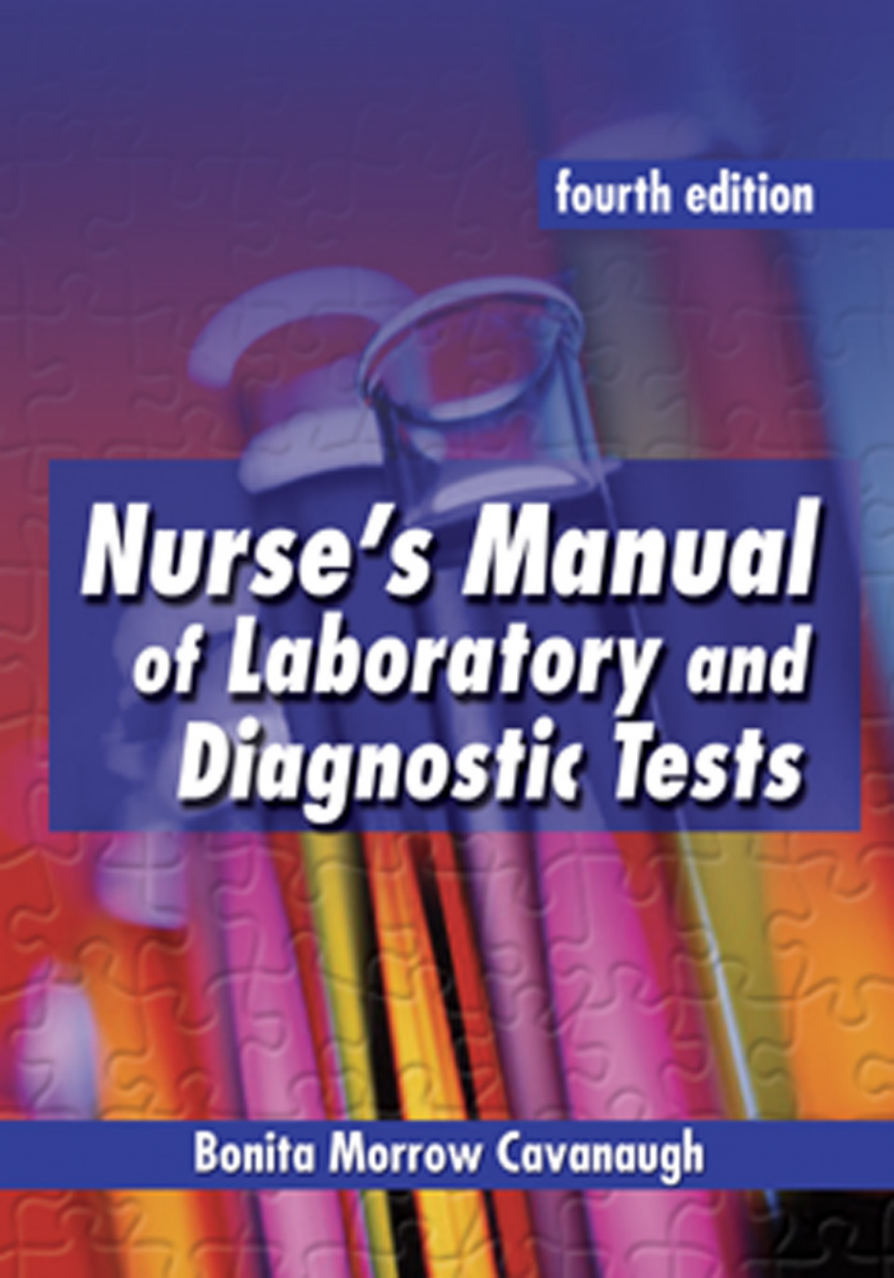

fourth edition

Nurse's Manual of Laboratory and Diagnostic Tests

Bonita Morrow Cavanaugh

Nurse's Manual of Laboratory and Diagnostic Tests

EDITION 4

Bonita Morrow Cavanaugh, PhD, RN

Clinical Nurse Specialist
Nursing Education
The Children's Hospital
Denver, Colorado

Clinical Faculty
University of Colorado
Health Sciences Center
School of Nursing
Denver, Colorado

Affiliate Professor
University of Northern Colorado
School of Nursing
Greeley, Colorado

F.A. Davis Company • Philadelphia

F. A. Davis Company
1915 Arch Street
Philadelphia, PA 19103
www.fadavis.com

Printed in the United States of America

Last digit indicates print number: 10 9 8 7 6 5 4 3 2 1

Publisher: Lisa Deitch
Developmental Editor: Diane Blodgett
Cover Designer: Louis J. Forgione

As new scientific information becomes available through basic and clinical research, recommended treatments and drug therapies undergo changes. The author and publisher have done everything possible to make this book accurate, up to date, and in accord with accepted standards at the time of publication. The author, editors, and publisher are not responsible for errors or omissions or for consequences from application of the book, and make no warranty, expressed or implied, in regard to the contents of the book. Any practice described in this book should be applied by the reader in accordance with professional standards of care used in regard to the unique circumstances that may apply in each situation. The reader is advised always to check product information (package inserts) for changes and new information regarding dose and contraindications before administering any drug. Caution is especially urged when using new or infrequently ordered drugs.

Library of Congress Cataloging-in-Publication Data

Cavanaugh, Bonita Morrow, 1952–
Nurse's manual of laboratory and diagnostic tests. – 4th ed. /
Bonita Morrow Cavanaugh.
p. cm.
Rev. ed. of: Nurse's manual of laboratory and diagnostic tests /
Juanita Watson. 3rd. ed. c1995.
Includes bibliographical references and index.
ISBN 0-8036-1055-6 (pbk.)
1. Diagnosis, Laboratory —Handbooks, manuals, etc. 2. Nursing-Handbook, manuals, etc. I. Watson, Juanita,
1946– Nurse's manual of laboratory and diagnostic tests. II. Title.
[DNLM: 1. Laboratory Techniques and Procedures nurses' instruction
handbooks. QY 39 C377n 1999]
RT48.5.W38 1999
616.07′5—dc21
DNLM/DLC
for Library of Congress 98-50920
CIP

To Laurie O'Neil Good, the finest nurse I have ever known.
Love,
Bonnie

This page intentionally left blank

Preface

This book is designed to provide both students and practitioners of nursing with the information they need to care for individuals undergoing laboratory and diagnostic tests and procedures. The content is presented as a guiding reference for planning care, providing specific interventions, and evaluating outcomes of nursing care.

In this edition, the background information and description of the test or procedure are followed directly by the clinical applications data, starting with reference values, for each test or group of tests.

The introductory sections include the anatomic, physiological, and pathophysiological content necessary for a thorough understanding of the purpose of and indications for specific tests and procedures. The inclusion of this information makes this book unlike many other references on this subject matter. This feature enhances the integration of basic science knowledge with an understanding of and application to diagnostic testing. This is extremely helpful for nursing students in developing critical thinking and clinical judgment.

For each test or study within the respective sections, reference values, including variations related to age or gender, are provided. Critical values, where appropriate, are highlighted. Both conventional units and international units are provided. Readers are encouraged to be aware of some variation in laboratory values from agency to agency.

For all tests, interfering factors are noted where appropriate. Contraindications and Nursing Alerts are included to provide information crucial to safe and reliable testing and nursing care.

Other features of this manual that contribute to its practical use are presentation of detailed content in tabular format when appropriate and the use of appendices to provide essential information applicable to most, if not all, tests and procedures.

Every effort has been made to include tests and procedures currently in use in practice settings. It is recognized that newer tests and procedures may have become available after this manuscript was prepared. Readers are encouraged to keep abreast of current literature and consult with laboratories and agencies in their area for new developments in the field of diagnostic tests.

BONITA MORROW CAVANAUGH

This page intentionally left blank

Acknowledgments

This book would not have been possible without the help, support, and encouragement of a number of people. Special appreciation is due to the staff of the F. A. Davis Company. I am particularly indebted to Lisa Deitch, Publisher, for her major contribution in developing the unique format of this text, for her encouragement, and for always being available for help when I needed it. I would also like to acknowledge Robert Martone, Nursing Publisher, who encouraged me to pursue this project, and Robert H. Craven, Jr., President, for his support and patience as the book evolved. Special thanks are also due to Ruth De George, Editorial Assistant, and Michele Reese, Editorial Aide, for their invaluable assistance. Many other individuals at the F. A. Davis Company contributed to the production of this book, and I wish to extend to all of them my sincere appreciation for their expertise and dedication to the high standards necessary to produce a good book. Special recognition in this regard is due to Jessica Howie Martin, Production Editor, and Bob Butler, Director of Production.

I thank the consultants who served as reviewers of the manuscript for their thoroughness and generosity in sharing their ideas and suggestions. Your comments proved invaluable! Finally, a special thanks to those family members, friends, and associates who offered and gave their support, patience, and encouragement.

B.M.C.

This page intentionally left blank

Consultants

Janice Brownlee, BScN, MAEd
Professor
Canadore College of Applied Arts and Technology
North Bay, Ontario, Canada

Marie Colucci, BS, MS, EdD
Associate Professor
Riverside Community College
Riverside, California

Mary Jo Goolsby, MSN, ARNP, EdD
Instructor
Florida State University
Tallahassee, Florida

Shelby Hawk, RN, MSN
Instructor
Mid Michigan Community College
Harrison, Michigan

Priscilla Innocent, RN, MSN
Associate Professor
Indiana Wesleyan University
Marion, Indiana

Dr. Fran Keen, RN, DNSc
Associate Professor
University of Miami
Coral Gables, Florida

Dolores Philpot, BSMT, AND, MSN
Instructor
University of Tennessee
Knoxville, Tennessee

Sylvan L. Settle, RN
Vocational Teacher
Tennessee Technology Center
Memphis, Tennessee

Joyce Taylor, RN, MSN, DSN, BA
Associate Professor
Henderson State University
Arkadelphia, Arkansas

Shelley M. Tiffin, ART (CSMLS), BMLSc
Bachelor of Medical Laboratory Science Program
Department of Pathology and Laboratory Medicine
University of British Columbia
Vancouver, British Columbia, Canada

Donna Yancey, BSN, MSN, DNS
Assistant Professor
Purdue University
West Lafayette, Indiana

This page intentionally left blank

Contents

SECTION I • Laboratory Tests, 1

This page intentionally left blank

SECTION

I

Laboratory Tests

This page intentionally left blank

CHAPTER

1

Hematology and Tests of Hematopoietic Function

TESTS COVERED

INTRODUCTION Blood constitutes 6 to 8 percent of total body weight. In terms of volume, women have 4.5 to 5.5 L of blood and men 5 to 6 L. In infants and children, blood volume is 50 to 75 mL/kg in girls and 52 to 83 mL/kg in boys. The principal functions of blood are the transport of oxygen, nutrients, and hormones to all tissues and the removal of metabolic wastes to the organs of excretion. Additional functions of blood are (1) regulation of temperature by transfer of heat to the skin for dissipation by radiation and convection, (2) regulation of the pH of body fluids through the buffer systems and facilitation of excretion of acids and bases, and (3) defense against infection by transportation of antibodies and other substances as needed.

Blood consists of a fluid portion, called plasma, and a solid portion that includes red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes). Plasma makes up 45 to 60 percent of blood volume and is composed of water (90 percent), amino acids, proteins, carbohydrates, lipids, vitamins, hormones, electrolytes, and cellular wastes.[1] Of the "solid" or cellular portion of the blood, more than 99 percent consists of red blood cells. Leukocytes and thrombocytes, although functionally essential, occupy a relatively small portion of the total blood cell mass.[2]

Erythrocytes remain within the blood throughout their normal life span of 120 days, transporting oxygen in the hemoglobin component and carrying away carbon dioxide. Leukocytes, while they are in the blood, are merely in transit, because they perform their functions in body tissue. Platelets exert their effects at the walls of blood vessels, performing no known function in the bloodstream itself.[3]

Hematology is traditionally limited to the study of the cellular elements of the blood, the production of these elements, and the physiological derangements that affect their functions. Hematologists also are concerned with blood volume, the flow properties of blood, and the physical relationships of red cells and plasma. The numerous substances dissolved or suspended in plasma fall within the province of other laboratory disciplines.[4]

HEMATOPOIESIS

Hematopoiesis is the process of blood cell formation. In normal, healthy adults, blood cells are manufactured in the red marrow of relatively few bones, notably the sternum, ribs, vertebral bodies, pelvic bones, and proximal portions of the humerus and the femur. This production is in contrast to that taking place in the embryo, in which blood cells are derived from the yolk sac mesenchyme. As the fetus develops, the liver, the spleen, and the marrow cavities of nearly all bones become active hematopoietic sites (Fig. 1–1). In the newborn, hematopoiesis occurs primarily in the red marrow, which is found in most bones at that stage of development. Beginning at about age 5 years, the red marrow is gradually replaced by yellowish fat-storage cells (yellow marrow), which are inactive in the hematopoietic process. By adulthood, blood cell production normally occurs in only those bones that retain red marrow activity.[5]

Adult reticuloendothelial cells retain the potential for hematopoiesis, although in the healthy state reserve sites are not activated. Under conditions of hematopoietic stress in later life, the liver, the spleen, and an expanded bone marrow may resume the production of blood cells.

All blood cells are believed to be derived from the pluripotential stem cell,[6] an immature cell with the capability of becoming an erythrocyte, a leukocyte, or a thrombocyte. In the adult, stem cells in hematopoietic sites undergo a series of divisions and maturational changes to form the mature cells found in the blood (Fig. 1–2). As they achieve the "blast" stage, stem cells are committed to becoming a specific type of blood cell. This theory also explains the origin of the several types of white blood cells (neutrophils, monocytes, eosinophils, basophils, and lymphocytes). As the cells mature, they lose their ability to reproduce and cannot further divide to replace themselves. Thus, there is a need for continuous hematopoietic activity to replenish worn-out or damaged blood cells.

Erythropoiesis, the production of red blood cells (RBCs), and leukopoiesis, the production of white blood cells (WBCs), are components of the hematopoietic process. Erythropoiesis maintains a population of approximately 25×10^{12} circulating RBCs, or an average of 5 million erythrocytes per cubic millimeter of blood. The production rate is about 2 million cells per second, or 35 trillion cells per day. With maximum stimulation, this rate can be increased sixfold to eightfold, or one volume per day equivalent to the cells contained in 0.5 pt of whole blood.

The level of tissue oxygenation regulates the production of RBCs; that is, erythropoiesis occurs in response to tissue hypoxia. Hypoxia does not,

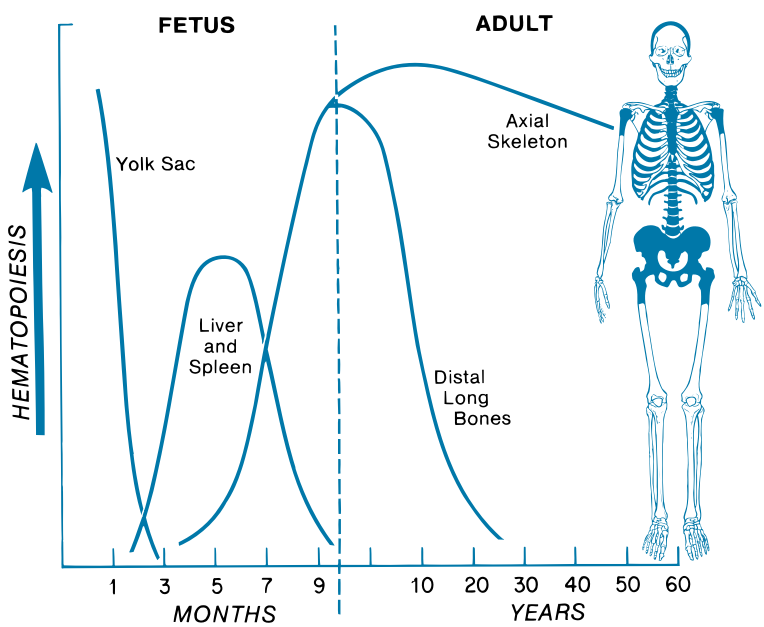

Figure 1–1. Location of active marrow growth in the fetus and adult. (From Hillman, RS, and Finch, CA: Red Cell Manual, ed 7. FA Davis, Philadelphia, 1996, p 2, with permission.)

Image/Text rights unavailable

however, directly stimulate the bone marrow. Instead, RBC production occurs in response to *erythropoietin,* precursors of which are found primarily in the kidney and to a lesser extent in the liver. When the renal oxygen level falls, an enzyme, renal erythropoietic factor, is secreted. This enzyme reacts with a plasma protein to form erythropoietin, which subsequently stimulates the bone marrow to produce more RBCs. Specifically, erythropoietin (1) accelerates production, differentiation, and maturation of erythrocytes; (2) reduces the time required for cells to enter the circulation, thereby increasing the number of circulating immature erythrocytes such as reticulocytes (see Fig. 1–2); and (3) facilitates the incorporation of iron into RBCs. When the number of produced erythrocytes meets the body's tissue oxygenation needs, erythropoietin release and RBC production are reduced. Table 1–1 lists causes of tissue hypoxia that may stimulate the release of erythropoietin.

TABLE 1–1 • Causes of Tissue Hypoxia That May Stimulate Erythropoietin Release

Acute blood loss
Impaired oxygen–carbon dioxide exchange in the lungs
Low hemoglobin levels
Impaired binding of oxygen to hemoglobin
Impaired release of oxygen from hemoglobin
Excessive hemolysis of erythrocytes due to hypersplenism or hemolytic disorders of antibody, bacterial, or chemical origin
Certain anemias in which abnormal red blood cells are produced (e.g., hereditary spherocytosis)
Compromised blood flow to the kidneys