
CURRENT PRACTICE

OF

RADIOLOGY

THRALL

CURRENT PRACTICE OF RADIOLOGY

JAMES H. THRALL, M.D.

*Juan M. Taveras Professor of Radiology
Harvard Medical School
Radiologist-in-Chief
Massachusetts General Hospital
Boston, Massachusetts*

with 1851 illustrations

B.C. Decker
An Imprint of Mosby-Year Book, Inc.



Executive Editor: Susan M. Gay
Senior Managing Editor: Lynne Gery
Project Supervisor: Allan S. Kleinberg
Manufacturing Supervisor: Betty Richmond

Copyright © 1993 by Mosby-Year Book, Inc.

A B.C. Decker imprint of 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, 27 Congress Street, Salem, MA 01970. 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.

Printed in the United States of America.

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

NOTICE: The authors and publisher have made every effort to ensure that the patient care recommended herein, including choice of drugs and drug dosages, is in accord with the accepted standards and practice at the time of publication. However, since research and regulation constantly change clinical standards, the reader is urged to check the product information sheet included in the package of each drug, which includes recommended doses, warnings, and contraindications. This is particularly important with new or infrequently used drugs.

Library of Congress Cataloging-in-Publication Data

Current practice of radiology / [edited by] James H. Thrall.

p. cm. — (Current therapy series)

Includes bibliographical references and index.

ISBN 1-55664-385-3

1. Radiography, Medical. I. Thrall, James H. II. Series.

[DNLM: 1. Technology, Radiologic. 2. Radiography. WN 160 C976

1993]

RC78.C86 1993

616.07'57—dc20

DNLM/DLC

for Library of Congress

93-10273

CIP

CURRENT PRACTICE OF RADIOLOGY



CURRENT THERAPY/CURRENT PRACTICE SERIES

Bardin

Current Therapy in Endocrinology and Metabolism

Bayless

Current Therapy in Gastroenterology and Liver Disease

Brain, Carbone

Current Therapy in Hematology-Oncology

Callahan

Current Practice of Emergency Medicine

Cameron

Current Surgical Therapy

Cherniack

Current Therapy in Respiratory Disease

Cooke, Frohlich

Current Management of Hypertensive and Vascular Diseases

Ernst, Stanley

Current Therapy in Vascular Surgery

Fazio

Current Therapy in Colon and Rectal Surgery

Foley, Payne

Current Therapy of Pain

Garcia, Mastroianni, Amelar, Dubin

Current Therapy of Infertility

Gates

Current Therapy in Otolaryngology—Head and Neck Surgery

Glasscock

Current Therapy in Nephrology and Hypertension

Grillo, Austen, Wilkins, Mathisen, Vlahakes

Current Therapy in Cardiothoracic Surgery

Horowitz

Current Management of Arrhythmias

Hurst

Current Therapy in Cardiovascular Disease

Jeejeebhoy

Current Therapy in Nutrition

Johnson, Griffin

Current Therapy in Neurologic Disease

Kadir

Current Practice of Interventional Radiology

Kaplan

Current Therapy in Pediatric Infectious Disease

Kass, Platt

Current Therapy in Infectious Disease

Kassirer

Current Therapy in Internal Medicine

Lichtenstein, Fauci

Current Therapy in Allergy, Immunology, and Rheumatology

Long

Current Therapy in Neurological Surgery

Marsh

Current Therapy in Plastic and Reconstructive Surgery

Myerson

Current Therapy in Foot and Ankle Surgery

Nelson

Current Therapy in Neonatal-Perinatal Medicine

Niederhuber

Current Therapy in Oncology

Parrillo

Current Therapy in Critical Care Medicine

Resnick, Kursh

Current Therapy in Genitourinary Surgery

Rogers

Current Practice in Anesthesiology

Spaeth, Katz

Current Therapy in Ophthalmic Surgery

Thrall

Current Practice of Radiology

Torg, Welsh, Shephard

Current Therapy in Sports Medicine

Trunkey, Lewis

Current Therapy of Trauma

CONTRIBUTORS



RONALD S. ADLER, Ph.D., M.D.

Assistant Professor of Radiology, University of Michigan Medical School; Director, Musculoskeletal Division, University of Michigan Medical Center, Ann Arbor, Michigan

BENNETT A. ALFORD, M.D.

Associate Professor of Radiology and Pediatrics, University of Virginia Hospital and Children's Medical Center, Charlottesville, Virginia

PIRAN ALIABADI, M.D.

Visiting Associate Professor of Radiology, Harvard Medical School; Radiologist, Director of Emergency Radiology Service, and Director, Division of Quality Assurance, Brigham and Women's Hospital, Boston, Massachusetts

HANNU J. ARONEN, M.D., Ph.D.

Assistant Professor of Radiology, University of Helsinki, Helsinki, Finland; Postdoctoral Research Fellow, Nuclear Magnetic Resonance Center, Massachusetts General Hospital, Boston, Massachusetts

JUDITH M. ASH, M.D., FRCPC, ABNM

Associate Professor of Radiology, University of Toronto Faculty of Medicine; Senior Staff Radiologist, Department of Diagnostic Imaging, The Hospital for Sick Children, Toronto, Ontario, Canada

GREGORY V. BABIGIAN, M.D.

Assistant Professor of Radiology, Sections of Neuroradiology and Vascular Interventional Radiology, State University of New York at Stony Brook Health Sciences Center, Stony Brook, New York

DEMETRIUS H. BAGLEY, M.D.

Professor of Urology and Radiology, Jefferson Medical College of Thomas Jefferson University, Philadelphia, Pennsylvania

STEPHEN R. BAKER, M.D.

Professor and Chairman, Department of Radiology, University of Medicine and Dentistry of New Jersey/ New Jersey Medical School; Director of Radiology, University Hospital, Newark, New Jersey

WILLIAM S. BALL, Jr., M.D.

Associate Professor of Radiology and Pediatrics, University of Cincinnati College of Medicine and Children's Hospital Medical Center; Chief, Section of Pediatric Neuroradiology, Children's Hospital Medical Center, Cincinnati, Ohio

EMIL J. BALTHAZAR, M.D.

Professor of Radiology and Chief of Gastrointestinal Radiology, New York University-Tisch-Bellevue Medical Center, New York, New York

MICHAEL A. BETTMANN, M.D.

Professor of Radiology, Boston University School of Medicine; Interim Director of Radiology, University Hospital, and Chief, Cardiovascular Radiology, Boston University Medical Center, Boston, Massachusetts

EDWARD I. BLUTH, M.D., FACR

Clinical Professor of Radiology, Tulane University School of Medicine; Associate Head, Section of Ultrasound, Ochsner Clinic, New Orleans, Louisiana

ROBERT L. BREE, M.D.

Associate Professor of Radiology, University of Michigan Medical Center; Chief, Radiology Services, Veterans Affairs Medical Center, Ann Arbor, Michigan

R. JAMES BRENNER, M.D., J.D.

Associate Clinical Professor of Radiology, University of California, Los Angeles, School of Medicine; Director, Tower Breast Imaging Center, Los Angeles, California

BRADLEY R. BUCHBINDER, M.D.

Instructor in Radiology, Harvard Medical School; Staff Neuroradiologist, Massachusetts General Hospital, Boston, Massachusetts

WILLIAM H. BUSH, Jr., M.D., FACR

Professor of Radiology, and Director of Genitourinary Radiology, Department of Radiology, University of Washington School of Medicine, Seattle, Washington

BARBARA L. CARTER, M.D.

Professor of Radiology and Otolaryngology, Tufts University School of Medicine; Chief, ENT Radiology, New England Medical Center, Boston, Massachusetts

MAURICIO CASTILLO, M.D.

Associate Professor of Radiology and Chief of Neuroradiology, University of North Carolina at Chapel Hill School of Medicine, Chapel Hill, North Carolina

STANLEY M. CHERNISH, M.D.

Associate Professor of Medicine, Indiana University School of Medicine; Consultant in Research, Methodist Hospital of Indiana, Indianapolis, Indiana

ROBERT H. CLEVELAND, M.D.

Associate Professor of Radiology, Harvard Medical School; Radiologist, The Children's Hospital, Boston, Massachusetts

R. EDWARD COLEMAN, M.D.

Professor of Radiology and Director of Nuclear Medicine, Duke University Medical Center, Durham, North Carolina

B. DAVID COLLIER, Jr., M.D.

Professor of Radiology and Director of Nuclear Medicine, Medical College of Wisconsin; Chief, Nuclear Medicine Service, Clement J. Zablocki Veterans Affairs Medical Center, and Director of Nuclear Medicine, Milwaukee County Medical Complex and Froedtert Memorial Hospital, Milwaukee, Wisconsin

HUGH D. CURTIN, M.D.

Professor of Radiology and Otolaryngology, University of Pittsburgh School of Medicine; Director of Radiology, Eye and Ear Institute, Pittsburgh, Pennsylvania

DAVID J. CURTIS, M.D., FACR

Professor of Radiology, George Washington University School of Medicine and Health Sciences, Washington, D.C.; Clinical Professor of Radiology and Nuclear Medicine, Uniformed Services University of the Health Sciences, Bethesda, Maryland

THOMAS R. DAMIANO, M.D.

Assistant Clinical Professor of Radiology, University of Colorado Health Sciences Center, Denver; Neuroradiologist, Fitzsimons Army Medical Center, Aurora, Colorado

KENNETH R. DAVIS, M.D.

Professor of Radiology, Harvard Medical School; Staff Neuroradiologist, Massachusetts General Hospital, Boston, Massachusetts

SHEILA D. DAVIS, M.D.

Associate Professor of Radiology, Cornell University Medical College; Associate Attending Radiologist, The New York Hospital, New York, New York

GERALD D. DODD III, M.D.

Assistant Professor of Radiology, University of Pittsburgh School of Medicine; Director of Sonography, Presbyterian-University Hospital, Pittsburgh, Pennsylvania

EDMUND A. FRANKEN, Jr., M.D.

Professor and Head, Department of Radiology, The University of Iowa College of Medicine; Director, Department of Radiology, The University of Iowa Hospitals and Clinics, Iowa City, Iowa

ANDRÉ J. DUERINCKX, M.D., Ph.D.

Assistant Professor, University of California, Los Angeles, School of Medicine, Los Angeles, and Veterans Administration Medical Center, West Los Angeles, California

MARY F. GASKILL-SHIPLEY, M.D.

Assistant Professor of Radiology, University Hospital, Cincinnati, Ohio

ROBERT R. EDELMAN, M.D.

Associate Professor of Radiology, Harvard Medical School; Director of Magnetic Resonance Imaging, Beth Israel Hospital, Boston, Massachusetts

G. SCOTT GAZELLE, M.D.

Instructor in Radiology, Harvard Medical School; Assistant Radiologist, Division of Gastrointestinal/Interventional Radiology, Massachusetts General Hospital, Boston, Massachusetts

ALLEN D. ELSTER, M.D.

Professor of Radiology and Director of Magnetic Resonance Imaging, Bowman Gray School of Medicine of Wake Forest University; Staff Neuroradiologist, North Carolina Baptist Hospital, Winston-Salem, North Carolina

WARREN B. GEFTER, M.D.

Professor of Radiology, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania

PETER J. FECZKO, M.D.

Staff Radiologist, William Beaumont Hospital, Royal Oak, Michigan

DAVID W. GELFAND, M.D.

Professor of Radiology, Bowman Gray School of Medicine of Wake Forest University; Attending Radiologist, North Carolina Baptist Hospital, Winston-Salem, North Carolina

MICHAEL P. FEDERLE, M.D.

Professor of Radiology, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania

HARRY K. GENANT, M.D.

Professor of Radiology, Medicine, and Orthopaedic Surgery; Chief, Skeletal Section, and Director, Osteoporosis Research Group, Department of Radiology, University of California, San Francisco, School of Medicine, San Francisco, California

ARTHUR C. FLEISCHER, M.D.

Professor of Radiology and of Obstetrics and Gynecology, and Chief, Diagnostic Sonography, Vanderbilt University Medical Center, Nashville, Tennessee

MARYELLEN L. GIGER, Ph.D.

Associate Professor of Radiology, University of Chicago Pritzker School of Medicine, Chicago, Illinois

BARRY D. FLETCHER, M.D.

Chairman, Department of Diagnostic Imaging, St. Jude Children's Research Hospital; Professor of Radiology and Pediatrics, University of Tennessee College of Medicine, Memphis, Tennessee

BARRY B. GOLDBERG, M.D.

Professor of Radiology, and Director, Division of Diagnostic Ultrasound, Department of Radiology, Jefferson Medical College of Thomas Jefferson University, Philadelphia, Pennsylvania

CALVIN H. FLOWERS, M.D.

Staff, Department of Radiology, Cook County Hospital, Chicago, Illinois

LUÍS FLÁVIO GONÇALVES, M.D.

Research Fellow in Ultrasound, Department of Radiology, Vanderbilt University Medical Center, Nashville, Tennessee

R. GILBERTO GONZÁLEZ, M.D., Ph.D.

Assistant Professor of Radiology, Harvard Medical School; Assistant Radiologist, Massachusetts General Hospital, Boston, Massachusetts

PHILIP C. GOODMAN, M.D.

Clinical Professor of Radiology, Duke University Medical Center, Durham, North Carolina

EDWARD G. GRANT, M.D.

Professor of Radiological Sciences, University of California, Los Angeles, School of Medicine; Chief, Radiology Services, Veterans Affairs Medical Center-West Los Angeles, Los Angeles, California

BARRY H. GROSS, M.D.

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

PETER F. HAHN, M.D., Ph.D.

Assistant Professor of Radiology, Harvard Medical School; Assistant Radiologist, Massachusetts General Hospital, Boston, Massachusetts

JACK O. HALLER, M.D.

Professor and Vice Chairman, Department of Radiology, State University of New York Downstate Medical Center; Director of Pediatric Radiology, King County Hospital, Brooklyn, New York

MARGARET E. HANSEN, M.D.

Assistant Professor of Radiology, University of Texas Southwestern School of Medicine; Attending Radiologist, Special Procedures Section, Parkland Memorial Hospital, Veterans Affairs Medical Center, and Zale-Lipshy University Hospital, Dallas, Texas

MICHAEL W. HANSON, M.D.

Assistant Professor of Radiology, Associate in Internal Medicine, and Chief of Nuclear Cardiology, Duke University Medical Center, Durham, North Carolina

JOHN H. HARRIS, Jr., M.D., D.Sc., FACR

John S. Dunn Chair in Radiology, and Professor and Chief of Emergency Radiology, University of Texas Medical School at Houston; Chief of Emergency Radiology, Hermann Hospital, Houston, Texas

MICHAEL F. HARTSHORNE, M.D.

Vice Chairman and Associate Professor of Radiology, University of New Mexico School of Medicine, Albuquerque, New Mexico

VICTOR M. HAUGHTON, M.D.

Professor of Radiology and Biophysics, and Director of Magnetic Resonance Imaging Research, Medical College of Wisconsin, Milwaukee, Wisconsin

ROBERT S. HELLMAN, M.D.

Associate Professor of Radiology, Medical College of Wisconsin; Staff Physician, Milwaukee County Medical Complex and Clement J. Zablocki Veterans Affairs Medical Center, Milwaukee, Wisconsin

CHARLES B. HIGGINS, M.D.

Professor of Radiology, University of California, San Francisco, School of Medicine; Chief, Magnetic Resonance Imaging, The Medical Center at University of California, San Francisco, California

NANCY YANES HOFFMAN, M.Sc.

Writer-in-Residence, Elizabeth Wende Breast Clinic, Rochester, New York

HEDVIG HRICAK, M.D., Ph.D.

Professor of Radiology, Urology, and Radiation Oncology, and Chief, Uroradiology Section, University of California, San Francisco, School of Medicine, San Francisco, California

CONRADE CARL JAFFE, M.D.

Professor of Diagnostic Radiology and Internal Medicine, Yale University School of Medicine; Attending Radiologist, Yale-New Haven Hospital, New Haven, Connecticut

DIEGO JARAMILLO, M.D.

Instructor in Radiology, Harvard Medical School; Radiologist, The Children's Hospital, Boston, Massachusetts

PHILIPPE JEANTY, M.D., Ph.D.

Associate Professor of Radiology, and Assistant Professor of Obstetrics and Gynecology, Vanderbilt University School of Medicine, Nashville, Tennessee

J. RANDY JINKINS, M.D.

Associate Professor and Director of Neuroradiology,
Department of Radiology, The University of
Texas Health Science Center at San Antonio,
San Antonio, Texas

SIMON CHING-SHUN KAO, M.D.

Associate Professor of Radiology, The University of
Iowa College of Medicine, Iowa City, Iowa

COLIN KARMODY, M.D., FRCSE, FACS

Professor of Otolaryngology, Tufts University School
of Medicine; Senior Surgeon, New England Medical
Center, Boston, Massachusetts

DAVID J. KASTAN, M.D.

Senior Staff, Henry Ford Hospital, Detroit, Michigan

SUSAN V. KATTAPURAM, M.D.

Assistant Professor of Radiology, Harvard Medical
School; Associate Radiologist, Massachusetts General
Hospital, Boston, Massachusetts

ROBERT A. KAUFMAN, S.B., M.D.

Professor of Radiology and Pediatrics, University of
Tennessee, Memphis, College of Medicine; Former
Director of Radiology, Le Bonheur Children's Medical
Center; Consultant in Radiology, St. Jude Children's
Hospital, Memphis, Tennessee

JOYCE KELLY, R.D.M.S.

Staff Sonographer, Department of Radiology,
Vanderbilt University Medical Center,
Nashville, Tennessee

PHILIP J. KENNEY, M.D.

Associate Professor of Radiology, University of
Alabama School of Medicine, Birmingham, Alabama

ARFA KHAN, M.D.

Associate Professor of Radiology, Albert Einstein
College of Medicine of Yeshiva University, Bronx;
Chief, Division of Thoracic Radiology, and Director,
Computed Body Tomography, Long Island Jewish
Medical Center, New Hyde Park, New York

WILLIAM C. KLINGENSMITH III, M.D.

Associate Clinical Professor, University of Colorado
School of Medicine, Denver; Radiologist, Radiology
Imaging Associates, Englewood, Colorado

SPYROS S. KOLLIAS, M.D.

Neuroradiology Research Fellow, Children's Hospital
Medical Center, Cincinnati, Ohio

DANIEL B. KOPANS, M.D.

Associate Professor of Radiology, Harvard Medical
School; Assistant Director, Ambulatory Care Radiology,
and Director, Breast Imaging, Massachusetts General
Hospital, Boston, Massachusetts

JONATHAN KRAMER, M.D.

Instructor in Radiology, Harvard Medical School;
Neuroradiologist, Beth Israel Hospital,
Boston, Massachusetts

JANET E. KUHLMAN, M.D.

Assistant Professor and Director, Chest
Radiology Section, The Johns Hopkins Hospital,
Baltimore, Maryland

FRED J. LAINE, M.D.

Assistant Professor of Radiology, and Clinical Director
of Magnetic Resonance, Medical College of Virginia,
Richmond, Virginia

TAL LAOR, M.D.

Fellow in Pediatric Radiology, Harvard Medical School;
Assistant in Radiology, The Children's Hospital,
Boston, Massachusetts

ROBERT L. LAPIDUS, M.D.

Resident Physician, Department of Radiology,
Vanderbilt University Medical Center,
Nashville, Tennessee

RICHARD E. LATCHAW, M.D.

Professor of Radiology and Neurosurgery, Margaret and
H. O. Peterson Chair of Neuroradiology, University of
Minnesota Medical School; Chief of Neuroradiology,
University of Minnesota Hospital and Clinic,
Minneapolis, Minnesota

IGOR LAUFER, M.D.

Professor of Radiology, University of Pennsylvania School of Medicine; Chief, Gastrointestinal Radiology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania

EVERETT MARC LAUTIN, M.D.

Associate Professor of Diagnostic Radiology, Albert Einstein College of Medicine of Yeshiva University; Attending Radiologist, Montefiore Medical Center, Bronx, New York

JEFFREY LEWIS LAUTIN, M.D.

Resident in Radiology, Mt. Sinai Hospital, New York, New York

J. NASH LAWRASON, M.D.

Clinical Instructor in Radiology, Harvard Medical School; Assistant Radiologist, Massachusetts General Hospital, Boston, Massachusetts

THOMAS L. LAWSON, M.D.

Professor and Chairman, Department of Radiology, Loyola University of Chicago Stritch School of Medicine, Maywood, Illinois

ROBERT L. LEBOWITZ, M.D.

Professor of Radiology, Harvard Medical School; Associate Radiologist-in-Chief, The Children's Hospital, Boston, Massachusetts

MICHAEL J. LEE, M.Sc., MRCPI, FRCR, FFR (RCSI)

Clinical Instructor of Radiology, Harvard Medical School; Assistant Radiologist, and Assistant Director of Ultrasound, Massachusetts General Hospital, Boston, Massachusetts

VICTOR W. LEE, M.D.

Professor of Radiology, Boston University School of Medicine; Chief of Nuclear Medicine, Boston City Hospital, Boston, Massachusetts

LEE R. LISKEY, M.D.

Private Practice, Clearwater Imaging Associates, Clearwater, Florida

JI-BIN LIU, M.D.

Research Assistant Professor, Division of Diagnostic Ultrasound, Department of Radiology, Jefferson Medical College of Thomas Jefferson University, Philadelphia, Pennsylvania

YU LIU, M.D.

Research Associate, Nuclear Medicine Division, Department of Radiology, Medical College of Wisconsin, Milwaukee, Wisconsin

WENDE WESTINGHOUSE LOGAN-YOUNG, M.D.

Director, The Elizabeth Wendé Breast Clinic, Rochester, New York

VINCENT H. S. LOW, M.B.B.S., FRACR

Fellow in Gastrointestinal Radiology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania

ROBERT R. LUKIN, M.D., FACR

Professor of Radiology, Director of Neuroradiology, and Adjunct Professor of Neurosurgery, University Hospital, Cincinnati, Ohio

HEBER MACMAHON, M.D.

Associate Professor of Radiology, The University of Chicago Hospitals, Chicago, Illinois

DEAN D. T. MAGLINTE, M.D., FACR

Clinical Professor of Radiology, Indiana University School of Medicine; Chief, Gastrointestinal Section, Department of Radiology, Methodist Hospital of Indiana, Indianapolis, Indiana

JOHN F. MATHEWS, M.B., Ch.B., FRACR

Lecturer in Radiology, The University of Michigan Hospitals, Ann Arbor, Michigan; Consultant Radiologist, Diagnostic Imaging, Campbelltown, New South Wales, Australia

JAMES J. McCORT, M.D.

Emeritus Clinical Professor of Radiology, Stanford University School of Medicine, Stanford; Radiologist, Santa Clara Valley Medical Center, San Jose, California

I. ROSS McDOUGALL, M.B., Ch.B., Ph.D.

Division of Nuclear Medicine, Stanford University
Medical Center, Stanford, California

**FRANK P. McGRATH, M.B., M.Sc., FFR (RCSI),
FRCR, FRCPC**

Assistant Professor of Diagnostic Radiology, and Active
Staff, McMaster University Medical Center, Hamilton,
Ontario, Canada

JOAN McILHENNY, M.D.

Assistant Professor of Radiology and Pediatrics,
University of Virginia Hospital and Children's Medical
Center, Charlottesville, Virginia

THERESA C. McLOUD, M.D.

Associate Professor of Radiology, Harvard Medical
School; Chief, Thoracic Radiology Division, and
Radiologist, Department of Radiology, Massachusetts
General Hospital, Boston, Massachusetts

ELLEN B. MENDELSON, M.D.

Clinical Associate Professor of Diagnostic Radiology,
University of Pittsburgh School of Medicine; Director,
Breast Diagnostic Imaging Center, The Western
Pennsylvania Hospital, Pittsburgh, Pennsylvania

ROBERT E. MINDELZUN, M.D.

Associate Professor of Radiology, Stanford University
School of Medicine, Stanford, California

STUART E. MIRVIS, M.D.

Associate Professor of Radiology, University of
Maryland School of Medicine; Director, Trauma
Radiology, Maryland Institute for Emergency Medical
Services Systems, Baltimore, Maryland

SHEILA G. MOORE, M.D.

Assistant Professor of Radiology, Stanford University
School of Medicine, Stanford, California

CONRAD E. NAGLE, M.D., FACNP, FACSM

Chief, Nuclear Medicine Services, William Beaumont
Hospital, Troy, Michigan; President, American College
of Nuclear Physicians

JEFFREY H. NEWHOUSE, M.D.

Professor of Radiology, Columbia University College of
Physicians and Surgeons; Attending Radiologist,
Presbyterian Hospital, New York, New York

ROBERT A. NOVELLINE, M.D.

Associate Professor of Radiology, Harvard Medical
School; Director, Emergency Radiology, Massachusetts
General Hospital, Boston, Massachusetts

JOHN F. O'CONNOR, M.D.

Professor of Radiology, Pediatrics, and Anatomy,
Boston University School of Medicine; Director,
Pediatric Radiology, Boston University Medical Center
and Boston City Hospital, Boston; Chief Radiologist,
Franciscan Children's Hospital, Brighton; and Director
of Radiology, North Shore Children's Hospital,
Salem, Massachusetts

JAMES OSKIN, D.O.

Fellow, Neuroradiology, Northwestern University
Medical School and Northwestern Memorial Hospital,
Chicago, Illinois

CHRISTOPHER J. PALESTRO, M.D.

Associate Professor of Nuclear Medicine and
Radiology, Albert Einstein College of Medicine of
Yeshiva University, Bronx; Attending Physician and
Chief, Division of Nuclear Medicine, Long Island
Jewish Medical Center, New Hyde Park, New York

EDWIN L. PALMER, M.D.

Instructor in Radiology, Harvard Medical School;
Associate Radiologist, Massachusetts General
Hospital, Boston, Massachusetts

WILLIAM E. PALMER, M.D.

Instructor in Radiology, Harvard Medical School;
Radiologist, Massachusetts General Hospital,
Boston, Massachusetts

ELLEN PANAGEAS, M.D.

Assistant Professor of Radiology, Westchester County
Medical Center, Valhalla, New York

NICHOLAS PAPANICOLAOU, M.D.

Associate Professor of Radiology, Harvard Medical School; Head, Division of Genitourinary Radiology, Massachusetts General Hospital, Boston, Massachusetts

STEVE H. PARKER, M.D.

Staff Radiologist, Radiology Imaging Associates, Englewood, Colorado

ROBERT S. PERRET, M.D.

Assistant Professor of Radiology, Section of Digital Imaging, Medical College of Wisconsin; Co-Director, Abdominal Imaging, Veterans Affairs Medical Center, Milwaukee, Wisconsin

ANN C. PRICE, M.D.

Associate Professor of Radiology, Harvard Medical School, Boston, Massachusetts

ROBERT M. QUENCER, M.D.

Professor and Chairman, Department of Radiology, University of Miami School of Medicine; Chief, Radiological Services, Jackson Memorial Hospital, Miami, Florida

LESLIE E. QUINT, M.D.

Associate Professor of Radiology, University of Michigan Hospitals, Ann Arbor, Michigan

HELEN C. REDMAN, M.D.

Professor of Radiology, University of Texas Southwestern Medical Center, Dallas, Texas

JAMES C. REED, M.D.

Professor of Radiology, Bowman Gray School of Medicine of Wake Forest University, Winston-Salem, North Carolina

CHARLES L. ROBERTSON, M.D.

Clinical Associate, Department of Radiology, Massachusetts General Hospital, Boston, Massachusetts; Director, Breast Imaging, St. Luke's Regional Medical Center, Boise, Idaho

BRUCE R. ROSEN, M.D., Ph.D.

Associate Professor of Radiology, Harvard Medical School; Co-Director, Nuclear Magnetic Resonance Center, Massachusetts General Hospital, Boston, Massachusetts

EVA RUBIN, M.D.

Associate Professor of Radiology, and Chief, Mammography Section, University of Alabama at Birmingham Medical Center, Birmingham, Alabama

VAL M. RUNGE, M.D.

Rosenbaum Professor of Diagnostic Radiology, and Director, Magnetic Resonance Imaging and Spectroscopy Center, University of Kentucky College of Medicine, Lexington, Kentucky

ERIC J. RUSSELL, M.D.

Associate Professor of Radiology, Northwestern University Medical School; Director of Neuroradiology, Northwestern Memorial Hospital, Chicago, Illinois

RICHARD SACKNOFF, M.D.

Instructor in Radiology, Harvard Medical School; Associate Radiologist, Massachusetts General Hospital, Boston, Massachusetts

SANJAY SAINI, M.D.

Associate Professor of Radiology, Harvard Medical School; Assistant Radiologist, and Director, Computed Tomography, Massachusetts General Hospital, Boston, Massachusetts

YUTAKA SATO, M.D.

Professor of Radiology (Pediatric Radiology and Neuroradiology), The University of Iowa Hospitals and Clinics, Iowa City, Iowa

DONALD S. SCHAUWECKER, Ph.D., M.D.

Professor of Radiology, Indiana University School of Medicine; Chief of Nuclear Medicine, Wishard Memorial Hospital, Indianapolis, Indiana

JAMES A. SCOTT, M.D.

Assistant Professor of Radiology, Harvard Medical School; Associate Radiologist, Massachusetts General Hospital, Boston, Massachusetts

JANE CHRESTMAN SHARE, M.D.

Instructor in Radiology, Harvard Medical School;
Radiologist, The Children's Hospital,
Boston, Massachusetts

FRANK G. SHELLOCK, Ph.D., FACSM, FACC

Assistant Professor of Radiological Sciences, University
of California, Los Angeles, School of Medicine;
Director of Research, Development, and Advanced
Applications, Tower Imaging, Los Angeles, California

JO-ANNE O. SHEPARD, M.D.

Assistant Professor of Radiology, Harvard Medical
School; Associate Radiologist, Massachusetts General
Hospital, Boston, Massachusetts

P. C. SHETTY, M.D.

Vice Chairman, Department of Diagnostic Radiology,
and Division Head, Special Procedures and
Interventional Radiology, Henry Ford Hospital,
Detroit, Michigan

EDWARD A. SICKLES, M.D.

Professor of Radiology, University of California,
San Francisco, School of Medicine; Chief, Breast
Imaging Section, Department of Radiology,
The Medical Center at the University of California,
San Francisco, California

JOSEPH F. SIMEONE, M.D.

Professor of Radiology, Harvard Medical School;
Head of Ultrasound, Department of Radiology, and
Radiologist, Massachusetts General Hospital,
Boston, Massachusetts

CARLOS J. SIVIT, M.D.

Assistant Professor of Radiology and Pediatrics, George
Washington University School of Medicine; Staff
Radiologist, Children's National Medical Center,
Washington, D.C.

M. LEON SKOLNICK, M.D.

Professor of Radiology, University of Pittsburgh School
of Medicine; Attending Radiologist, Presbyterian-
University Hospital, Pittsburgh, Pennsylvania

JAMES G. SMIRNIOTPOULOS, M.D.

Associate Professor of Radiology and Nuclear
Medicine, Uniformed Services University of the Health
Sciences, Bethesda, Maryland; Associate Clinical
Professor of Radiology, Georgetown University, and
Associate Professorial Lecturer in Radiology, George
Washington University School of Medicine and Health
Sciences, Washington, D.C.

WENDY R. K. SMOKER, M.D.

Professor of Radiology and Director of Neuroradiology,
Medical College of Virginia, Richmond, Virginia

DAVID L. SPIZARNY, M.D.

Director, Division of Body Computed Tomography,
Department of Radiology, Henry Ford Hospital,
Detroit, Michigan

PAUL STARK, M.D.

Associate Professor of Radiology, Harvard Medical
School, Boston, Massachusetts, and Professor of
Radiology, Loma Linda University School of Medicine,
Loma Linda, California; Co-Director, Division of
Thoracic Radiology, Brigham and Women's Hospital,
Boston, Massachusetts

FRED STEINBERG, M.D.

President, Steinberg Medical Imaging, Sherman Oaks,
California

GILES W. STEVENSON, B.M., FRCP, FRCR, FRCPC

Professor and Chairman, Department of Radiology,
McMaster University School of Medicine; Head of
Section, Department of Radiology, Chedoke-McMaster
Hospitals, Hamilton, Ontario, Canada

JOHN R. STY, M.D.

Clinical Professor of Radiology, Medical College of
Wisconsin, Milwaukee, and University of Wisconsin
Medical School, Madison; Chief of Radiology,
Children's Hospital of Wisconsin,
Milwaukee, Wisconsin

DENNIS P. SWANSON, R.Ph., M.S.

Associate Professor and Assistant Dean, University of
Pittsburgh School of Pharmacy, and Adjunct Associate
Professor, University of Pittsburgh School of Medicine;
Manager, Radiology Pharmacy Services, University of
Pittsburgh Medical Center, Pittsburgh, Pennsylvania

E. TURGUT TALI, M.D.

Chairman, Department of Radiology, Betemar CT and MRI Health Services Company, Ankara, Turkey

RITA LITTLEWOOD TEELE, M.D.

Radiologist and Ultrasonologist, The Children's Hospital, and Consultant in Neonatal Radiology, Brigham and Women's Hospital, Boston, Massachusetts

SHEKHAR C. THAKUR, M.D.

Resident, Nuclear Medicine, Medical College of Wisconsin, Milwaukee, Wisconsin

M. KRISTIN THORSEN, M.D.

Associate Professor of Radiology, Medical College of Wisconsin; Staff Radiologist, Milwaukee County Medical Complex, and Froedtert Memorial Lutheran Hospital, Milwaukee, Wisconsin

JAMES H. THRALL, M.D.

Juan M. Taveras Professor of Radiology, Harvard Medical School; Radiologist-in-Chief, Massachusetts General Hospital, Boston, Massachusetts

RONALD S. TIKOFSKY, Ph.D.

Research Assistant Professor, Department of Radiology, Section of Nuclear Medicine, Medical College of Wisconsin; Director, Brain Imaging Research, Clement J. Zablocki Veterans Affairs Medical Center, Milwaukee, Wisconsin

CHARLES L. TRUWIT, M.D.

Chief, Neuroradiology and Magnetic Resonance Imaging, Fitzsimons Army Medical Center, Aurora, Colorado

BARRY A. TURNBULL, Ph.D.

Associate Director of Biostatistics, Parexel International Corporation, Waltham, Massachusetts

CORNELIS VAN KUIJK, M.D., Ph.D.

Visiting Assistant Research Radiologist, Osteoporosis Research Group, Department of Radiology, The Medical Center at the University of California, San Francisco, California; Department of Radiology, Erasmus University, Rotterdam, The Netherlands

A. CHRISTINE WATT, M.B., Ch.B.

Department of Radiology, St. John Hospital and Medical Center, Detroit, Michigan

RALPH WEISSLEDER, M.D., Ph.D.

Director, Magnetic Resonance Pharmaceutical Program, Massachusetts General Hospital Nuclear Magnetic Resonance Center, Charlestown, Massachusetts

BARBARA N. WEISSMAN, M.D.

Associate Professor of Radiology, Harvard Medical School; Assistant Chairman, Radiology and Ambulatory Services, and Director, Musculoskeletal Radiology, Brigham and Women's Hospital, Boston, Massachusetts

ROBERT G. WELLS, M.D.

Associate Clinical Professor of Radiology, Medical College of Wisconsin; Staff Radiologist, Children's Hospital of Wisconsin, Milwaukee, Wisconsin

JACK WITTENBERG, M.D.

Professor of Radiology, Harvard Medical School; Radiologist, Massachusetts General Hospital, Boston, Massachusetts

AIZIK L. WOLF, M.D.

Assistant Professor of Neurosurgery and Neurology, University of Maryland Medical System, Veterans Hospital, and Mercy Medical Center, Baltimore, Maryland

NANCY WOLF, M.S., R.Ph., B.C.N.P.

Clinical Nuclear Pharmacist, Veterans Affairs Medical Center, Albuquerque, New Mexico

BEVERLY P. WOOD, M.D.

Professor of Radiology and Pediatrics, University of Southern California School of Medicine; Radiologist-in-Chief, Children's Hospital of Los Angeles, Los Angeles, California

TINA I. YOUNG, M.D.

Instructor in Radiology, Harvard Medical School; Assistant Radiologist, Massachusetts General Hospital, Boston, Massachusetts

E. KENT YUCEL, M.D.

Instructor in Radiology, Harvard Medical School;
Assistant Radiologist, Massachusetts General Hospital,
Boston, Massachusetts

WILLIAM T. C. YUH, M.D., M.S.E.E.

Director of Magnetic Resonance Imaging, The University
of Iowa College of Medicine, Iowa City, Iowa

ROBERT A. ZIMMERMAN, M.D.

Professor of Radiology, University of Pennsylvania School
of Medicine; Chief, Pediatric Neuroradiology and
Pediatric Magnetic Resonance Imaging, Children's
Hospital of Philadelphia, Philadelphia, Pennsylvania



PREFACE



Current Practice of Radiology is a departure from the style of both textbooks and review articles. The intention of the book is to provide an opportunity for recognized experts in radiology to share their current approaches to common and important diagnostic problems. It is a logical extension of the *Current Therapy* series, which has been very successful using the same philosophy of asking experts to describe their own approaches to practice.

Each author was charged with presenting his or her viewpoint rather than presenting a comprehensive spectrum of opinion from the literature or the point and counterpoint of controversies. It is the goal of this book to give the reader a clear statement from an authoritative figure, recognizing that many background details are not included. The authors also have kept the suggested readings to a minimum, emphasizing only the more important articles that can serve as an entry point to a wider pursuit of the literature.

It was not possible or practical to be encyclopedic or exhaustive in selecting material for this book. Rather, emphasis has been placed on topics that reflect the forefront of current practice. Other chapters are contemporary presentations of areas of longstanding interest in radiology.

The intended audience for this work is primarily the practicing radiologist who needs to stay abreast of contemporary thinking in the specialty. The book should

also be of interest to radiologists in training who have mastered the fundamentals and are ready for more advanced material in which the fundamentals are put into practice.

A unique feature of this work is the "book-within-the-book" concept. One of the problems with radiology is the taxonomy of our specialty. The academic framework for radiology has increasingly become organ-system specialization. However, many individual radiologists also have an interest in the technical modalities that cross organ-system boundaries. The basic organization of the book into sections follows an organ-system outline. The table of contents is then restated so that all chapters dealing with nuclear medicine, ultrasonography, computed tomography, or magnetic resonance imaging can be readily accessed.

It is hoped that *Current Practice of Radiology* will become an enduring part of the educational resource in radiology. Contributors to this first edition have done a marvelous job in capturing the spirit of presenting a personal statement of their practice. Feedback and critique will guide topical selections for future editions.

I would like to thank the many authors for their excellent contributions to the book. Lynne Gery provided excellent editorial support, and Doreen Flynn did yeoman work in keeping the many correspondences going to the right people.

James H. Thrall, M.D.