

VOLUME ONE



DIAGNOSTIC ULTRASOUND

SECOND EDITION

Carol M. Rumack
Stephanie R. Wilson
J. William Charboneau

V O

N E



DIAGNOSTIC ULTRASOUND

SECOND EDITION

Carol M. Rumack, M.D.

Professor of Radiology and Pediatrics
University of Colorado Health Sciences Center
Denver, Colorado

Stephanie R. Wilson, M.D.

Professor of Radiology and Obstetrics and Gynecology
University of Toronto
Head, Division of Ultrasound
The Toronto Hospital
Toronto, Ontario, Canada

J. William Charboneau, M.D.

Professor of Radiology
Mayo Clinic
Rochester, Minnesota

with 3698 illustrations, including 461 in color

M Mosby

St. Louis Baltimore Boston Carlsbad Chicago Minneapolis New York Philadelphia Portland
London Milan Sydney Tokyo Toronto



Executive Editor: Robert A. Hurley
Managing Editor: Elizabeth Corra
Associate Developmental Editor: Mia Cariño
Project Manager: Christopher J. Baumle
Project Specialist: David Orzechowski
Manufacturing Manager: William A. Winneberger, Jr.
Designer: Carolyn O'Brien

Copyright © 1998 Mosby-Year Book, Inc.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher.

Permission to photocopy or reproduce solely for internal or personal use is permitted for libraries or other users registered with the Copyright Clearance Center, provided that the base fee of \$4.00 per chapter plus \$.10 per page is paid directly to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collected works, or for resale.

Composition by Accu-Color Inc.
Printing/binding by Von Hoffman Press, Inc.
Printed in the United States of America

Mosby-Year Book, Inc.
11830 Westline Industrial Drive
St. Louis, Missouri 63146

Library of Congress Cataloging-in-Publication Data

Diagnostic ultrasound / [edited by] Carol M. Rumack, Stephanie R.
Wilson, J. William Charboneau. — 2nd ed.
p. cm.

Includes bibliographical references and index.

ISBN 0-8151-8683-5

1. Diagnosis, Ultrasonic. I. Rumack, Carol M. II. Wilson,
Stephanie R. III. Charboneau, J. William.

[DNLM: 1. Ultrasonography. WN 208 D5357 1997]

RC78.7.U4D514 1997

616.07'543—dc21

DNLM/DLC

for Library of Congress

97-41915

CIP

V O L U M E O N E
DIAGNOSTIC ULTRASOUND

SECOND EDITION

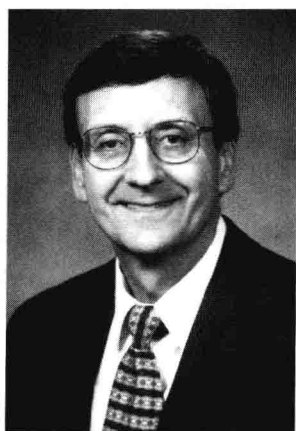
EDITORS



CAROL M. RUMACK, M.D., is Professor of Radiology and Pediatrics at the University of Colorado School of Medicine in Denver, Colorado. Her clinical practice is based at The Children's Hospital and University Hospital in Denver. Her main research focus has been on neonatal sonography in the high-risk perinatal nursery and in newborns referred for complex imaging. Dr. Rumack has published widely in this field and has lectured frequently on pediatric ultrasound. She was the Founding President of the American Association for Women Radiologists and has been a member of the Board of Directors of the American Institute of Ultrasound in Medicine and the Society for Pediatric Radiology. She and her husband, Barry, have two children, Becky and Marc.



STEPHANIE R. WILSON, M.D., is Professor of Radiology and Obstetrics and Gynecology at the University of Toronto and Head of the Division of Ultrasound at The Toronto Hospital. Her current research endeavors with Dr. Peter N. Burns are focused on oral and intravascular ultrasound contrast agents. An authority on ultrasound of the gastrointestinal tract and abdominal and pelvic viscera, she is the recipient of many university awards and is a frequent international speaker and author. Dr. Wilson also was the first woman President of the Canadian Association of Radiologists and a past Vice President of the Radiological Society of North America. A golf enthusiast, she and her husband, Ken, have two children, Jessica and Jordan.



J. WILLIAM CHARBONEAU, M.D., is Professor of Radiology at the Mayo Clinic at Rochester, Minnesota. His current research interests are in small-parts imaging and ultrasound-guided interventional procedures. He is a coauthor of approximately 100 publications, assistant editor of the *Mayo Clinic Family Health Book*, and an active lecturer nationally and internationally. He and his wife, Cathy, have three children, Nick, Ben, and Laurie.

C O N T R I B U T O R S

Mostafa Atri, M.D., F.R.C.P.(C)

Associate Professor of Radiology
McGill University
Director, Division of Ultrasound
Montreal General Hospital
Montreal, Quebec, Canada

E. Michel Azouz, M.D., F.R.C.P.C.

Professor of Radiology
McGill University
Assistant Director, Department of Medical Imaging
Montreal Children's Hospital
Montreal, Quebec, Canada

Diane S. Babcock, M.D., F.A.C.R.

Professor of Radiology and Pediatrics
University of Cincinnati College of Medicine
University Hospital
Children's Hospital Medical Center
Cincinnati, Ohio

Carol B. Benson, M.D.

Associate Professor of Radiology
Harvard Medical School
Co-Director of Ultrasound
Brigham & Women's Hospital
Boston, Massachusetts

William E. Brant, M.D.

Associate Professor of Radiology
University of California, Davis, School of Medicine
Department of Radiology
University of California, Davis, Medical Center
Sacramento, California

Robert L. Bree, M.D.

Professor of Radiology
University of Michigan Medical School
University of Michigan Medical Center
Ann Arbor, Michigan

Linda K. Brown, M.D.

Staff Radiologist
Quantum Radiology Northwest
Atlanta, Georgia

Peter N. Burns, Ph.D.

Professor of Medical Biophysics and Radiology
University of Toronto
Senior Scientist, Imaging Research
Sunnybrook Health Science Centre
Toronto, Ontario, Canada

Barbara A. Carroll, M.D.

Professor of Radiology
Chief, Section of Ultrasound
Duke University Medical Center
Durham, North Carolina

John M. Caspers, M.D.

Abdominal Imaging Fellow
Mayo Clinic
Rochester, Minnesota
Staff Radiologist
St. Paul Radiology
United Hospital
St. Paul, Minnesota

**Daniel E. Challis, M.B., B.S.,
F.R.A.C.O.G., D.D.U.**

Clinical Fellow
University of Toronto
Mount Sinai Hospital
Toronto, Ontario, Canada

William F. Chandler, M.D.

Professor of Neurosurgery
University of Michigan Medical Center
Ann Arbor, Michigan

J. William Charboneau, M.D.

Professor of Radiology
Mayo Clinic
Rochester, Minnesota

**David Chitayat, M.D., F.C.C.M.G.,
F.A.B.M.G., F.R.C.P.C.**

Associate Professor
University of Toronto
Head, Prenatal Diagnosis Program
The Toronto Hospital General Division
Toronto, Ontario, Canada

Christine H. Comstock, M.D.

Assistant Professor
Wayne State University
Detroit, Michigan
Director, Fetal Imaging
William Beaumont Hospital
Royal Oak, Michigan

Peter L. Cooperberg, M.D., F.R.C.P.C.

Professor and Vice Chairman of Radiology
University of British Columbia
Chairman of Radiology
St. Paul's Hospital
Vancouver, British Columbia, Canada

Jeanne A. Cullinan, M.D.

Assistant Professor of Radiology
and Radiological Sciences
Assistant Professor of Obstetrics and Gynecology
Vanderbilt University Medical Center
Nashville, Tennessee

Timothy J. Dambro, M.D.

Hospital of the University of Pennsylvania
Philadelphia, Pennsylvania

Sidney M. Dashefsky, M.D., F.R.C.P.

Assistant Professor of Radiology
University of Manitoba
Radiologist
Health Sciences Centre
Winnipeg, Manitoba, Canada

Michael A. DiPietro, M.D.

Associate Professor of Radiology
University of Michigan
Pediatric Radiologist
C.S. Mott Children's Hospital
Ann Arbor, Michigan

Peter M. Doubilet, M.D., Ph.D.

Associate Professor of Radiology
Harvard Medical School
Co-Director of Ultrasound
Brigham & Women's Hospital
Boston, Massachusetts

**Dónal B. Downey, M.B., B.Ch.,
F.R.C.P.C.**

Assistant Professor, Department of Diagnostic
Radiology and Nuclear Medicine
Associate Scientist, The John P. Robarts
Research Institute
University of Western Ontario
Director of Diagnostic Ultrasound
London Health Sciences Centre
London, Ontario, Canada

Julia A. Drose, B.A., R.D.M.S., R.D.C.S.

Senior Instructor
University of Colorado School of Medicine
Chief Diagnostic Medical Sonographer
University of Colorado Health Sciences Center
Denver, Colorado

Steven Falcone, M.D.

Assistant Professor of Clinical Radiology and
Neurological Surgery
University of Miami School of Medicine
University of Miami/Jackson Memorial
Medical Center
Attending Neuroradiologist
MRI Center
Miami, Florida

Dan Farine, M.D., F.R.C.S.C.

Associate Professor, Department of Obstetrics
and Gynecology
University of Toronto
Staff Perinatologist and Director of Obstetrics
Mount Sinai Hospital
Toronto, Ontario, Canada

**Paul W. Finnegan, M.D., C.M.,
F.R.C.P.(C)**

MBA Program
University of Chicago, Graduate School of Business
Chicago, Illinois
Private Practice
Toronto, Ontario, Canada, and Chicago, Illinois

**Katherine W. Fong, M.B., B.S.,
F.R.C.P.(C)**

Assistant Professor of Medical Imaging
University of Toronto
Head, Division of Ultrasound
Women's College Hospital
Toronto, Ontario, Canada

Bruno D. Fornage, M.D.

Professor of Radiology
Chief, Section of Ultrasound
University of Texas, M.D. Anderson Cancer Center
Houston, Texas

J. Brian Fowlkes, Ph.D.

Assistant Research Scientist
University of Michigan Medical Center
Ann Arbor, Michigan

Margaret A. Fraser-Hill, M.D., F.R.C.P.C.

Assistant Professor
Faculty of Medicine
McGill University
Department of Radiology
Montreal General Hospital
Montreal, Quebec, Canada

Kelly S. Freed, M.D.

Clinical Associate
Duke University Medical Center
Durham, North Carolina

Phyllis Glanc, M.D., F.R.C.P.C.

Assistant Professor
University of Toronto
Women's College Hospital
Toronto, Ontario, Canada

Charles M. Glasier, M.D.

Professor of Radiology and Pediatrics
University of Arkansas for Medical Sciences
Chief, Magnetic Resonance Imaging
Arkansas Children's Hospital
Little Rock, Arkansas

Lawrence P. Gordon, M.D.

Associate Pathologist
Crouse Hospital
Associate Professor of Pathology
State University of New York Health Science Center
Syracuse, New York

Calvin A. Greene, M.D., F.R.S.C.(C)

Assistant Clinical Professor
University of Calgary
Division Chief, Reproductive Endocrinology
and Infertility
Director, Regional Fertility Program
Foothills Hospital
Calgary, Alberta, Canada

Leslie E. Grissom, M.D.

Assistant Professor of Radiology and Pediatrics
Jefferson Medical College
Philadelphia, Pennsylvania
Attending Radiologist
Chief of Diagnostic Imaging
Alfred I. duPont Institute
Wilmington, Delaware

H. Theodore Harcke, M.D.

Professor of Radiology and Pediatrics
Jefferson Medical College
Philadelphia, Pennsylvania
Attending Radiologist
Chief of Imaging Research
Alfred I. duPont Institute
Wilmington, Delaware

Curtis L. Harlow, M.D.

Assistant Clinical Professor
University of Colorado
Chief of Radiology
St. Thomas More Hospital
Cañon City, Colorado

Christopher R. Harman, M.D., F.R.C.S.C.

Associate Professor, Department of Obstetrics
and Gynecology
University of Manitoba
Director, Fetal Assessment Unit
Women's Hospital
Winnipeg, Manitoba, Canada

**Ian D. Hay, M.B., Ph.D., F.A.C.E.,
F.A.C.P., F.R.C.P.**

Professor of Medicine
Mayo Medical School
Consultant in Endocrinology and Internal Medicine
Mayo Clinic
Rochester, Minnesota

Christy K. Holland, Ph.D.

Associate Professor, Department of Radiology
University of Cincinnati College of Medicine
Cincinnati, Ohio

Susan C. Holt, M.D., F.R.C.P.(C)

Assistant Professor, Department of Radiology
Health Sciences Centre
Winnipeg, Manitoba, Canada

C. Richard Hopkins, M.D.

Associate in Radiology
Ogden Regional Medical Center
Ogden, Utah
Davis North Hospital
Layton, Utah

E. Meredith James, M.D., F.A.C.R.

Associate Professor of Radiology
Mayo Clinic
Rochester, Minnesota

Ann Jefferies, M.D., F.R.C.P.C.

Assistant Professor
University of Toronto
Neonatologist
Mount Sinai Hospital
Toronto, Ontario, Canada

Susan D. John, M.D.

Associate Professor of Radiology and Pediatrics
University of Texas Medical Branch
Galveston, Texas

Jo-Ann M. Johnson, M.D., F.R.C.S.C.

Assistant Professor
University of Toronto
Division of Maternal Fetal Medicine
The Toronto Hospital
Toronto, Ontario, Canada

**Neil D. Johnson, M.B., B.S., F.R.A.C.R.,
M.Med.**

Assistant Professor
University of Cincinnati
Associate Director, Department of Radiology
Children's Hospital Medical Center
Cincinnati, Ohio

Robert A. Kane, M.D., F.A.C.R.

Vice Chairman, Department of Radiological Sciences
Director, Ultrasonography
Associate Professor of Radiology
Harvard Medical School
Beth Israel Deaconess Medical Center
Boston, Massachusetts

Terese I. Kaske, M.D.

Radiology Resident
University of Colorado Health Sciences Center
Denver, Colorado

Bernard F. King, Jr., M.D.

Associate Professor, Department of
Diagnostic Radiology
Mayo Graduate School
Mayo Clinic and Affiliated Hospitals
Rochester, Minnesota

Cheryl L. Kirby, M.D.

Assistant Professor of Diagnostic Imaging
Temple University School of Medicine
Attending Radiologist
Albert Einstein Medical Center
Philadelphia, Pennsylvania

Janet S. Kirk, M.D.

Assistant Director, Fetal Imaging
William Beaumont Hospital
Royal Oak, Michigan

Faye C. Laing, M.D.

Professor of Radiology
Harvard University
Director, Resident Education and Training
Brigham & Women's Hospital
Boston, Massachusetts

Eric J. Lantz, M.D.

Assistant Professor
Mayo Medical School
Staff Radiologist
Mayo Clinic
Rochester, Minnesota

Robert A. Lee, M.D.

Assistant Professor of Radiology
Consultant in Diagnostic Radiology
Mayo Foundation
Rochester, Minnesota

Richard E. Leithiser, Jr., M.D.

Associate Professor of Radiology
University of Arkansas for Medical Sciences
Arkansas Children's Hospital
Little Rock, Arkansas

Clifford S. Levi, M.D., F.R.C.P.(C)

Professor of Radiology
University of Manitoba
Section Head, Diagnostic Ultrasound
Health Sciences Centre
Winnipeg, Manitoba, Canada

**Bernard J. Lewandowski, M.D., C.M.,
R.V.T., M.B.A.**

Clinical Associate Professor
University of Ottawa
Head, Ultrasound (Radiology)
Ottawa Civic Hospital
Ottawa, Ontario, Canada

Bradley D. Lewis, M.D.

Assistant Professor
Mayo Medical School
Mayo Graduate School of Medicine
Consultant in Diagnostic Imaging
Mayo Clinic
Rochester, Minnesota

**Edward A. Lyons, M.D., F.R.C.P.(C),
F.A.C.R.**

Professor of Radiology and Obstetrics
and Gynecology
University of Manitoba
Health Sciences Centre
Winnipeg, Manitoba, Canada

†Laurence A. Mack, M.D.

Professor of Radiology, Obstetrics and Gynecology,
and Orthopaedics
Director of Ultrasound
University of Washington School of Medicine
Seattle, Washington

Marie-Jocelyne Martel, M.D.

Fellow, Maternal Fetal Medicine
University of Manitoba
Winnipeg, Manitoba, Canada

John R. Mathieson, M.D., F.R.C.P.C.

Head, Section of Radiology
Department of Medical Imaging
Capital Health Region
Royal Jubilee Hospital
Victoria, British Columbia, Canada

Frederick A. Matsen, III, M.D.

Professor and Chairman, Department
of Orthopaedics
University of Washington Medical Center
Seattle, Washington

John P. McGahan, M.D.

Professor of Radiology
Professor and Director of Abdominal Imaging
University of California, Davis, Medical Center
Sacramento, California

Ellen B. Mendelson, M.D.

Clinical Associate Professor of Diagnostic Radiology
University of Pittsburgh School of Medicine
Director, Mammography and Women's Imaging
Western Pennsylvania Hospital
Pittsburgh, Pennsylvania

Christopher R.B. Merritt, M.D.

Chairman, Department of Radiology
Ochsner Clinic and the Alton Ochsner
Medical Foundation
New Orleans, Louisiana

Berta Maria Montalvo, M.D.

Associate Professor of Radiology
University of Miami School of Medicine
Medical Director, Vascular Diagnostic Center
University of Miami Hospitals and Clinics
University of Miami/Jackson Memorial Medical Center
Miami, Florida

**Khanh T. Nguyen, M.Sc., M.D.,
F.R.C.P.C.**

Associate Professor
Queen's University
Kingston General Hospital
Hotel Dieu Hospital
Kingston, Ontario, Canada

Stuart F. Nicholson, M.D., F.R.C.P.C.

Clinical Associate Professor
University of Calgary
Foothills Hospital
Calgary, Alberta, Canada

Carl A. Nimrod, M.B., F.R.C.S.C.

Professor of Obstetrics and Gynecology
and Radiology
University of Ottawa
Chief of Obstetrics and Gynecology
Ottawa General Hospital
Ottawa, Ontario, Canada

Robert L. Nolan, B.Sc., M.D., F.R.C.P.C.

Professor and Head, Department of
Diagnostic Radiology
Queen's University
Head, Imaging Services
Kingston General Hospital
Hotel Dieu Hospital
St. Mary's of the Lake Hospital
Kingston, Ontario, Canada

David A. Nyberg, M.D.

Associate Clinical Professor of Radiology and
Obstetrics and Gynecology
University of Washington Medical Center
Co-Director of Obstetric Ultrasound
Swedish Medical Center
Seattle, Washington

Heidi B. Patriquin, M.D., F.R.C.P.(C)

Clinical Professor of Radiology
University of Montreal
Hopital Ste. Justine
Montreal, Quebec, Canada

Roger A. Pierson, M.S., Ph.D.

Professor, Department of Obstetrics and Gynecology
University of Saskatchewan College of Medicine
Royal University Hospital
Saskatoon, Saskatchewan, Canada

Joseph F. Polak, M.D., M.P.H.

Associate Professor of Radiology
Harvard Medical School
Director of Noninvasive Vascular Imaging
Brigham & Women's Hospital
Boston, Massachusetts

Carl C. Reading, M.D.

Professor of Diagnostic Radiology
Mayo Medical School
Consultant, Diagnostic Radiology
Mayo Clinic
Rochester, Minnesota

**Henrietta Kotlus Rosenberg, M.D.,
F.A.C.R., F.A.A.P.**

Professor of Diagnostic Imaging
Temple University School of Medicine
Chairman, Department of Radiology
Albert Einstein Medical Center
Philadelphia, Pennsylvania

Jonathan M. Rubin, M.D., Ph.D.

Professor of Radiology
University of Michigan
Ann Arbor, Michigan

Carol M. Rumack, M.D., F.A.C.R.

Professor of Radiology and Pediatrics
University of Colorado School of Medicine
Denver, Colorado

**Greg Ryan, M.B., M.R.C.O.G.,
F.R.C.S.C.**

Assistant Professor, Department of Obstetrics
and Gynecology
Faculty of Medicine
University of Toronto
Director of the Fetal Assessment Unit
Staff Perinatologist
Mount Sinai Hospital
Toronto, Ontario, Canada

Shia Salem, M.D., F.R.C.P.C.

Associate Professor, Medical Imaging
University of Toronto
Head, Division of Ultrasound
Mount Sinai Hospital
Toronto, Ontario, Canada

**Eric E. Sauerbrei, B.Sc., M.Sc., M.D.,
F.R.C.P.C.**

Professor of Radiology
Queen's University
Director of Ultrasound
Kingston General Hospital
Hotel Dieu Hospital
Kingston, Ontario, Canada

Joanna J. Seibert, M.D.

Professor of Radiology and Pediatrics
University of Arkansas for Medical Sciences
Director of Radiology
Arkansas Children's Hospital
Little Rock, Arkansas

Robert W. Seibert, M.D.

Professor, Department of Otolaryngology-Head and
Neck Surgery
University of Arkansas for Medical Sciences
Chief, Pediatric Otolaryngology
Arkansas Children's Hospital
Little Rock, Arkansas

†Nancy H. Sherman, M.D.

Assistant Professor of Radiology
Jefferson Medical College
Philadelphia, Pennsylvania
Director of Ultrasound
Alfred I. duPont Institute
Wilmington, Delaware

Luigi Solbiati, M.D.

Vice Chairman and Radiologist
Department of Radiology
General Hospital
Busto Arsizio, Varese, Italy

Beverly A. Spirt, M.D., F.A.C.R.

Professor of Radiology and Obstetrics
and Gynecology
Chief of Women's Imaging Section
State University of New York Health Science Center
Syracuse, New York

Elizabeth R. Stamm, M.D.

Associate Professor
University of Colorado Health Sciences Center
Administrative Co-Director of Body CT
University Hospital
Denver, Colorado

Rhonda R. Stewart, M.D.

Diagnostic Radiologist
Director of CT
Alexandria Hospital
Alexandria, Virginia

Leonard E. Swischuk, M.D.

Professor of Radiology and Pediatrics
University of Texas Medical Branch
Director of Pediatric Radiology
Children's Hospital
Galveston, Texas

George A. Taylor, M.D.

Associate Professor of Radiology and Pediatrics
Harvard Medical School
Director, Body Imaging Division
Children's Hospital
Boston, Massachusetts

Wendy Thurston, M.D., B.Sc., F.R.C.P.C.

Assistant Professor
Division Head, Genitourinary Radiology
University of Toronto
Staff Radiologist
The Toronto Hospital
Toronto, Ontario, Canada

Ants Toi, M.D., F.R.C.P.C.

Associate Professor
University of Toronto
Radiologist
The Toronto Hospital
Toronto, Ontario, Canada

Marnix T. van Holsbeeck, M.D.

Associate Professor of Radiology
Case Western Reserve University
Director, Musculoskeletal and ER Radiology
Henry Ford Hospital
Detroit, Michigan

Keith Y. Wang, Ph.D., M.D.

Clinical Assistant Professor, Department
of Radiology
University of Washington
Swedish Medical Center
Seattle, Washington

Stephanie R. Wilson, M.D., F.R.C.P.C.

Professor of Radiology and Obstetrics and
Gynecology
University of Toronto
Head, Division of Ultrasound
The Toronto Hospital
Toronto, Ontario, Canada

David A. Wiseman, M.D., F.R.C.P.(C)

Associate Professor
Faculty of Medicine
University of Calgary School of Medicine
Radiologist
Foothills Hospital
Calgary, Alberta, Canada

Cynthia E. Withers, M.D., F.R.C.P.C.

Staff Radiologist
Sansum Medical Clinic
Santa Barbara, California

To Barry, Becky, and Marc, for their love and wonderful support through an extremely intense year. To my parents, for their love and their belief in me. And to all my students, for responding to the challenge and joy of studying medicine, in particular ultrasound.

CMR

To Ken, Jessica, and Jordan, who generously lived without me for the many months required for this endeavor. Your independence and continuous encouragement were my inspiration.

SRW

To Cathy, Nicholas, Ben, and Laurie, for all the love and joy you bring to my life. You are all I could ever hope for.

JWC

P R E F A C E TO THE SECOND EDITION

The First Edition of *Diagnostic Ultrasound*, released at the RSNA in 1991, has become the most commonly used reference textbook at ultrasound practices worldwide. Because sonography has so expanded its frontiers in the past 6 years, we believed that a major revision was required for *Diagnostic Ultrasound* to remain the definitive reference work for this specialty. In particular, greater use of color and power Doppler imaging and improved high-resolution transducers have required the introduction of new chapters and new authors, as well as the expansion and enhancement of the First Edition's original material.

Approximately 100 outstanding authors, all recognized experts in the field of ultrasound, bring you the latest state-of-the-art concepts on ultrasound performance, imaging, diagnosis, and expanded applications, including hysterosonography, laparoscopic sonography, and ultrasound-guided biopsy and drainage techniques.

There has been a 25% increase in the size of the two volumes, the major space reallocation applied to obstetrics and gynecology. Thousands of the original images have been replaced, and new images have been added. The Second Edition also includes more than 450 images in full color. The layout has been exhaustively revamped and now includes multiple-picture "Key Feature Collages." These reflect the spectrum of sonographic changes that may occur in a given disease instead of just the most common manifestation.

Many improvements in the book's format have been designed to facilitate reading and review. Color-enhanced boxes highlight the important or critical features of sonographic diagnoses. Key terms and concepts are emphasized in boldface type. To direct the reader to other research and literature of interest, the comprehensive reference lists are well organized by topic.

The book is again divided into two volumes. Volume I consists of Parts I–IV. Part I contains chapters on physics and biologic effects of ultrasound, as well as the latest developments in ultrasound contrast agents. Part II covers abdominal, pelvic, and thoracic sonography, including interventional procedures. Part III presents intraoperative and laparoscopic sonography. Part IV contains many chapters on small-parts imaging, including carotid and peripheral artery and vein evaluation. Volume II begins with Part V, a greatly expanded section on obstetric and fetal sonography. Part VI comprehensively covers pediatric sonography. Two new chapters on pediatric brain Doppler and pediatric interventional sonography have been added to Part VI.

This book is for practicing physicians, residents, medical students, sonographers, and others interested in understanding the vast applications of diagnostic sonography in patient care. As with the First Edition, *it is our goal to present to you the most comprehensive reference book available on diagnostic ultrasound.*

P R E F A C E TO THE FIRST EDITION

Sonography has expanded rapidly over the last two decades on a world-wide basis. Despite the explosive growth of this field and the extensive applications of sonographic techniques, few comprehensive reference texts are available. To this end, we undertook the task of producing a state-of-the-art text on ultrasonography.

The authors who have contributed chapters to this book are recognized experts in their fields. We believe that they have provided the most up-to-date information available, making the book current and comprehensive. We hope that it will become a trusted primary reference for all who are interested in this exciting field of medical imaging.

This book is intended for practicing physicians, residents, medical students, and sonographers. It is organized into six parts, covering all aspects of sonography except cardiac and ophthalmologic applications. The information in Volume One, Part I, covers the physics of sonography; Part II, abdominal, pelvic, and thoracic imaging; Part III, intraoperative imaging; and Part IV, small parts imaging, including carotid and peripheral

vessels. The contents of Volume Two include Part V, obstetric and fetal topics and Part VI, pediatric applications. Every effort was made to cover the broad scope of ultrasound practice without redundancy.

We greatly appreciate the efforts of the contributing authors. Without their experience, expertise, and commitment, we could not have achieved the goal of a comprehensive and authoritative textbook. We are indebted to them.

The high-quality images are the product of many talented sonographers, and to them we offer our sincere thanks. Their dedication to sonography has contributed substantially to its rapid growth and acceptance.

We also thank Janine Jacobson, our talented manuscript coordinator, whose patience and care with multiple manuscript revisions has led to a first-class product. Further, we acknowledge the support of Elaine Steinborn, Jo Salway, Jim Ryan, and Anne Patterson of Mosby-Year Book for encouraging us in this endeavor.

A C K N O W L E D G M E N T S

Our deepest appreciation and sincerest gratitude:

To all of our outstanding authors who have contributed extensive, newly updated, and authoritative text and images. We cannot thank them enough for their efforts on this project.

To Lisa Wolfe in Denver, Colorado, whose outstanding secretarial skills and smooth coordination supported the review and final revision of the entire manuscript between editors and authors. Her speed and organization are greatly appreciated.

To Mark Sawyer of Science Imaging Group in Toronto, Canada for excellent photographic assistance, and Jenny Tomash, also in Toronto, for her beautiful illustrations.

To Nick Charboneau, our digital image editor, for his outstanding work in the production of the “Key Image Collages” and other image enhancements.

To Rose Baldwin and Lori Kulas, our secretaries, for their expert and energetic assistance in the preparation of the manuscripts.

To Mia Cariño and Dave Orzechowski at Mosby who have been dedicated and enthusiastic coordinators of the project through development and production.

To Liz Corra at Mosby, an outstanding managing editor, who has guided the project with patient and untiring encouragement.

To Anne Patterson at Mosby who guided this project through its First Edition and has encouraged us to climb this steep mountain of effort again.

V O L U M E O N E
DIAGNOSTIC ULTRASOUND
SECOND EDITION