10th Edition

LABORATORY AND DIAGNOSTIC TESTS

WITH NURSING IMPLICATIONS

Pearson

Joyce LeFever Kee

CONTENTS

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with Nursing Implications

TENTH EDITION

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This book I dedicate in loving memory of my mother and father

Esther Baker LeFever and Samuel Herr LeFever

for their years of love, encouragement, and support.

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NOTICE OF PRIVACY PRACTICES

HEALTH INSURANCE PORTABILITY AND ACCOUNTABILITY PRIVACY ACT (HIPAA)

HIPAA, also known as "Notice of Privacy Practices," was first passed as an act on August 21, 1996. The details of the act and regulations were published on December 28, 2000. All agencies, including medical care personnel and facilities (physicians, care givers, institutions), laboratory and diagnostic facilities, pharmacies, and others, were required to comply with the act by April 14, 2003.

The clients sign a form to protect their medical information and laboratory test results from public disclosure without permission. This act provides the clients with more control over their health information and test results. It sets boundaries on the use and release of health records. It establishes appropriate safeguards to protect the privacy of health information. Also, this privacy act informs clients of how their health information may be used.

More information regarding HIPAA can be obtained at http://www.cdc.gov/mmwr/preview/mmwrhtml/su5201a1.htm.

CONTENTS

PREFACE

Each day hundreds of thousands of laboratory and diagnostic tests are performed, and thus nursing responsibilities are forever increasing. Nurses should understand laboratory and diagnostic tests and should provide nursing implications through nursing assessment, judgment, implementation, teaching, and interaction.

Laboratory and Diagnostic Tests with Nursing Implications, 10th edition, is designed to provide nurses and other health professionals with the necessary information regarding laboratory and diagnostic tests and corresponding nursing implications. It gives quick, pertinent information about the tests, emphasizing the purposes, procedure, and nursing implications with rationale. Reference values are given for adults and children. The tests (laboratory and diagnostic) are arranged in alphabetical order, which provides the user with quick access to the tests.

This text is appropriate for students in various types of nursing programs, including students in master's, baccalaureate, associate degree, diploma, and practical nursing programs. This book should be most valuable to the registered nurse and licensed practical nurse in hospital settings, including specialty areas such as the ICU and emergency room, clinics, health care providers' and physicians' offices, and in independent nursing practice.

NEW TO THIS EDITION

- ***Fifteen New or Rewritten Laboratory and Diagnostic Tests.*** These tests include the following: Zika virus; human immunodeficiency virus (HIV); antineutrophil cytoplasmic antibody; arterial blood gases (ABGs); bladder cancer/tumor markers; diabetes mellitus autoantibodies; infertility screen; placental growth factor; pregnancy-associated plasma protein-A; thyroid peroxidase (TPO); lung, lymph nodes, prostate gland, and thyroid biopsy; cardiac calcium scoring; D & C; and electroneurography.
- ***Thoroughly Updated!*** Updated tests include the following: arterial blood gases (ABGs), bilirubin tests, echocardiography (major revision), HIV (major revision), computed tomography (CT), magnetic resonance imaging (MRI), nuclear scan, positron emission tomography (PET), Pap smear, Pacemaker (major revision), and ultrasonography.
- ***Situational Study Questions.*** Practical study questions regarding common health problems, such as possible heart attack, heart failure, breast cancer, diabetes mellitus, colorectal cancer, peptic ulcer, pulmonary embolism, and others, are found at the end of Part One and Part Two. Students are given the opportunity to reflect on which tests should be considered and conducted in such instances and why.
- ***Updated Part Three: Laboratory and Diagnostic Assessments of Body Function.*** Laboratory and diagnostic tests have been added to the 12 categories related to organ, body structure, and clinical conditions that are within Part Three.
- ***Updated! Therapeutic Drug Monitoring.*** Part One has been updated to include drugs used for HIV monitoring.
- ***Updated!*** Appendices on abbreviations, 60 health problems with laboratory and diagnostic tests, and test values for adults and children.

- ***Appendix C.*** The appendix "Health Problems with Laboratory and Diagnostic Tests" includes 60 various health problems, such as Alzheimer disease, angina pectoris, and others. With each health problem, laboratory and diagnostic tests are given. This includes 20 newly added health problems since the last edition.

ORGANIZATION

Each test is discussed in seven subsections in the following sequence: (1) reference values/normal findings, (2) description, (3) purpose(s), (4) clinical problems, (5) procedure, (6) factors affecting laboratory or diagnostic results, and (7) nursing implications with rationale, including client teaching. Following the name and abbreviation for each test, there may be names of other closely associated tests. **Reference values/normal findings** are given for children and adults, including the elderly. The **description** focuses on background data and pertinent information related to the test. The general **purpose or purposes** for each test is listed. **Clinical problems** include disease entities, drugs, and foods that cause or are associated with abnormal test results. The **procedure** gives appropriate steps that the nurse and other health professionals can follow for each test. **Factors affecting laboratory or diagnostic results** alert the nurse to factors that could cause an abnormal test result. The last subsection and most valuable information for each test concerns the **nursing implications with rationale and client teaching**. For most diagnostic tests, nursing implications are given as "pretest" and "posttest." With laboratory and diagnostic tests, client teaching is included in these subsections.

There are five parts in the text: Part One, Laboratory Tests; Part Two, Diagnostic Tests; Part Three, Laboratory/Diagnostic Assessments of Body Function; Part Four, Therapeutic Drug Monitoring (TDM); and Part Five, School Health Services: Education, Screening, and Testing. There is a list of laboratory tests with page numbers at the beginning of Part One and a list of diagnostic tests with page numbers at the beginning of Part Two. In addition, general information appears in the introduction to the book, including the importance of **specimen collection** with detailed information about all types of specimen collection. Included is an explanation of the laboratory data warehouse. The value differences between men and women are presented. The **Instructions for Laboratory and Diagnostic Tests** section explains the information that will be found under the eight major subheadings for each test and gives basic information that relates to most of the laboratory and diagnostic tests.

Part Three, **Laboratory/Diagnostic Assessments of Body Function**, should be most valuable to both the practicing nurse and the student. The section consists of 12 categories related to organ system and clinical conditions. These are as follows: **Cardiac Function; Respiratory Function; Renal Function; Liver, Gallbladder, and Pancreatic Function; Gastrointestinal Function; Neurologic and Musculoskeletal Function; Endocrine Function; Reproductive Function; Arthritic, Collagen, and Infectious and Allergic Conditions; Shock; Neoplastic Conditions;** and **Hematologic Conditions.** Each category contains numerous laboratory and diagnostic tests ordered to assist in the diagnosis of disease entities and to determine organ function. These tests are briefly discussed with reference values as they relate to the organ or condition of that category. A few of the tests (e.g., enzyme tests) can be found in more than one category (cardiac, muscle, liver). **The nursing implications** are found at the end of each category.

Part Four, **Therapeutic Drug Monitoring (TDM)**, lists drugs that are monitored frequently by serum and urine for the purposes of achieving and maintaining therapeutic drug effects and

for preventing drug toxicity. The TDM section includes 120 drugs and their therapeutic range, peak time, and toxic level. The current HIV drugs are given at the end of TDM, and dosing is based on the client's viral load or CD_4 counts.

Part Five, **School Health Services: Education, Screening, and Testing**, explains that school nurses are responsible for screening and testing for health problems in schoolchildren.

There are four appendices: **Abbreviations, Laboratory Test Groups** (laboratory profiles ordered for diagnosing clinical problems), **Health Problems with Laboratory and Diagnostic Tests**, and **Laboratory Test Values for Adults and Children**. Twenty new health problems have been added to Appendix C. The detailed index can assist in locating a test when the test name is different from the alphabetical listing used.

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Many thanks to Hilarie Surrena, Michael Giacobbe and Sudip Sinha for their help on this edition. To my husband, Edward, go my love and appreciation for his support.

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Joyce LeFever Kee received her bachelor of science and master of science in nursing degrees from the University of Maryland and earned 36 postgraduate credits from the University of Delaware. She was an instructor at the University of Maryland for four years and instructor to associate professor at the University of Delaware for 27 years, teaching subjects including pharmacology, pathophysiology, fluid and electrolyte imbalances, and medical-surgical nursing in the classroom and clinical areas. She retired as associate professor emerita from the University of Delaware after teaching in both the undergraduate and graduate programs there.

A member of the Sigma Theta Tau Nursing Honor Society and the Phi Kappa Phi Honor Society, Kee has received the Excellence in Teaching Award and was inducted into the Mentor's Circle at the University of Delaware.

Kee gave numerous lectures and presentations throughout the United States and in Barbados from 1970 to 1990. She has written various articles, particularly on fluids and electrolytes, laboratory and diagnostic tests, and research projects, in the *American Journal of Nursing*, *Nursing Clinics of North America*, *Nursing Journal*, and *Critical Care Quarterly*. She has participated in several research studies on identification of hypertensive young adults.

Kee has authored and coauthored several texts and reference books, including *Fluids and Electrolytes with Clinical Applications* (2010); *Handbook of Fluid, Electrolyte, and Acid-Base Imbalances* (2010); *Handbook of Laboratory and Diagnostic Tests*, 8th ed. (2017); *Laboratory and Diagnostic Tests*, 10th ed. (2018); *Clinical Calculations in General and Specialty Areas*, 8th ed. (2017); and *Pharmacology: A Nursing Process Approach*, 8th ed. (2015). She has also developed a testbank booklet, instructor's manual, and study guide for some of the texts.

Consummate travelers, Kee and her husband have enjoyed visiting most parts of the world, including Australia, New Zealand, China, Japan, Great Britain, Russia, Greece, Italy, France, Turkey, Africa, South America, Egypt, Spain, India, Scandinavian countries, Mexico, the Caribbean islands, and others. They enjoy Florida in the winter.

INTRODUCTION

THE IMPORTANCE OF SPECIMEN COLLECTION

Nurses actively participate in laboratory testing protocols for clients. In addition to ordering laboratory tests, either on requisition slips or electronically, nurses provide input critical to obtaining valid and reliable laboratory test results. The nurse, in the role of caregiver and teacher, must communicate with the client, physician, and laboratory personnel to obtain information that might affect test results. Nursing responsibilities include explaining the laboratory test, ensuring that both the client and staff follow the procedure, assessing clinical findings with laboratory test results, noting pertinent information on the laboratory requisition slip (e.g., drugs the client is taking that might affect test results), and collecting the specimen. In some clinical settings, such as ICU, ER, and CCU, nurses also perform some laboratory procedures classified by the Clinical Laboratory Improvement Act (CLIA) as "Waivered Tests."

During the past decade, increasing numbers of point-of-care tests (POCT) have been performed by nurses. These tests have the major advantages of shortening the turnaround times for test results and of using a smaller sample of capillary blood from fingersticks. It is essential that the nurse be knowledgeable of the principle of the tests, be appropriately trained in performing the tests, and be aware of the potential errors.

Collection of specimens is the focus of this section. The following paragraphs present an overview of the various aspects of specimen collection: the types of specimens, the collection sites, the effect of the client's position and activity on test results, the importance of the time of collection, drug interference, labeling and handling of specimens, types of collection tubes, and the types of reported laboratory measurement.

Types of Specimens: The types of specimens that are used for laboratory studies are blood; urine (random or 24-hour collection); cerebrospinal fluid (CSF); feces; sputum; tissue or biopsy samples from surgery; and synovial, pleural, peritoneal, and wound exudate. Because blood is the most frequently analyzed specimen, its collection will be outlined below. When blood is withdrawn in a plain container, it clots. The fluid that can be separated from the clotted blood is called *serum*. The term *serum* is often used interchangeably with *plasma*. When an anticoagulant is added to a collection container, *no* clot is formed. The clear fluid is known as plasma, which contains the protein *fibrinogen*, a component that is converted to the substance that composes the clot, *fibrin*. Most tests (e.g., electrolyte levels) use serum from clotted blood. If a laboratory test requires plasma or whole blood, the tube used to collect the blood must contain an anticoagulant.

Drug Interference: Due to the growing number of drugs taken by clients, there is an increased chance that the laboratory results will be affected. This is especially true if drugs are taken over a period of time and at high doses. Drugs affecting test results should be noted on the laboratory slip. Drugs with a short half-life are withheld until the blood is drawn and thereby do not adversely affect the laboratory test result.

Labeling and Handling: Laboratory requisitions are designed by the institutions that use them and should include the following information: the client's full name, age, sex, room location, and possible diagnosis; the physician's name; the test being requested (indicated by a check mark); the date; the time of collection; and any special notation (such as drugs). Another type of identification, such as the client's Social Security number or medical record number, may be required. In computerized laboratories, a barcode label may be applied.

Specimen Transport: Proper handling and prompt transport of the specimen to the laboratory are vitally important. The goal for proper transport and handling is to maintain the integrity of the specimen as close to the vivo state as possible. When a blood specimen is not processed promptly, hemolysis can occur, causing inaccurate results; when a urine specimen sits longer than 30 minutes, the pH of the urine becomes alkaline as a result of bacteria growth.

Collection Tubes: Tubes have color-coded stoppers that indicate the type of additive in the tube. The additives include anticoagulants such as oxalates, citrates, ethylenediaminetetraacetic acid (EDTA), and heparin. Blood-serum specimens are obtained in a red-top tube that does not contain a chemical additive. However, there is a gel in the tube to hasten clotting and provide a separation barrier between the blood and serum. Examples of the laboratory groups and color-top tubes follow:

Red: No additive, clotted blood. Serum is obtained from the clotted blood mass. Laboratory test groups that use red-top tubes are chemistries (electrolytes, proteins, enzymes, lipids, hormones), drug monitoring, radioimmunoassay (RIA) methods, serology, and blood banking. Hemolysis should be avoided.

Lavender: The anticoagulant additive is EDTA. Laboratory test groups that use lavender-top tubes are hematologic tests (complete blood cell count [CBC], platelet count) and certain chemistries.

Green: The anticoagulant additive is heparin. Laboratory test groups that use green-top tubes are arterial blood gases and the lupus erythematosus (LE) test. Although electrolyte levels are usually obtained from serum (red-top tube), a green-top tube may be substituted. In a stat situation, one need not wait for the blood to clot (red-top tube). The heparinized tube would allow the laboratory to centrifuge and separate the blood and plasma immediately.

Blue: The anticoagulant additive is citrate. Laboratory groups that use blue-top tubes are coagulation studies (prothrombin time [PT], international normalized ratio [INR], activated partial thromboplastin time [APTT], partial thromboplastin time [PTT], and hemoglobin levels).

Gray: The anticoagulant additive is sodium fluoride. The laboratory test for glucose uses gray-top tubes. The additive has a dual function as an anticoagulant and in preventing glycolysis, thus preserving the glucose concentration in the vivo state.

NOTE: The proper selection and usage of the color-coded collection tubes is critical for obtaining reliable test results. The additives must be compatible with the laboratory procedure. The nurse should always check with the institution's collection manual.

It would be beneficial for an institute to obtain a reference copy of the Clinical Laboratory Standards Institute (CLSI), H3-A6, Vol. 27, No. 26, sixth edition, "Procedures for Collection of Diagnostic Blood Specimens by Venipuncture." This comprehensive document provides

improved safety guidelines, updated phlebotomy standards, and recommendations for order of draw for multiple-tube collections.

Types of Reported Laboratory Measurements

International System of Units: The World Health Organization (WHO) recommends that the medical and scientific community throughout the world adopt the Système International d'Unites (SI units) in order to establish a common international language for communicating laboratory measurements. Most clinical laboratories in Canada, Australia, and western Europe, and some in the United States, are now using SI units. Currently both metric and SI units are usually reported.

Reference Values: Reference values (expected values) are based on "apparently healthy" individuals and the equipment and methods used in laboratories. Due to differences in the methods and equipment used, reference values may vary among institutions.

Critical (Panic) Values: At times a client's test results may fall outside the range of reference values, and a decision must be made as to whether the physician should be notified. Most laboratories have a list of critical values. When a client's results exceed the values on this list, the physician or charge nurse must be notified immediately. The critical value policy and list are specific to each institution.

Clinical Laboratory Data Warehouse

The clinical laboratory data warehouse is created by the saving and using of data obtained from the laboratory database. Building a data warehouse provides a representation of laboratory values for the population. Test results for a few hundred people do not adequately represent the laboratory reference values for a large client population. A data warehouse of laboratory values of clients collected over numerous years is considered more effective in evaluating the population-based reference values. This method is less expensive than the traditional recruiting of volunteers for testing to determine laboratory "norms." The warehouse data include 5–10 times more people for the laboratory values/intervals. They provide a range according to age and sex better than the traditional method for obtaining laboratory values. For example, the young male has a higher alanine aminotransferase (ALT) level than the adult. Alkaline phosphatase (ALP) is usually higher in teenagers because of bone growth. By using warehouse laboratory data, accuracy for diagnosis and treatment of diseases is enhanced.

Descriptive interpretations are included for immunological procedures.

Helen Tang Yates, 2012

Instructions for Laboratory and Diagnostic Tests

This edition of *Laboratory and Diagnostic Tests with Nursing Implications* includes new and additional laboratory and diagnostic tests. Statements made in the **procedure** section, such as "there is no food or fluid restriction," will not be repeated in the **nursing implications** section. With all laboratory and diagnostic tests, the nurse needs to explain the purpose and procedure of the test, both of which can be obtained from the **description** and **procedure** sections. The following headings for laboratory and diagnostic tests help to clarify the changes.

Reference Values: Laboratory (norm) values can differ somewhat among institutions. The values given in this text are comparable to the reference values given in most institutions; however, nurses need to check the reference values at their institution.

Description: General information, such as the indications for a test or the pharmacology of a drug, is included in the description. Much of this information should be included when discussing the purpose of the test with the client.

Purpose: The general purpose is given for each laboratory and diagnostic test. If there is more than one purpose, only the most common ones are provided.

Clinical Problems: The disease entities that are associated with decreased and increased test results are listed according to decreasing frequency of occurrence. Drugs that influence test results are given for both decreased and increased levels. Drugs taken by the client that can affect test results should be listed on the laboratory requisition slip.

Procedure: The procedure is an important part of the test, and the nurse must discuss the procedure, step by step, with the client. Most of the procedures for laboratory and diagnostic tests are similar among institutions. The following are helpful suggestions applicable to most tests:

Laboratory Tests

1. Follow institutional policy and procedure.
2. Collect the recommended amount of specimen (blood, urine, etc.).
3. Avoid using the arm/hand that has an intravenous (IV) line for drawing venous blood.
4. Label clearly the specimen container with the client's identifying information.
5. Note significant drug data on the label or laboratory requisition slip or both.
6. Avoid hemolysis; do not shake blood specimens.
7. Observe strict aseptic technique when collecting and handling each specimen. Use OSHA guidelines as adopted by each institution (e.g., universal precautions).
8. Enforce food and fluid restriction only when indicated.
9. Collect 24-hour urine specimens:
   a. Have the client void prior to test, discard urine, and then save all urine for the specified time, such as 24 hours.
   b. Instruct the client to urinate into a sterile container, usually provided by the laboratory, then pour the urine into the large 24-hour container.
   c. Instruct the client to avoid contaminating the urine specimen with toilet paper or feces.
   d. Refrigerate the 24-hour urine or keep it on ice, unless preservatives are added or unless otherwise indicated.
   e. Label the urine collection bottle/container with the client's name, date, and exact time of collection (e.g., 6/21/20, 7:00 AM to 6/22/20, 7:01 AM).
10. List drugs and food the client is taking that could affect test results.
11. When possible, withhold medications and foods that could cause false test results until after the test. Before withholding drugs, check with the health care provider. This may not be practical or possible; however, if the client takes medication and the laboratory test is abnormal, this should be brought to the health care provider's attention.
12. Promptly send the specimen to the laboratory.

Diagnostic Tests

1. A signed consent form is usually requested.
2. Food and fluid restriction is frequently ordered. Check the procedure.
3. Institutional policies must be followed.

Factors Affecting Laboratory and Diagnostic Tests: Factors that affect test results should be identified and avoided when possible. When test results are abnormal, determine if factors identified could be contributing to the test results and report to the health care provider.

Nursing Diagnoses

General Basic Nursing Diagnoses: NANDA approved 2012–2014

- Activity intolerance related to diagnostic testing (e.g., angiography), pain (e.g., bone metastasis), and others.
- Anxiety related to the unknown.
- Impaired comfort related to the test procedure.
- Ineffective coping related to disease process and laboratory/diagnostic procedures.
- Disabled family coping related to numerous laboratory and diagnostic tests, hospitalization, and/or treatment.
- Deficient or excess fluid volume related to numerous laboratory and diagnostic tests and/or treatment regimen.
- Risk for injury related to allergic reactions to contrast medium (dye) because of the diagnostic test procedure.
- Deficient knowledge related to lack of understanding of laboratory and diagnostic procedures, disease process, and/or outcome.
- Noncompliance related to lack of adequate explanation and/or anxiety of the prescribed laboratory and diagnostic tests.
- Imbalanced nutrition: less than body requirements related to NPO, anorexia, vomiting, and/or diarrhea.
- Fear related to body changes, dependence, and results of the test(s).

General Basic Nursing Implications

1. Be knowledgeable about laboratory and diagnostic tests.
2. Explain the purpose(s) and procedure of each test to the client and family.
3. Provide time, and be available to answer questions. Be supportive of the client and family.
4. Follow the procedure that is stated for each test. Label specimens with client information.
5. Relate test findings to clinical problems and drugs. The test may be repeated to confirm a suspected problem.
6. Report abnormal results to the health care provider.
7. Compare test results with other related laboratory and/or diagnostic tests.
8. Encourage clients to keep medical appointments for follow-up.
9. Provide health teaching related to the clinical problem.
10. With diagnostic tests:
    - **a.** Have the client void before premedication or before the test or both.
    - **b.** Obtain a history of allergies to iodine or seafood. Observe for severe allergic reaction to contrast dye.
    - **c.** Obtain baseline vital signs. Monitor vital signs as indicated following the test.
    - **d.** If a sedative is used, instruct the client not to drive home.

DIFFERENCES IN REFERENCE VALUES BETWEEN MEN AND WOMEN*

In females, hematocrit (Hct), hemoglobin (Hgb), and red blood cell (RBC) count are less than in males. Serum ferritin is also decreased. This is due to monthly female menses. Normal values are as follows:

Hematocrit (Hct): male: 40–54%, 0.4–0.54 (SI units)
female: 36–46%, 0.36–0.46 (SI units)

Hemoglobin (Hgb): male: 13.5–18 g/dL, 8.4–11.2 mmol/L (SI units)
female: 12–15 g/dL, 7.45–9.31 mmol/L (SI units)

Red blood cell (RBC): male: 4.6–6; female: 4–5

Serum ferritin: male: 15–445 ng/mL, 15–445 mcg/L
female: less than 40 years old: 10–120 ng/mL, 10–120 mcg/mL (SI units); greater than 40 years old: 10–235 ng/mL, 10–235 mcg/L (SI units); postmenopausal: 10–310 ng/mL, 10–310 mcg/L (SI units)

Apolipoprotein-A levels are increased in females due to the presence of estrogen and are decreased in males due to the presence of testosterone. Normal values are as follows:

Young adult: male: 80–155 mg/dL; 0.80–1.55 g/L (SI units)
female: 80–186 mg/dL; 0.80–1.86 g/L (SI units)

Middle-aged adult: male: 100–165 mg/dL; 1–1.65 g/L (SI units)
female: 93–200 mg/dL; 0.93–2 g/L (SI units)

Elderly: male: 85–166 mg/dL; 0.85–1.66 g/L (SI units)
female: 120–215 mg/dL; 1.20–2.15 g/L (SI units)

Apolipoprotein-B levels are increased in males due to the presence of androgens such as testosterone. Normal values are as follows:

Adult/elderly: male: 50–170 mg/dL; 0.50–1.70 g/L (SI units)
female: 46–155 mg/dL; 0.46–1.55 g/L (SI units)

Serum copper is present in increased amounts in females. Estrogen stimulates the liver to produce a compound that is responsible for transporting copper. Normal values are as follows:

Adult: male: 70–140 mcg/dL
female: 80–155 mcg/dL

The serum cholesterol in females before menopause is lower than after menopause. This is because of the presence of endogenous estrogen. Normal values are as follows:

Adult: male: less than 205 mg/dL
female: less than 190 mg/dL

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The fact that females typically have less muscle mass than their male counterparts explains why females usually have decreased serum creatinine, serum myoglobin, and creatinine clearance. Normal values are as follows:

Adult serum creatinine: male: 0.5–1.5 mg/dL
female: slightly lower than male values

Adult serum myoglobin: male: 20–90 ng/mL, 20–90 mcg/L (SI units)
female: 12–75 ng/mL, 12–75 mcg/L (SI units)

Adult creatinine clearance: male: 85–135 mL/min
female: slightly lower than male values

Females experience a slightly lower creatine kinase (CK), which is the result of higher muscle mass in males. Normal values are as follows:

Adult: male: 5–35 mcg/mL, 38–180 international units/L
female: 5–25 mcg/mL, 25–150 international units/L

The erythrocyte sedimentation rate (ESR) in males is often lower than in females. This difference is caused by the female menstrual cycle and associated hormones. Normal values are as follows:

Adult less than 50 years old: male: 0–15 mm/h (Westergren method)
female: 0–20 mm/h

Adult greater than 50 years old: male: 0–20 mm/h (Westergren method)
female: 0–30 mm/h

Adult (Wintrobe method): male: 0–9 mm/h
female: 0–15 mm/h

The gamma-glutamyl transferase (for detecting hepatic disease) is usually lower in females than males. It is higher in newborns and slightly higher in the elderly than adults. Normal values are as follows.

Adult: male: 4–23 international units/L; 9–69 units/L (SI units)
female: 3–13 international units/L; 4–33 units/L (SI units)

Females have increased levels of human growth hormone (measured as somatotrophic hormone [STH]). The presence of estrogen explains this increase. Normal values are as follows:

Adult: male: less than 5 ng/mL
female: less than 10 ng/mL

The adrenal hormone metabolites 17-hydroxycorticosteroids (17-OHCS) and 17-ketosteroids (17-KS) are found in lesser amounts in females. 17-OHCS is lesser because males typically have more muscle mass than females. The fact that females have more estrogen than androgens explains why females have less 17-KS. Pregnanetriol is also a substance produced by the adrenal glands and is available in lower amounts in females. Normal values are as follows:

Adult 17-OHCS: male: 3–12 mg/24 h
female: 2–10 mg/24 h

Adult 17-KS: male: 5–25 mg/24 h
female: 5–15 mg/24 h

Adult pregnanetriol: male: 0.4–2.4 mg/24 h
female: 0.5–2.0 mg/24 h

Iron (serum) level is lower in females than males. This could be due to menses. Normal value is as follows:

Adult: male: 80–180 mcg/dL
female: 69–160 mcg/dL

Leucine aminopeptidase (LAP) is an enzyme that is prescribed to detect bone disease. LAP is slightly higher in males than females. Normal values are as follows:

Adult: male: 80–200 units/mL
female: 75–185 units/mL

Osteocalcin is an indicator of bone metabolism. Elevated levels occur in females during postmenopause due to osteoporosis. The osteocalcin enters the circulation. Normal values are as follows:

Adult: male: 1.5–11.5 ng/mL; 1.5–11.5 mcg/L (SI units)
female: premenopausal: 0.5–7.8 ng/mL; 0.5–7.8 mcg/L (SI units)
postmenopausal: 1.2–11.5 ng/mL; 1.2–11.5 mcg/L (SI units)

Average serum prealbumin levels in males are higher than in females due to increased muscle mass in males and estrogen levels in females. Normal values are as follows:

Adult averages: male: 21.6 mg/dL, 216 mg/L (SI units)
female: 18 mg/dL, 180 mg/L (SI units)

Thyroxine (T_4) is the major hormone secreted by the thyroid gland. The serum value is about the same in males and females, though it can be slightly higher in females. The value is higher in newborns and in children up to the age of 6 years. Normal values are as follows:

Adult: male: 4–12 mcg/dL
female: 5–12 mcg/dL

Serum uric acid levels are higher in males than in females because estrogen promotes excretion of uric acid. Normal values are as follows:

Adult: male: 3.5–8 mg/dL
female: 2.8–6.8 mg/dL

Pulmonary function tests also differ between males and females due to factors such as age, height, weight, body type, and gender. The categories of pulmonary function tests include but are not limited to the following:

- Tidal volume
- Inspiratory capacity
- Expiratory reserve volume
- Inspiratory reserve volume
- Vital capacity
- Residual volume
- Functional residual capacity
- Forced vital capacity
- Forced inspiratory volume
- Forced expiratory volume timed
- Peak expiratory flow
- Peak inspiratory flow
- Total lung capacity

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Part One

Laboratory Tests

A

Acetaminophen (serum)

Tylenol, Tempra, Datril, Liquiprin, Paracetamol, Panadol, Aceta

Reference Values

Adult: *Therapeutic:* 5–20 mcg/mL, 31–124 µmol/L (SI units). *Toxic:* Greater than 50 mcg/mL, 305 µmol/L (SI units), greater than 200 mcg/mL possible hepatotoxicity.

Child: *Therapeutic:* Same as adult. *Toxic:* Similar to adult.

Description

Acetaminophen has a similar antipyretic and non-narcotic analgesic effect to that of aspirin. Unlike salicylates (e.g., aspirin), acetaminophen does not inhibit platelet aggregation, does not produce gastric distress and bleeding, and has only a weak anti-inflammatory response.

Overdose of acetaminophen can be dangerous, since it can lead to hepatotoxicity. It is metabolized in the liver to active metabolites and is absorbed rapidly from the gastrointestinal (GI) tract. Peak time occurs ½–2 hours after oral ingestion. When there is an accumulation of acetaminophen in the body from massive dose(s) or chronic use, one of its metabolites tends to cause hepatotoxicity. Actually, a single dose of 10 g or 20–30 tablets (500/325 mg each) could cause liver damage. The half-life of acetaminophen is about 3 hours. If the half-life is greater than 4 hours, hepatic injury is likely to occur. After ingestion of a large amount of acetaminophen, either accidentally (e.g., ingested by children) or in a suicide attempt, serum concentrations are plotted on a semilogarithmic scale. If the serum value is 200 mcg/mL (1,240 µmol/L) in 4 hours, or 50 mcg/mL (310 µmol/L) in 12 hours after ingestion, hepatotoxicity could occur 3–6 days later. A suggested oral dose of acetaminophen is 2–3 g (2,000–3,000 mg) per day.

The antidote to acetaminophen toxicity is *N*-acetylcysteine (Mucomyst). It must be administered soon after acetaminophen ingestion. Liver function tests (i.e., AST [SGOT], ALT [SGPT]), bilirubin, prothrombin time (PT), and electrolytes should be closely monitored.

Purposes

- To determine if the therapeutic acetaminophen dose is within therapeutic range.
- To check for acetaminophen toxicity.

Clinical Problems

Decreased Level: High-carbohydrate meal.

Increased Level: Acetaminophen overdose, liver disease. *Drug Influence:* Phenobarbital.

Procedure

- There is no food or fluid restriction.
- Collect 3–5 mL of venous blood in a red-top tube.
- Record the dose and the time the drug was taken on the laboratory requisition slip.

Factors Affecting Laboratory Results

- None known.

A

NURSING IMPLICATIONS WITH RATIONALE

- Explain to the client that the purpose of the test is to monitor the therapeutic level or the toxic level of acetaminophen (give trade name).
- Suggest to the health care provider that liver function tests be ordered periodically for clients on long-term acetaminophen therapy. Liver damage could result when the drug is taken for weeks and/or months.
- Keep the acetaminophen bottle tightly closed and away from light.

Increased Level

- Recognize that liver disease and acetaminophen overdose could result in hepatotoxicity.
- Observe for signs and symptoms of acetaminophen toxicity (e.g., anorexia, nausea, vomiting, lethargy, generalized weakness, epigastric or abdominal pain).
- Observe for signs and symptoms of liver damage (e.g., vomiting, jaundice, right upper quadrant tenderness, abnormal liver function tests).

Client Teaching

- Inform the client about the need to take the prescribed dosage. An overdose or chronic use of acetaminophen could cause liver damage. Usually the drug should not be taken for more than 10 days at a time unless prescribed by the health care provider.
- Inform the client who consumes large amounts of alcohol of the need to consult his or her health care provider before taking acetaminophen products. This person could be prone to liver damage, and ingestion of acetaminophen would compound the liver problem.
- Instruct the client to keep acetaminophen products out of the reach of children. If a child ingests large amounts of the drug, the poison center should be called immediately, syrup of ipecac given if indicated by the center, and the child taken to the emergency room. Acetylcysteine (Mucomyst) has been used as an antidote for adults within 16 hours after drug overdose.

Acetone, ketone bodies (serum or plasma)

Reference Values

Adult: *Acetone:* Semiquantitative: Negative (less than 1 mg/dL); quantitative: 0.3–2 mg/dL, 51.6–344 µmol/L (SI units). *Ketones:* 0.5–4 mg/dL.

Child: *Newborn to 1 Week:* Slightly higher than adult. *Over 1 Week:* Same as adult.

Description

Ketone bodies are composed of three compounds—acetone, acetoacetic (diacetic) acid, and beta-hydroxybutyric acid—which are products of fat metabolism and fatty acids. Ketone bodies result from uncontrolled diabetes mellitus and starvation, causing increased fat catabolism instead of carbohydrate metabolism. In diabetic ketoacidosis, the serum acetone is greater than 50 mg/dL.

Ketones are small and excretable in the urine. However, the elevation is first apparent in the plasma or serum, then in the urine. Serum acetone (as ketones) is useful in monitoring acidosis caused by uncontrolled diabetes or starvation, since the serum level will decrease toward normal before the urine test (Acetest) does.

Purposes

- To detect the presence of ketone bodies.
- To identify the occurrence of diabetic ketoacidosis.

Clinical Problems

Increased Level: Diabetic ketoacidosis, starvation/malnutrition, vomiting and diarrhea, heat stroke, exercise.

Procedure

- There is no food or fluid restriction.
- Collect 3–5 mL of venous blood in a red-top tube.

Factors Affecting Laboratory Results

- Contamination can cause false-positive results.

NURSING IMPLICATIONS WITH RATIONALE

Increased Level

- Relate increased serum acetone levels to diabetic acidosis and starvation. Many of the diet programs call for high-protein and low-carbohydrate intake. Daily carbohydrate intake of less than 100 g can result in ketosis (excess ketone bodies) caused by the substitution of fat metabolism for energy.
- Obtain a history from the client concerning his or her diet. If the client is on a reducing diet, the increased serum level (ketosis) could be caused by a low-carbohydrate diet.
- Assess for signs and symptoms of diabetic ketoacidosis, such as rapid, vigorous breathing; restlessness; confusion; sweet-smelling breath; and a serum acetone level greater than 50 mg/dL.
- Check the urine for ketone bodies. An Acetest is usually performed and is positive.

Acetylcholine receptor antibody (AChR) (serum)

Acetylcholine Receptor Binding Antibody Test, Anti-Acetylcholine Receptor Antibody

Reference Values

Less than 0.02 to less than 0.03 nmol/L or negative.