

GENERAL THORACIC SURGERY

fifth edition

volume

2

Thomas W. Shields

Joseph LoCicero III

Ronald B. Ponn



LIPPINCOTT WILLIAMS & WILKINS

GENERAL THORACIC SURGERY

fifth edition

volume

2

Edited by

Thomas W. Shields, M.D., D.Sc. (Hon.)

Professor Emeritus of Surgery
Northwestern University Medical School
Chicago, Illinois

Joseph LoCicero III, M.D.

Associate Professor of Surgery
Harvard Medical School
Boston, Massachusetts

Ronald B. Ponn, M.D.

Assistant Clinical Professor of Surgery
Yale University School of Medicine
New Haven, Connecticut



LIPPINCOTT WILLIAMS & WILKINS

A Wolters Kluwer Company

Philadelphia • Baltimore • New York • London
Buenos Aires • Hong Kong • Sydney • Tokyo

Acquisitions Editor: Lisa McAllister
Developmental Editor: Michelle M. LaPlante
Production Editor: Jane Bangley McQueen, Silverchair Science + Communications
Manufacturing Manager: Kevin Watt
Cover Designer: Christine Jenny
Compositor: Silverchair Science + Communications
Printer: Edwards Brothers

5th Edition

© 2000 by LIPPINCOTT WILLIAMS & WILKINS
227 East Washington Square
Philadelphia, PA 19106-3780 USA
LWW.com

All rights reserved. This book is protected by copyright. No part of this book may be reproduced in any form or by any means, including photocopying, or utilized by any information storage and retrieval system without written permission from the copyright owner, except for brief quotations embodied in critical articles and reviews. Materials appearing in this book prepared by individuals as part of their official duties as U.S. government employees are not covered by the above-mentioned copyright.

Printed in the USA

Library of Congress Cataloging-in-Publication Data

General thoracic surgery / edited by Thomas W. Shields, Joseph

LoCicero III, Ronald B. Ponn. -- 5th ed.

p. cm.

Includes bibliographical references and indexes.

ISBN 0-683-30619-7

I. Chest--Surgery. I. Shields, Thomas W., 1922-

II. LoCicero, Joseph, 1948- III. Ponn, Ronald B.

[DNLM: 1. Thoracic Surgical Procedures. WF 980 G326 1999]

RD536.G45 1999

617.5'4059--dc21

DNLM/DLC

for Library of Congress

99-34438

CIP

Care has been taken to confirm the accuracy of the information presented and to describe generally accepted practices. However, the authors, editors, and publisher are not responsible for errors or omissions or for any consequences from application of the information in this book and make no warranty, expressed or implied, with respect to the currency, completeness, or accuracy of the contents of the publication. Application of this information in a particular situation remains the professional responsibility of the practitioner.

The authors, editors, and publisher have exerted every effort to ensure that drug selection and dosage set forth in this text are in accordance with current recommendations and practice at the time of publication. However, in view of ongoing research, changes in government regulations, and the constant flow of information relating to drug therapy and drug reactions, the reader is urged to check the package insert for each drug for any change in indications and dosage and for added warnings and precautions. This is particularly important when the recommended agent is a new or infrequently employed drug.

Some drugs and medical devices presented in this publication have Food and Drug Administration (FDA) clearance for limited use in restricted research settings. It is the responsibility of health care providers to ascertain the FDA status of each drug or device planned for use in their clinical practice.

Contributing Authors

Homerios Aletras, M.D.

*Professor and Chairman
Department of Surgery
Salonika University
Salonika, Greece*

John C. Alexander, Jr., M.D.

*Professor of Surgery
Northwestern University Medical School
Chicago, Illinois*

Mark S. Allen, M.D.

*Associate Professor of Surgery
Mayo Medical School
Rochester, Minnesota*

Thomas A. Aloia, M.D.

*Research Fellow
Department of General and Thoracic Surgery
Duke University Medical Center
Durham, North Carolina*

Scott K. Alpard, M.D.

*Research Fellow in Surgery
University of Texas Medical School at Galveston
Galveston, Texas*

Robert W. Anderson, M.D.

*Professor and Chairman
Department of Surgery
Duke University School of Medicine
Durham, North Carolina*

William Scott Arnold, M.D.

*Attending Physician
Cardiothoracic Service
Carilion Roanoke Memorial Hospital
Roanoke, Virginia*

Carl L. Backer, M.D.

*Associate Professor of Surgery
Northwestern University Medical School
Chicago, Illinois*

Manjit S. Bains, M.B., B.S.

*Clinical Professor of Surgery
Weill Medical College of Cornell University
New York, New York*

Felix D. Battistella, M.D.

*Associate Professor of Surgery
University of California, Davis, School
of Medicine
Sacramento, California*

Ronald H. R. Belsey, M.D.

*Former Visiting Professor
University of Chicago Pritzker School
of Medicine
Chicago, Illinois*

John R. Benfield, M.D.

*Professor Emeritus of Cardiothoracic Surgery
University of California, Davis, School
of Medicine
Sacramento, California*

Akhil Bidani, M.D.

*Professor of Internal Medicine
University of Texas Medical School at Galveston
Galveston, Texas*

Charles E. Blevins, Ph.D.

*Professor Emeritus of Anatomy
Indiana University School of Medicine
Indianapolis, Indiana*

Jean-Philippe Bocage, M.D.

*Assistant Professor of Thoracic Surgery
University of Medicine and Dentistry of New
Jersey—Robert Wood Johnson Medical School
New Brunswick, New Jersey*

Anne Greth Bondeson

*Professor of Surgery
Central Hospital
Skovde, Sweden*

Christiana M. Brenin, M.D.

*Westchester Institute for the Treatment of Cancer
and Blood Diseases
Dickstein Cancer Treatment Center
White Plains, New York*

Edward A. Brunner, M.D., Ph.D.

*Professor of Anesthesiology
Northwestern University Medical School
Chicago, Illinois*

Aart Brutel de la Rivière, M.D., Ph.D.

*Professor and Chairman of Cardiothoracic
Surgery
University Medical Center Utrecht
Utrecht, The Netherlands*

Peter H. Burri, M.D.

*Professor and Chairman of Anatomy
University of Berne
Berne, Switzerland*

Robert J. Caccavale, M.D.

*Associate Clinical Professor of Surgery
University of Medicine and Dentistry of New
Jersey—Robert Wood Johnson Medical School
New Brunswick, New Jersey*

Christian T. Campos, M.D.

*Assistant Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

J. Jeffrey Carr, M.D., M.S.

*Assistant Professor of Radiology and Public
Health Sciences
Wake Forest University School of Medicine
Winston-Salem, North Carolina*

C. James Carrico, M.D.

*Professor and Chairman
Department of Surgery
University of Texas Southwestern Medical School
Dallas, Texas*

Robert J. Cerfolio, M.D.

*Associate Professor of Cardiothoracic Surgery
University of Alabama School of Medicine
Birmingham, Alabama*

Martin H. Cohen, M.D.

*Professor of Medicine
Temple University School of Medicine
Philadelphia, Pennsylvania*

Juan A. Cordero, Jr., M.D.

*Chief Resident in Surgery
University of Rochester School of Medicine and
Dentistry
Rochester, New York*

Yvon Cormier, M.D.

*Professor of Medicine
Laval University Faculty of Medicine
Sainte-Foy, Quebec, Canada*

James D. Cox, M.D.

*Professor and Head of Radiation Oncology
University of Texas M. D. Anderson Cancer
Center
Houston, Texas*

Robert M. Craig, M.D.

*Professor of Medicine
Northwestern University Medical School
Chicago, Illinois*

Lawrence L. Creswell, M.D.

*Assistant Professor of Surgery
Washington University School of Medicine
St. Louis, Missouri*

Anne McB Curtis, M.D.

*Professor of Diagnostic Radiology
Yale University School of Medicine
New Haven, Connecticut*

Richard S. D'Agostino, M.D.

*Attending Thoracic and Cardiovascular Surgeon
Lahey-Hitchcock Medical Center
Burlington, Massachusetts*

Benedict D. T. Daly, M.D.

*Professor of Cardiothoracic Surgery
Tufts University School of Medicine
Boston, Massachusetts*

Thomas M. Daniel, M.D.

*Professor of Thoracic Surgery
University of Virginia School of Medicine
Charlottesville, Virginia*

Gail Darling, M.D.

*Assistant Professor of Surgery
University of Toronto Faculty of Medicine
Toronto, Ontario, Canada*

Philippe G. Dartevelle, M.D.

*Professor of Thoracic and Vascular Surgery
Paris Sud University
Paris, France*

Steven R. DeMeester, M.D.

*Assistant Professor of Surgery
University of Southern California School
of Medicine
Los Angeles, California*

Tom R. DeMeester, M.D.

*Professor and Chairman
Department of Surgery
University of Southern California School
of Medicine
Los Angeles, California*

Claude Deschamps, M.D.

*Associate Professor of Surgery
Mayo Medical School
Rochester, Minnesota*

Jean Deslauriers, M.D.

*Professor of Surgery
Laval University Faculty of Medicine
Sainte-Foy, Quebec, Canada*

Ronald B. Dietrick, M.D.

*Formerly Director of Medical Services
Kwangju Christian Hospital
Kwangju, South Korea*

Ali Dodge-Khatami, M.D.

*Fellow in Pediatric Cardiac Surgery
Northwestern University Medical School
Chicago, Illinois*

Donald B. Doty, M.D.

*Clinical Professor of Surgery
University of Utah School of Medicine
Salt Lake City, Utah*

John R. Doty, M.D.

*Chief Resident in General Surgery
Johns Hopkins Hospital
Baltimore, Maryland*

Robert J. Downey, M.D.

*Assistant Professor of Surgery
Weill Medical College of Cornell University
New York, New York*

Carolyn M. Dresler, M.D.

*Associate Professor of Surgery
Temple University School of Medicine
Philadelphia, Pennsylvania*

André C. H. Duranceau, M.D.

*Professor of Surgery
University of Montreal Faculty of Medicine
Montreal, Quebec, Canada*

Forrest C. Eggleston, M.D.

*Formerly Professor and Head of Surgery
Christian Medical College
Ludhiana, Punjab, India*

Nabil M. El-Baz, M.D.

*Associate Professor of Anesthesiology
Rush Medical College of Rush University
Chicago, Illinois*

John A. Eleftheriades, M.D.

*Professor and Chief
Department of Cardiothoracic Surgery
Yale University School of Medicine
New Haven, Connecticut*

F. Henry Ellis, Jr., M.D.

*Clinical Professor of Surgery, Emeritus
Harvard Medical School
Boston, Massachusetts*

Bahman Emami, M.D.

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

Gary R. Epler, M.D.

*Associate Clinical Professor of Medicine
Harvard Medical School
Boston, Massachusetts*

L. Penfield Faber, M.D.

*Professor of Surgery
Rush Medical College of Rush University
Chicago, Illinois*

John A. Federico, M.D.

*Assistant Clinical Professor of Surgery
Yale University School of Medicine
New Haven, Connecticut*

Richard H. Feins, M.D.

*Assistant Professor of Surgery
University of Rochester School of Medicine and
Dentistry
Rochester, New York*

Ronald Feld, M.D.

*Professor of Medicine
University of Toronto Faculty of Medicine
Toronto, Ontario, Canada*

Stanley C. Fell, M.D.

*Professor of Thoracic Surgery
Albert Einstein College of Medicine
Bronx, New York*

Pasquale Ferraro, M.D.

*Assistant Professor of Surgery
University of Toronto Faculty of Medicine
Toronto, Ontario, Canada*

Willard A. Fry, M.D.

*Professor of Surgery
Northwestern University Medical School
Chicago, Illinois*

Patrick J. Fultz, M.D.

*Associate Professor of Radiology
University of Rochester School of Medicine and
Dentistry
Rochester, New York*

Henning A. Gaissert, M.D.

*Assistant Professor of Surgery
Brown University School of Medicine
Providence, Rhode Island*

Warren B. Geftter, M.D.

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

Gary G. Ghahremani, M.D.

*Professor of Radiology
Northwestern University Medical School
Chicago, Illinois*

Juan Gil, M.D.

*Professor of Pathology
Mount Sinai School of Medicine
New York, New York*

Robert J. Ginsberg, M.D.

*Professor of Surgery
Weill Medical College of Cornell University
New York, New York*

Jeffrey Glassroth, M.D.

*George R. and Elaine Love Professor and Chair
Department of Medicine
University of Wisconsin Medical School
Madison, Wisconsin*

Peter Goldstraw, Ch.M.

*Consultant Thoracic Surgeon and Clinical Director
of Surgery
Royal Brompton and Harefield National Health
Service Trust
London, United Kingdom*

Leo I. Gordon, M.D.

*Professor of Medicine
Northwestern University Medical School
Chicago, Illinois*

Richard M. Gore, M.D.

*Professor of Radiology
Northwestern University Medical School
Chicago, Illinois*

F. Anthony Greco, M.D.

*Director of the Sarah Cannon–Minnie Pearl
Cancer Center
Department of Medical Oncology
Centennial Medical Center
Nashville, Tennessee*

Hermes C. Grillo, M.D.

*Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

Sean C. Grondin, M.D.

*Fellow in Thoracic Surgery
Harvard Medical School
Boston, Massachusetts*

Jay L. Grosfeld, M.D.

*Lafayette F. Page Professor and Chairman
Department of Surgery
Indiana University School of Medicine
Indianapolis, Indiana*

Milton D. Gross, M.D.

*Professor of Internal Medicine
University of Michigan Medical School
Ann Arbor, Michigan*

Robert A. Gustafson, M.D.

*Professor of Surgery
West Virginia University School
of Medicine
Morgantown, West Virginia*

Jeffrey A. Hagen, M.D.

*Associate Professor of Surgery
University of Southern California School
of Medicine
Los Angeles, California*

John D. Hainsworth, M.D.

*Associate Professor of Medicine
Vanderbilt University School of Medicine
Nashville, Tennessee*

David H. Harpole, Jr., M.D.

*Associate Professor of Surgery
Duke University School of Medicine
Durham, North Carolina*

Renee S. Hartz, M.D.

*Professor of Surgery
Tulane University School of Medicine
New Orleans, Louisiana*

Hiroto Hatabu, Ph.D., M.D.

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

John H. Hay, M.B., B.Chir.

*Clinical Associate Professor of Surgery
(Radiation Oncology)
University of British Columbia Faculty
of Medicine
Vancouver, British Columbia, Canada*

Lauren D. Holinger, M.D.

*Professor of Otolaryngology–Head and Neck
Surgery
Northwestern University Medical School
Chicago, Illinois*

Babette J. Horn, M.D.

*Assistant Professor of Anesthesiology
Northwestern University Medical School
Chicago, Illinois*

Guo Jun Huang, M.D.

*Professor of Thoracic Surgery
Chinese Academy of Medical Sciences
Beijing, China*

C. Anthony Hughes, M.D.

*Department of Otolaryngology
Children's Memorial Hospital
Chicago, Illinois*

Alfred Jaretzki III, M.D.

*Associate Professor of Clinical Surgery
Columbia University College of Physicians and
Surgeons
New York, New York*

K. "Jay" Jeyasingham, M.B., Ch.M.

*Honorary Clinical Lecturer in Surgery
University of Bristol
Bristol, United Kingdom*

Larry R. Kaiser, M.D.

*Eldridge Eliason Professor of Surgery
University of Pennsylvania School of Medicine
Philadelphia, Pennsylvania*

Gregory P. Kalemkerian, M.D.

*Clinical Associate Professor of Medicine
University of Michigan School of Medicine
Ann Arbor, Michigan*

Rajeev Kapoor, M.B.B.S., M.S.

*Reader in Surgery
Christian Medical College
Ludhiana, Punjab, India*

Thomas J. Keane, M.B., B.Ch.

*Professor and Chairman of Surgery (Radiation
Oncology)
University of British Columbia Faculty
of Medicine
Vancouver, British Columbia, Canada*

Merrill S. Kies, M.D.

*Professor of Medicine
Northwestern University Medical School
Chicago, Illinois*

Timothy J. Kinsella, M.D.

*Professor and Chair
Department of Radiation Oncology
Case Western Reserve University School of Medicine
Cleveland, Ohio*

Thomas J. Kirby, M.D.

*Professor of Surgery
Case Western Reserve University School of Medicine
Cleveland, Ohio*

Paul A. Kirschner, M.D.

*Professor of Cardiothoracic Surgery
Mount Sinai School of Medicine
New York, New York*

Herbert Knight, M.D.

*Assistant Clinical Professor of Medicine
Yale University School of Medicine
New Haven, Connecticut*

Ritsuko Komaki, M.D.

*Professor of Radiation Oncology
University of Texas M. D. Anderson Cancer Center
Houston, Texas*

Michael J. Kornstein, M.D.

*Professor of Pathology
Virginia Commonwealth University Medical
College of Virginia School of Medicine
Richmond, Virginia*

Robert J. Korst, M.D.

*Assistant Attending Thoracic Surgeon
Memorial Sloan-Kettering Cancer Center
New York, New York*

Mark J. Krasna, M.D.

*Associate Professor of Surgery
University of Maryland School of Medicine
Baltimore, Maryland*

Rodney J. Landreneau, M.D.

*Professor of Surgery and Human Oncology
MCP Hahnemann University School of Medicine
Pittsburgh, Pennsylvania*

Johanna M. LaSala, M.D.

*Attending Physician
Hospital of St. Raphael
New Haven, Connecticut*

Pierre Leblanc, M.D.

*Professor of Chest Medicine
Laval University Faculty of Medicine
Sainte-Foy, Quebec, Canada*

Ralph J. Lewis, M.D.

*Clinical Professor of Surgery
University of Medicine and Dentistry of New
Jersey—Robert Wood Johnson Medical School
New Brunswick, New Jersey*

Claudia R. Libertin, M.D.

*Clinical Professor of Medicine
Yale University School of Medicine
New Haven, Connecticut*

Richard W. Light, M.D.

*Professor of Medicine
Vanderbilt University School of Medicine
Nashville, Tennessee*

Jeffrey C. Lin, M.D.

*Department of Cardiothoracic Surgery
MCP Hahnemann Allegheny General Hospital
Pittsburgh, Pennsylvania*

Michael J. Liptay, M.D.

*Assistant Professor of Surgery
Northwestern University Medical School
Chicago, Illinois*

Joseph LoCicero III, M.D.

*Associate Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

Massimo Loda, M.D.

*Associate Professor of Pathology
Harvard Medical School
Boston, Massachusetts*

Susan R. Luck, M.D.

*Professor of Surgery
Northwestern University Medical School
Chicago, Illinois*

John C. Lucke, M.D.

*Chief of Cardiothoracic Surgery
Department of Veterans Affairs Medical Center
Asheville, North Carolina*

Jeffrey P. Ludemann, M.D.

*Clinical Instructor in Otolaryngology
University of British Columbia Faculty of
Medicine
Vancouver, British Columbia, Canada*

Paolo Macchiarini, M.D., Ph.D.

*Chair of Thoracic and Vascular Surgery
Hannover University Medical School
Hannover, Germany*

Michael J. Mack, M.D.

*Assistant Professor of Thoracic Surgery
University of Texas Southwestern Medical School
Dallas, Texas*

James W. Mackenzie, M.D.

*Professor of Surgery
University of Medicine and Dentistry of New
Jersey—Robert Wood Johnson Medical School
New Brunswick, New Jersey*

Kamal A. Mansour, M.D.

*Professor of Surgery
Emory University School of Medicine
Atlanta, Georgia*

Gilbert Massard, M.D.

*Professor of Surgery
University of Strasbourg
Strasbourg, France*

Douglas J. Mathisen, M.D.

*Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

Richard A. Matthay, M.D.

*Boehringer Ingelheim Professor of Medicine
Yale University School of Medicine
New Haven, Connecticut*

Donna E. Maziak, M.D.C.M.

*Assistant Professor of Thoracic Surgery
University of Ottawa Faculty of Medicine
Ottawa, Ontario, Canada*

Robert J. McKenna, Jr., M.D.

*Clinical Professor of Thoracic Surgery
University of California, Los Angeles, UCLA
School of Medicine
Los Angeles, California*

Joseph S. McLaughlin, M.D.

*Professor of Surgery
University of Maryland School of Medicine
Baltimore, Maryland*

Máirín McMenamin, M.D.

*Resident in Pathology
Beth Israel Deaconess Medical Center
Boston, Massachusetts*

Minesh P. Mehta, M.D.

*Associate Professor of Human Oncology
University of Wisconsin Medical School
Madison, Wisconsin*

Steven J. Mentzer, M.D.

*Associate Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

Bryan F. Meyers, M.D.

*Assistant Professor of Surgery
Washington University School of Medicine
St. Louis, Missouri*

Daniel L. Miller, M.D.

*Assistant Professor of Surgery
Mayo Medical School
Rochester, Minnesota*

Joseph I. Miller, Jr., M.D.

*Professor of Cardiothoracic Surgery
Emory University School of Medicine
Atlanta, Georgia*

Wallace T. Miller, M.D.

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

Wallace T. Miller, Jr., M.D.

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

Darroch W. O. Moores, M.D.

*Clinical Associate Professor of Surgery
Albany Medical College
Albany, New York*

Donald G. Mulder, M.D.

*Professor of Surgery
University of California, Los Angeles, UCLA
School of Medicine
Los Angeles, California*

Thomas Muley, Ph.D.

*Department of Thoracic Surgery
Thoraxklinik Heidelberg-Rohrbach
Heidelberg, Germany*

Gordon F. Murray, M.D.

*Professor and Chairman
Department of Surgery
West Virginia University School of Medicine
Morgantown, West Virginia*

Tsuguo Naruke, M.D.

*Deputy Director and Chairman of Surgery
National Cancer Center Hospital
Tokyo, Japan*

Keith S. Naunheim, M.D.

*Professor of Surgery
St. Louis University School of Medicine
St. Louis, Missouri*

Dao M. Nguyen, M.D.

*Senior Investigator
Thoracic Oncology Section
National Cancer Institute, National Institutes
of Health
Bethesda, Maryland*

John L. Noshier, M.D.

*Clinical Professor and Chair
Department of Radiology
University of Medicine and Dentistry of New
Jersey—Robert Wood Johnson Medical School
New Brunswick, New Jersey*

Christopher J. O'Connor, M.D.

*Assistant Professor of Anesthesiology
Rush Medical College of Rush University
Chicago, Illinois*

Jemi Olak, M.D.

*Attending Thoracic Surgeon
Lutheran General Hospital
Park Ridge, Illinois*

Gerald N. Olsen, M.D.

*Professor of Medicine
University of South Carolina School of Medicine
Columbia, South Carolina*

Kenji Omura, M.D.

*Gastrointestinal Surgical Section
Kanazawa University School of Medicine
Kanazawa, Japan*

Mark B. Orringer, M.D.

*John Alexander Distinguished Professor
of Surgery
University of Michigan Medical School
Ann Arbor, Michigan*

Andranik Ovassapian, M.D.

*Professor of Clinical Anesthesia and Critical
Care
University of Chicago Pritzker School of Medicine
Chicago, Illinois*

Kerry Paape, M.D.

*Attending Surgeon
Cardiovascular Institute of the South
Houma, Louisiana*

Peter C. Pairolero, M.D.

*Professor of Surgery
Mayo Medical School
Rochester, Minnesota*

Harvey I. Pass, M.D.

*Professor of Surgery and Oncology
Wayne State University School of Medicine
Detroit, Michigan*

G. Alexander Patterson, M.D.

*Professor of Surgery
Washington University School of Medicine
St. Louis, Missouri*

David Payne, M.D.

*Assistant Professor of Radiation Oncology
University of Toronto Faculty of Medicine
Toronto, Ontario, Canada*

Carlos A. Perez, M.D.

*Professor of Radiology
Washington University School of Medicine
St. Louis, Missouri*

Marvin Pomerantz, M.D.

*Professor of Surgery
University of Colorado School of Medicine
Denver, Colorado*

Ronald B. Ponn, M.D.

*Assistant Clinical Professor of Surgery
Yale University School of Medicine
New Haven, Connecticut*

John Popp, M.D.

*Professor and Chairman
Department of Surgery
Albany Medical College
Albany, New York*

Joe B. Putnam, Jr., M.D.

*Associate Professor of Thoracic and Cardiovascular
Surgery
University of Texas M. D. Anderson Cancer
Center
Houston, Texas*

Jacquelyn A. Quin, M.D.

*Fellow in Cardiothoracic Surgery
University of Texas Southwestern Medical School
Dallas, Texas*

Carolyn E. Reed, M.D.

*Professor of Surgery
Medical University of South Carolina College
of Medicine
Charleston, South Carolina*

Frederick J. Rescorla, M.D.

*Associate Professor of Surgery
Indiana University School of Medicine
Indianapolis, Indiana*

Marleta Reynolds, M.D.

*Associate Professor of Surgery
Northwestern University Medical School
Chicago, Illinois*

Thomas W. Rice, M.D.

*Head
General Thoracic Surgery
Cleveland Clinic Foundation
Cleveland, Ohio*

Melanie L. Richards, M.D.

*Assistant Professor of Surgery
University of Texas Medical School at
San Antonio
San Antonio, Texas*

Philip G. Robinson, M.D.

*Assistant Professor of Clinical Pathology
University of Miami School of Medicine
Miami, Florida*

Valerie W. Rusch, M.D.

*Professor of Surgery
Weill Medical College of Cornell University
New York, New York*

Steven A. Sahn, M.D.

*Professor of Medicine
Medical University of South Carolina
Charleston, South Carolina*

L. R. Scherer III, M.D.

*Clinical Associate Professor of Surgery
Indiana University School of Medicine
Indianapolis, Indiana*

Joachim Schirren, M.D.

*Assistant Chief of Thoracic Surgery
Thoraxklinik Heidelberg-Rohrbach
Heidelberg, Germany*

David S. Schrump, M.D.

*Senior Investigator and Head
Surgery Branch, Thoracic Oncology Section
National Cancer Institute, National Institutes
of Health
Bethesda, Maryland*

Granger R. Scruggs

*Research Assistant to Michael J. Mack, M.D.
University of Texas Southwestern Medical
School
Dallas, Texas*

William P. Sexauer, M.D.

*Assistant Professor of Medicine
MCP Hahnemann University School of Medicine
Philadelphia, Pennsylvania*

Robert C. Shamberger, M.D.

*Associate Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

Farid M. Shamji, M.D.

*Associate Professor of Thoracic Surgery
University of Ottawa Faculty of Medicine
Ottawa, Ontario, Canada*

Brahm Shapiro, M.D., Ch.B., Ph.D.

*Professor of Internal Medicine
University of Michigan Medical School
Ann Arbor, Michigan*

Frances A. Shepherd, M.D.

*Associate Professor of Medicine
University of Toronto Faculty of Medicine
Toronto, Ontario, Canada*

Thomas W. Shields, M.D., D.Sc. (Hon.)

*Professor Emeritus of Surgery
Northwestern University Medical School
Chicago, Illinois*

Gerard A. Silvestri, M.D.

*Associate Professor of Medicine
Medical University of South Carolina College
of Medicine
Charleston, South Carolina*

Sunil Singhal, M.D.

*Resident
Johns Hopkins Hospital
Baltimore, Maryland*

William G. Spies, M.D.

*Associate Professor of Radiology
Northwestern University Medical School
Chicago, Illinois*

Amit Srivastava, M.D.

*Senior Attending Physician
MacNeal Hospital
Berwyn, Illinois*

Robert D. Stewart, M.D.

*Attending Cardiothoracic Surgeon
Beth Israel Deaconess Medical Center
Boston, Massachusetts*

Alan H. Stolpen, M.D., Ph.D.

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

John M. Streitz, Jr., M.D.

*Clinical Assistant Professor of Surgery
University of Minnesota—Duluth School of
Medicine
Duluth, Minnesota*

David J. Sugarbaker, M.D.

*Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

Scott J. Swanson, M.D.

*Assistant Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

Panagiotis N. Symbas, M.D.

*Professor of Surgery
Emory University School of Medicine
Atlanta, Georgia*

Lynn T. Tanoue, M.D.

*Associate Professor of Medicine
Yale University School of Medicine
New Haven, Connecticut*

Weike Tao, M.D.

*Resident in Anesthesiology
University of Texas Medical School at
Galveston
Galveston, Texas*

Norman W. Thompson, M.D.

*Henry King Ransom Professor of Surgery
University of Michigan Medical School
Ann Arbor, Michigan*

Victor F. Trastek, M.D.

*Professor of Surgery
Mayo Medical School
Rochester, Minnesota*

Przemek W. Twardowski, M.D.

*Medical Oncologist
City of Hope Comprehensive Cancer Center
Duarte, California*

Hiroshi Urayama, M.D.

*Vascular Surgical Section
Kanazawa University School of Medicine
Kanazawa, Japan*

Harold C. Urschel, Jr., M.D., Ph.D.

*Clinical Professor of Thoracic and Cardiovascular
Surgery
University of Texas Southwestern Medical School
Dallas, Texas*

Arvydas D. Vanagunas, M.D.

*Associate Professor of Medicine
Northwestern University Medical School
Chicago, Illinois*

Robert M. Vanecko, M.S., M.D.

*Professor of Surgery
Northwestern University Medical School
Chicago, Illinois*

Alexander Vasilakis, M.D.

*Assistant Professor of Surgery
West Virginia University School of Medicine
Morgantown, West Virginia*

Mohan Verghese, M.D.

*Professor and Head
Department of Surgery and Cardiothoracic Surgery
Christian Medical College
Ludhiana, Punjab, India*

Romeo A. Vidone, M.D.

*Associate Clinical Professor of Pathology
Yale University School of Medicine
New Haven, Connecticut*

Ingolf Vogt-Moykopf, M.D.

*Professor of Thoracic Surgery
Heidelberg University
Heidelberg, Germany*

Richard L. Wahl, M.D.

*Professor of Internal Medicine and Radiology
University of Michigan Medical School
Ann Arbor, Michigan*

Fady S. Wana, M.D.

*Chief Resident in Cardiothoracic Surgery
Emory University School of Medicine
Atlanta, Georgia*

William H. Warren, M.D.

*Associate Professor of Surgery
Rush Medical College of Rush University
Chicago, Illinois*

Lacey Washington, M.D.

*Attending Radiologist
MCP Hahnemann Allegheny General Hospital
Pittsburgh, Pennsylvania*

Yoh Watanabe, D.M.Sc.

*Professor and Chairman
Department of Surgery
Kanazawa University School of Medicine
Kanazawa, Japan*

Ewald R. Weibel, M.D.

*Professor of Anatomy
University of Berne
Berne, Switzerland*

Jean-Marie Wihlm, M.D.

*Thoracic and Cardiovascular Surgeon
University of Strasbourg
Strasbourg, France*

Earle W. Wilkins, Jr., M.D.

*Clinical Professor of Surgery, Emeritus
Harvard Medical School
Boston, Massachusetts*

John G. Williams, M.D.

*Assistant Professor of Surgery
University of Texas Southwestern Medical School
Dallas, Texas*

Hak Yui Wong, M.D.

*Assistant Professor of Anesthesiology
Northwestern University Medical School
Chicago, Illinois*

Cameron D. Wright, M.D.

*Associate Professor of Surgery
Harvard Medical School
Boston, Massachusetts*

Manoel Ximenes III, M.D., Ph.D.

*Professor and Head of Thoracic Surgery
University of Brasilia
Brasilia, Brazil*

Anjana V. Yeldandi, Ph.D.

*Associate Professor of Pathology
Northwestern University Medical School
Chicago, Illinois*

Joseph B. Zwischenberger, M.D.

*Professor of Surgery
University of Texas Medical School at Galveston
Galveston, Texas*

Preface

The fifth edition of *General Thoracic Surgery* has been extensively expanded and revised to present comprehensive coverage of the ever-expanding field of general thoracic surgery. The pertinent information necessary for understanding and management of the many problems related to the thorax and its contents that may confront the general thoracic surgeon is presented in exquisite detail. To ensure the attainment of this goal, I have enlisted the aid of Dr. Joseph LoCicero III and Dr. Ronald B. Ponn as associate editors. Together, we have selected acknowledged experts from many fields of endeavor: the basic sciences; pulmonary medicine; radiology; nuclear medicine; pathology; bronchoesophagology; anesthesiology; endocrinology; medical, radiologic, and surgical oncology; and general thoracic surgery, as well as other surgical specialties, to contribute their expertise to this text.

There are 29 sections, as well as an appendix devoted to presentation of the basics of statistical analysis that has become so important in the evaluation of clinical trials. There are 190 chapters, of which 54 are new. The new chapters primarily present advances in the basic sciences, diagnostic procedures, and surgical techniques that are relevant to the general thoracic surgeon. The sections on Carcinoma of the Lung and Other Tumors of the Lung contain many of the new chapters to more extensively cover these important fields. Likewise, the sections on the Mediastinum have been greatly expanded and essentially present the detailed and updated coverage that was originally published in the text *Mediastinal Surgery* by the senior editor in 1991. A few of the chapters from the fourth edition remain unchanged, but the vast majority of the previous chapters have been rewritten by new authors or have been extensively revised by the previous authors to be current with the literature through 1998 and early 1999.

As with any text that becomes more inclusive, repetition and differences in opinion have become common. These, within bounds, are healthy, as each author frequently views the same subject from a different vantage point and adds additional references that are of value in understanding the subject under consideration. Cross-references again are in abundance. Effort has been made to further expand the index so that it appropriately reflects all the subjects included in the text.

My associates and I wish to thank the many contributors from here in North America and abroad in Europe, Asia, and South America for the effort that they have expended in preparation of their contributions to the fifth edition. Each is of inestimable value and enhances the validity and importance of the text. We believe this text should not only be of interest to the thoracic surgeon but also useful to our colleagues in other specialties who have an interest in the chest and its contents.

Thomas W. Shields
Senior Editor

Acknowledgment

The editors wish to acknowledge the outstanding effort and dedication of Ms. Diane April of the Department of Surgery of Northwestern Memorial Hospital in the preparation and editorial unification of the contributions to the text. Without her expertise in traveling the information highway of the present computer age, we truly could not have produced this outstanding text.

Contents

Contributing Authors	xix
Preface	xxxi
Acknowledgment	xxxiii

Volume I

The Lung, Pleura, Diaphragm, and Chest Wall

SECTION I. ANATOMY OF THE CHEST WALL AND LUNGS

1. Anatomy of the Thorax	3
<i>Charles E. Blevins</i>	
2. Embryology of the Lung	17
<i>David H. Harpole, Jr., and Thomas A. Aloia</i>	
3. Ultrastructure and Morphometry of the Human Lung	31
<i>Peter H. Burri, Juan Gil, and Ewald R. Weibel</i>	
4. Cellular and Molecular Biology of the Lung	51
<i>Steven J. Mentzer</i>	
5. Surgical Anatomy of the Lungs	63
<i>Thomas W. Shields</i>	
6. Lymphatics of the Lungs	77
<i>Thomas W. Shields</i>	

SECTION II. PHYSIOLOGY OF THE LUNGS

7. Pulmonary Gas Exchange	93
<i>William P. Sexauer and Jeffrey Glassroth</i>	
8. Mechanics of Breathing	103
<i>William P. Sexauer and Jeffrey Glassroth</i>	

SECTION III. THORACIC IMAGING

9. Radiographic Evaluation of the Lungs and Chest	115
<i>Anne McB Curtis and Wallace T. Miller</i>	
10. Computed Tomography of the Lungs, Pleura, and Chest Wall	145
<i>Lacey Washington and Wallace T. Miller, Jr.</i>	