18. (4) The client with acute renal failure would be expected to have metabolic acidosis (low HCO_3) resulting in acid blood pH (acidemia) and respiratory alkalosis (lowered PCO_2) as a compensating mechanism. Normal values are pH 7.35–7.45; HCO_3 23–27 mEq; and PCO_2 35–45 mm Hg.

    NP:A; CN:PH; CA:M; CL:AN

19. (1) The normal hemoglobin (Hgb) for a female is above 12–16 g/dL. With the data given, the nurse would suspect anemia. Hypovolemia (2) will alter Hgb if the loss of blood volume was due to hemorrhage. Dehydration (3) may increase the level by hemoconcentration. Cardiogenic shock (4) may increase the Hgb because of the need for increased oxygen-carrying capacity.

    NP:A; CN:PH; CA:M; CL:A

20. (1) The normal electrolyte values for an adult are as follows: sodium 135–145 mEq/L, chloride 100–106 mEq/L (2), potassium 3.5–5.0 mEq/L (3), and bicarbonate 22–29 mEq/L (4). The serum sodium is the only abnormal value.

    NP:A; CN:PH; CA:M; CL:AN

21. (2) Because the client is not on anticoagulant therapy, the results are abnormal (normal PT is 11–15 seconds). It is important to notify the physician before the biopsy; bleeding could be life-threatening. The client will probably be given vitamin K therapy; when the PT results return to the normal range, the procedure can be done. Liver disease likely caused the prolonged PT.

    NP:I; CN:PH; CA:M; CL:AN

22. (2) This is a normal sedimentation rate for a female over age 60. Under age 50, normal is 20 mm/hr. If it were increased, it would indicate the presence of infection or inflammation and surgery might have to be postponed.

    NP:I; CN:PH; CA:M; CL:A

23. (4) The clearest and best reply is a general description of the test, but one that is not specific enough to frighten the client, as in (1) and (2). Answer (3) is inaccurate because this answer refers to the radioactive iodine uptake test.

    NP:I; CN:PS; CA:S; CL:C

24. (3) The best answer is to be truthful, but not to frighten the client by telling him that he may have diabetes (this is the domain of the physician). Levels of more than 200 mg/dL on more than one occasion would, however, be diagnostic of diabetes, so the doctor would order at least two tests.

    NP:I; CN:PH; CA:M; CL:C

25. (4) High gastric acid levels may indicate duodenal ulcer. Pernicious anemia (1) would yield low results. TB (3) may be diagnosed by gastric washings for acid-fast bacilli, especially if sputum analysis is difficult to procure.

    NP:AN; CN:PH; CA:M; CL:A