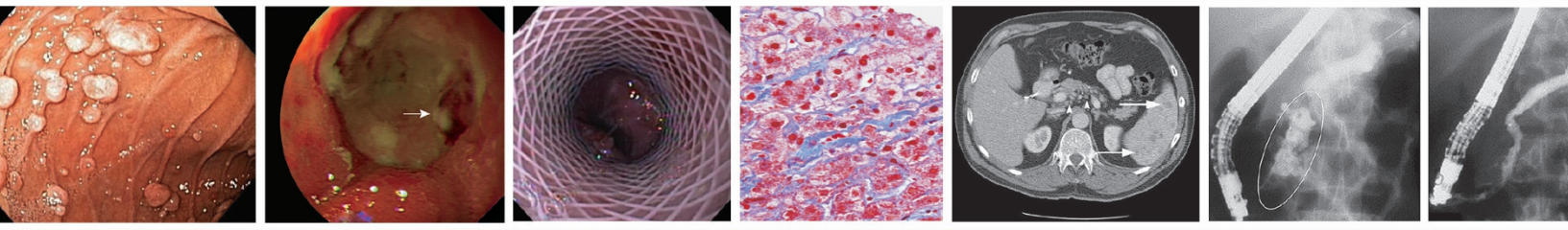
YAMADA'S Atlas of Gastroenterology



SIXTH EDITION

EDITED BY

Timothy C. Wang, Michael Camilleri, Benjamin Lebwohl, Anna S. Lok, William J. Sandborn, Kenneth K. Wang, and **Gary D. Wu**

with website

WILEY Blackwell

Yamada's Atlas of Gastroenterology

Yamada's Atlas of Gastroenterology

Sixth Edition

Edited by

Editors

Timothy C. Wang, MD

Chief, Division of Digestive and Liver Diseases
Silberberg Professor of Medicine
Department of Medicine and Irving Cancer Research Center
Columbia University Medical Center
New York, NY, USA

Michael Camilleri, MD

Atherton and Winifred W. Bean Professor
Professor of Medicine, Pharmacology and Physiology
Distinguished Investigator
Division of Gastroenterology and Hepatology
Mayo Clinic
Rochester, MN, USA

Associate Editors

Benjamin Lebwohl, MD

Associate Professor of Clinical Medicine and Epidemiology
Columbia University Medical Center
New York, NY, USA

Anna S. Lok, MD

Alice Lohrman Andrews Research Professor of Hepatology
Division of Gastroenterology and Hepatology
University of Michigan
Ann Arbor, MI, USA

William J. Sandborn, MD

Professor of Medicine
University of California
San Diego, CA, USA

Kenneth K. Wang, MD

Russell G. and Kathleen M. Van Cleve Professor of Medicine
Division of Gastroenterology and Hepatology
Mayo Clinic, Rochester, MN, USA

Gary D. Wu, MD

Ferdinand G. Weisbrod Professor in Gastroenterology
Division of Gastroenterology and Hepatology
Perelman School of Medicine
University of Pennsylvania
Philadelphia, PA, USA

WILEY Blackwell

This sixth edition first published 2022

Edition History
John Wiley & Sons Ltd (5e, 2016); Blackwell Publishing Ltd (4e, 2009)

Registered Offices
John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office
9600 Garsington Road, Oxford, OX4 2DQ, UK

For details of our global editorial offices, customer services, and more information about Wiley products visit us at www.wiley.com.

Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

Library of Congress Cataloging-in-Publication Data applied for:

ISBN 9781119600428 (hardback)

Cover Design: Wiley
Cover Images: Courtesy Dr. Rosa Miquel; Courtesy of Iain Kirkpatrick; Courtesy of Dr. Richard A. Kozarek; Courtesy of Dr. Krish Ragunath and Dr. Jon White; Courtesy of Dr. Martin L. Freeman

Set in 9.5/12pt Minion by Straive, Pondicherry, India

10 9 8 7 6 5 4 3 2 1

Contents

I Miscellaneous

PART 3 Diagnostic and therapeutic modalities in gastroenterology

A Endoscopic

B Imaging

C Pathology

Contributors

Dwight Aberle, MD
Resident, Radiology
Columbia University Irving Medical Center, New York, USA

Andres Acosta, MD, PhD
Consultant
Mayo Clinic, Rochester, MN, USA

Paul C. Adams, MD, FRCP
Professor
Western University, London, ON, Canada

Ahmad Hassan Ali, MD, FACE
Endocrinologist
Division of Gastroenterology and Hepatology,
College of Medicine, Mayo Clinic,
Rochester, MN, USA

Juan Pablo Arab, MD
Assistant Professor of Medicine
Department of Gastroenterology and Hepatology,
Medicine School, Pontifical Catholic University of Chile, Santiago, Chile

Frederick K. Askari, MD, PhD
Gastroenterologist
University of Michigan, Ann Arbor, MI, USA

John C. Atherton, MD, FRCP
Professor of Gastroenterology
Pro Vice Chancellor
Dean of the Faculty of Medicine and Health Sciences
University of Nottingham, Queen's Medical Centre,
Nottingham, UK

Stephen R. Atkinson, PhD
Visiting Research Scholar
The University of Pittsburgh, Pittsburgh, Pennsylvania, PA, USA;
Department of Hepatology, Department of Metabolism
Digestion and Reproduction, Imperial College London
London, UK

Joseph N. Badaoui, MD
Research Fellow
Department of Otorhinolaryngology, Head and Neck Surgery,
Mayo Clinic, Rochester, MN, USA

Todd H. Baron, MD
Director of Advanced Therapeutic Endoscopy
University of North Carolina, Chapel Hill, NC, USA

Adam J. Bass, MD, MSc
Associate Professor
Dana-Farber Cancer Institute and Harvard Medical School,
Boston, MA, USA

Ramon Bataller, MD, PhD
Chief of Hepatology
Center for Liver Diseases, Division of Gastroenterology, Hepatology, and
Nutrition, Department of Medicine, Pittsburgh Liver Research Center,
University of Pittsburgh, Pittsburgh, PA, USA

Daniel P. Beiting, PhD
Assistant Professor
University of Pennsylvania, School of Veterinary Medicine,
Philadelphia, PA, USA

Stuart Bentley-Hibbert, MD, PhD
Division Chief
Body Imaging, Columbia University Irving Medical Center,
New York, USA

Adil E. Bharucha MBBS, MD
Gastroenterologist
Division of Gastroenterology and Hepatology,
Mayo Clinic College of Medicine, Rochester, MN, USA

Jacob Bilhartz, MD
Professor
Department of Pediatrics, University of Michigan, Ann Arbor, MI, USA

Michael J. Bourke, MBBS, FRACP
Director of Endoscopy
Westmead Hospital, Westmead Clinical School University of Sydney,
Sydney New South Wales, Australia;
Department of Medicine, University of British Columbia
Vancouver, British Columbia, Canada

Sidney Z. Brejt, MD
Assistant Professor of Radiology
Columbia University Irving Medical Center, New York, NY, USA

Robert S. Brown Jr, MD, MPH
Professor of Medicine
Department of Gastroenterology and Hepatology, New York Presbyterian Weill
Cornell Medical Center, New York, USA

James L. Buxbaum, MD
Assistant Professor of Clinical Medicine
University of Southern California, Los Angeles, CA, USA

Dustin A. Carlson, MD, MS
Assistant Professor of Medicine (Gastroenterology and Hepatology)
Division of Gastroenterology, Department of Internal Medicine,
Northwestern University Feinberg School of Medicine, Chicago, IL, USA

John A. Chabot, MD, FACS
Chief, Division of GI/Endocrine Surgery
Columbia University Irving Medical Center, Herbert Irving
Comprehensive Cancer Center, New York, NY, USA

Andrew T. Chan, MD, MPH
Professor
Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA

Lin Chang, MD
Professor of Medicine
David Geffen School of Medicine at UCLA, Los Angeles, CA, USA

Joan W. Chen
Gastroenterologist
University of Michigan, Ann Arbor, MI, USA

Kyung Jae Cho, MD, FSIR
Professor Emeritus
Radiology, Department of Radiology, Division of Vascular and Interventional Radiology, Michigan Medicine,
Ann Arbor, MI, USA;
University of Michigan Frankel Cardiovascular Center,
Ann Arbor, MI, USA

Daniel C. Chung, MD
Associate Professor
Massachusetts General Hospital,
Boston, MA, USA

Mitchell B. Cohen, MD
Chair
Department of Pediatrics, University of Alabama at Birmingham,
Birmingham, AL, USA

Margaret H. Collins, MD
Director of Pathology
Cincinnati Children's Hospital Medical Center and University of Cincinnati College of Medicine, Cincinnati, OH, USA

Darwin L. Conwell, MD
Physician
Division of Gastroenterology, Hepatology, and Nutrition,
Ohio State University Wexner Medical Center, Columbus, OH, USA

Emmanuel Coronel, MD
Gastroenterologist and Advanced Therapeutic Endoscopist
University of Texas, MD Anderson Cancer Center, Houston, TX, USA

Philip I. Craig, MB, BS, FRACP, PhD
Associate Professor
St George and Sutherland Clinical School, University of New South Wales, Sydney, Australia;
Department of Gastroenterology and Hepatology,
St George Hospital, Kogarah, New South Wales, Australia

Marcia Cruz-Correa, MD, PhD
Professor
University of Puerto Rico Medical Sciences Campus and Comprehensive Cancer Center, San Juan, Puerto Rico

Laurie D. DeLeve, MD, PhD
Professor of Medicine
USC Keck School of Medicine, USC Research Center for Liver Diseases and Division of Gastrointestinal and Liver Diseases, Los Angeles, CA, USA

Evan S. Dellon, MD, MPH
Professor
Department of Medicine, Division of Gastroenterology and Hepatology, School of Medicine, University of North Carolina, Chapel Hill, NC, USA

John K. DiBaise, MD
Professor of Medicine
Mayo Clinic in Arizona, Scottsdale, AZ, USA

Eric C. Ehman, MD
Assistant Professor
Mayo Clinic, Rochester, MN, USA

Emad M. El-Omar, BSC(Hons), MB, CHB, MD(Hons)
Professor of Medicine
Microbiome Research Center, St George and Sutherland Clinical School, University of New South Wales, Sydney, Australia

B. Mark Evers, MD, FACS
Professor of Surgery
Director, Markey Cancer Center
Director, Markey Cancer Center Affiliate Network
Physician in Chief of Oncology Service
Vice-Chair for Research, Department of Surgery
University of Kentucky, Lexington, KY, USA

David R. Farley, MD
Professor of Surgery
Mayo Clinic, Rochester, MN, USA

James J. Farrell, MD, MBChB
Director
Yale Center for Pancreatic Diseases and Advanced Endoscopy,
Yale School of Medicine, New Haven, CT, USA

Maria Rosario Ferreira, MD
Assistant Professor
Medicine (Gastroenterology and Hepatology), Northwestern University Feinberg School of Medicine, Chicago, IL, USA

José Ferrusquía-Acosta, MD
Hepatologist
Hepatic Hemodynamic Laboratory, Liver Unit, Institute of Gastrointestinal and Metabolic Diseases, Hospital Clinic Barcelona, Institute of Biomedical Research August Pi i Sunyer (IDIBAPS), Barcelona, Spain

Elliot K. Fishman, MD
Professor of Radiology and Radiological Science
Johns Hopkins University, Baltimore, MD, USA

Mary Flanagan, MD
Specialist Registrar
Paediatric Gastroenterology, Children's Health Ireland at Crumlin, University College Dublin, Dublin;
Royal College of Surgeons in Ireland, Dublin, Ireland

Robert J. Fontana, MD
Professor
Division of Gastroenterology, University of Michigan,
Ann Arbor, MI, USA

Alyson N. Fox, MD
Medical Director
Living Donor Liver Team, Center for Liver Disease and Transplantation, Columbia University Medical Center, Department of Gastroenterology and Hepatology, New York, USA

Mary Raina Angeli Fujiyoshi, MD
Research Fellow
Digestive Diseases Center, Showa University Koto Toyosu Hospital, Tokyo, Japan

Yusuke Fujiyoshi, MD
Assistant Professor
Digestive Diseases Center, Showa University Koto Toyosu Hospital, Tokyo, Japan

John J. Garber, MD
Associate Medical Director
Translational Medicine at Vertex Pharmaceuticals Boston, MA, USA; Massachusetts General Hospital, Instructor, Harvard Medical School Boston, MA, USA

Guadalupe Garcia-Tsao, MD
Professor of Medicine
Yale University School of Medicine, New Haven, CT, USA

Timothy B. Gardner, MD, MS
Associate Professor of Medicine
Dartmouth-Hitchcock Medical Center, Lebanon, NH, USA

Omar M. Ghanem, MD
Bariatric Surgeon
Mayo Clinic, Rochester, MN, USA

Marc G. Ghany, MD
Gastroenterologist
National Institute of Diabetes, Digestive and Kidney Diseases, National Institutes of Health, Bethesda, MD, USA

Victoria Gómez, MD
Associate Professor of Medicine
Mayo Clinic, Jacksonville, FL, USA

Tamas A. Gonda, MD
Gastroenterologist
Chief of Endoscopy, Department of Medicine, Tisch Hospital, and Pancreas Disease Program, New York University, New York, USA

Nirmala Gonsalves, MD
Professor of Medicine (Gastroenterology and Hepatology)
Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Beth Gordon, MD
Gastroenterologist
Children's Health Ireland at Crumlin, University College Dublin, Dublin; Royal College of Surgeons in Ireland, Dublin, Ireland

Sugantha Govindarajan, MD
Professor of Pathology
USC Keck School of Medicine, Los Angeles, CA, USA

Richard J. Grand, MD
Director Emeritus
Boston Children's Hospital, Boston, MA, USA

Chandan Guha, MBBS, PhD
Professor
Department of Radiation Oncology, Albert Einstein College of Medicine, Montefiore Medical Center, New York, USA

Sunil Gupta, MD
University of Sydney, Westmead Clinical School, Sydney, New South Wales, Australia

Christina Ha, MD
Clinical Associate Professor
F. Widjaja Foundation Inflammatory Bowel and Immunobiology Research Institute, Cedars-Sinai Medical Center, Los Angeles, CA, USA; David Geffen School of Medicine at UCLA, Los Angeles, CA, USA

Phil A. Hart, MD
Program Director
Pancreas Fellowship, Ohio State University Wexner Medical Center, Columbus, OH, USA

Gail A. Hecht, MD
Professor
Division Director, Gastroenterology and Nutrition
Department of Medicine, Loyola University Medical Centre Maywood, IL, USA

Yasmin G. Hernandez-Barco, MD
Gastroenterologist
Massachusetts General Hospital, Boston, MA, USA

Ikuo Hirano, MD
Professor of Medicine (Gastroenterology and Hepatology)
Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Karen M. Horton, MD
Professor of Radiology and Radiological Science
Director (Chair),
Johns Hopkins University, Baltimore, MD, USA

Séamus Hussey, MD
Consultant Gastroenterologist
Children's Health Ireland at Crumlin, University College Dublin, Dublin; Royal College of Surgeons in Ireland, Dublin, Ireland

Haruo Ikeda, PhD
Professor
Digestive Diseases Center, Showa University Koto Toyosu Hospital, Tokyo, Japan

Haruhiro Inoue, MD, PhD, FASGE
Professor and Chairman
Digestive Diseases Center, Showa University Koto Toyosu Hospital, Tokyo, Japan

Shayan Irani, MD
Gastroenterologist
Digestive Disease Institute, Virginia Mason Medical Center, Seattle, WA, USA

Edward N. Janoff, MD
Clinical Professor
University of Colorado Health Sciences Center Denver, Aurora, CO, USA; Veterans Affairs Medical Center, Denver, CO, USA

Robert T. Jensen, MD
Section Chief
Gastrointestinal Cell Biology Section, Digestive Disease Branch, National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health, Bethesda, MD, USA

Mathurika Jeyasingam, MD
Chief Resident
Division of Nuclear Medicine and Molecular Sciences,
Russel H. Morgan Department of Radiology,
Johns Hopkins Hospital, Baltimore, MD, USA

Audrey R. Odom John, MD, PhD
Chief
Children's Hospital of Philadelphia,
Division of Pediatric Infectious Diseases
Philadelphia, PA, USA

Pamela T. Johnson, MD
Professor of Radiology and Radiological Science
Vice President of Care Transformation, Johns Hopkins Health System,
Johns Hopkins University, Baltimore, MD, USA

Stella Joyce, MB, BCh, BAO, MRCPI, MRCP(UK)
Radiology Resident
Department of Radiology, University College Cork,
Cork University Hospital, Cork, Ireland

Barbara H. Jung, MD
Professor of Medicine
University of Washington, Seattle, WA, USA

Peter J. Kahrilas, MD
Professor of Medicine (Gastroenterology and Hepatology)
Northwestern University, Feinberg School of Medicine,
Chicago, IL, USA

Patrick S. Kamath, MD
Professor of Medicine
Mayo Clinic College of Medicine and Science, Rochester, MN, USA

Alyson J. Kaplan, MD
Fellow
Department of Gastroenterology and Hepatology,
New York Presbyterian Weill Cornell Medical Center,
New York, USA

David A. Katzka, MD
Professor of Medicine
Department of Gastroenterology and Hepatology
Mayo Clinic, Rochester, MN, USA

Margaret G. Keane, MD
Advanced Endoscopy Fellow
Johns Hopkins Hospital, Baltimore, MD, USA

Todd A. Kellogg, MD
General Surgeon
Department of Surgery, Mayo Clinic, Rochester, MN, USA

Samuel Kesseli, MD
Resident
Duke University Medical Center, Durham, NC, USA

Mouen A. Khashab, MD
Associate Professor
Johns Hopkins Hospital, Baltimore, MD, USA

Sun A. Kim, MD, MS, PhD
Assistant Professor
Pathology, The George Washington University,
Washington, DC, USA

Ravi Pokala Kiran, MD
Chief and Program Director, Division of Colorectal Surgery
Director, Center for Innovation and Outcomes Research
Columbia University Irving Medical Center,
Department of Surgery, New York, USA

Richard A. Kozarek, MD
Executive Director
Digestive Disease Institute, Virginia Mason Medical Center,
Seattle, WA, USA

Abraham Krikhely, MD, FACS
Assistant Professor of Surgery
Columbia University Irving Medical Center, New York, USA

Uri Ladabaum, MD
Professor of Medicine
Division of Gastroenterology and Hepatology,
Stanford University School of Medicine, Stanford, CA, USA

Laura Lamps, MD
Director
Department of Gastrointestinal Pathology,
University of Michigan, Ann Arbor, MI, USA

Jacob C. Langer, MD
Professor of General Surgery
University of Toronto and Hospital for Sick Children,
Toronto, ON, Canada

Ryan J. Law, DO
Gastroenterologist
Mayo Clinic, Rochester, MN, USA

Konstantinos N. Lazaridis, MD
Professor of Medicine
Division of Gastroenterology and Hepatology,
Mayo Clinic, Rochester, MN, USA

Benjamin Lebwohl, MD
Herbert Irving Associate Professor of Medicine
Assistant Professor of Epidemiology
Columbia University Irving Medical Center,
New York, NY, USA

Daniel A. Leffler, MD
Gastroenterologist
Beth Israel Deaconess Medical Center, Boston, MA, USA

Jonathan A. Leighton, MD
Internist
Division of Gastroenterology and Hepatology,
Mayo Clinic, Scottsdale, AZ, USA

Anne Marie Lennon, MD, PhD
Director
Division of Gastroenterology and Hepatology,
Johns Hopkins Hospital, Baltimore, MD, USA

Joseph W. Leung, MD
Professor Emeritus
Sacramento VA Medical Center, VA Northern California Health Care System, Mather, CA, USA;
University of California Davis School of Medicine, Sacramento, CA, USA

Marc S. Levin, MD, AGAF
Professor of Medicine
Division of Gastroenterology, John T. Milliken Department of Medicine
Washington University School of Medicine, St Louis, MO, USA

Marc S. Levine, MD, FACR
Emeritus Professor CE of Radiology
Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, PA USA

T. Jake Liang, MD
Chief
Liver Diseases Branch, National Institute of Diabetes, Digestive and Kidney Diseases, National Institutes of Health, Bethesda, MD, USA

Anna S. Lok, MD
Professor
Division of Gastroenterology and Hepatology, Department of Internal Medicine, University of Michigan, Ann Arbor, MI, USA

Val J. Lowe, MD
Professor
Department of Radiology, Mayo Clinic College of Medicine, Mayo Clinic, Rochester, MN, USA

Shelly C. Lu, MD
Gastroenterologist
Cedars-Sinai Medical Center, Los Angeles, CA, USA

Jay Luther, MD
Director
Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA

Michael M. Maher, MD
Professor
Department of Radiology, University College Cork, Cork University Hospital, Cork, Ireland

Carolina Malagelada, MD
Digestive System Specialist
Hospital Universitari Vall d'Hebron, Autonomous University of Barcelona, Barcelona, Spain

Juan-Ramón Malagelada, MD
Researcher
Digestive System Research Unit, Hospital General Universitari Vall d'Hebron, Autonomous University of Barcelona, Barcelona, Spain

Harmeet Malhi, MBBS
Associate Professor of Physiology
Mayo Clinic, Rochester, MN, USA

Michael P. Manns, MD
President
Hannover Medical School, Hannover, Germany

Jorge A. Marrero, MD
Medical Director
Liver Transplantation, University of Texas Southwestern Medical Center, Dallas, TX, USA

Marlyn J. Mayo, MD
Professor
Internal Medicine, University of Texas Southwestern Medical Center, Dallas, TX, USA

Dermot P.B. McGovern, MD, FRCP, PhD
Director of Translational Medicine
F. Widjaja Foundation Inflammatory Bowel and Immunobiology Research Institute, Cedars-Sinai Medical Center, Los Angeles, CA, USA;
David Geffen School of Medicine at UCLA, Los Angeles, CA, USA

Gil Y. Melmed, MD, MS
Assistant Clinical Professor of Medicine
David Geffen School of Medicine at UCLA, Los Angeles, CA, USA;
F. Widjaja Foundation Inflammatory Bowel and Immunobiology Research Institute, Cedars-Sinai Medical Center, Los Angeles, CA, USA

David C. Metz, MBBCh
Professor of Medicine
Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA

Kevin P. Murphy, MD
Consultant Radiologist
Mercy University Hospital, Cork, Ireland;
Department of Radiology, University College Cork, Cork University Hospital, Cork, Ireland

Lalitha S. Y. Nanduri, PhD
Instructor
Department of Radiation Oncology, Albert Einstein College of Medicine, Montefiore Medical Center, New York, USA

Haresh Naringrekar, MD
Clinical Assistant Professor
Diagnostic Radiology, Thomas Jefferson University Hospital, Philadelphia, PA, USA

Owen J. O'Connor, MD
Senior Lecturer and Consultant Radiologist
Department of Radiology, University College Cork, Cork University Hospital, Cork, Ireland

Paula O'Leary, MD
Professor
Department of Medicine Roinn na Sláinte, University College Cork, Cork, Ireland

Manabu Onimaru, MD, PhD
Professor
Digestive Diseases Center, Showa University Koto Toyosu Hospital, Tokyo, Japan

Nicole C. Panarelli, MD
Associate Professor
Department of Pathology, Albert Einstein College of Medicine, Montefiore Medical Center, New York, USA

John E. Pandolfino, MD
Chief
Gastroenterology and Hepatology, Northwestern University Medical School, Chicago, IL, USA

Henry P. Parkman, MD
Professor
Department of Medicine, Lewis Katz School of Medicine at Temple University, Philadelphia, PA, USA

Shabana F. Pasha, MD
Gastroenterologist
Division of Gastroenterology and Hepatology, Mayo Clinic, Scottsdale, AZ, USA

Tushar Patel, MB, ChB
Professor of Medicine
Mayo Clinic, Jacksonville, FL, USA

Richard M. Peek Jr, MD
Director
Division of Gastroenterology, Vanderbilt University Medical Center, Nashville, TN, USA

Roman E. Perri, MD
Assistant Professor of Medicine
Vanderbilt University Medical Center, Nashville, TN, USA

M. Blanca Piazuelo, MD
Research Associate Professor of Medicine
Division of Gastroenterology, Department of Medicine, Vanderbilt University Medical Center, Nashville, TN, USA

Piero Portincasa, MD, PhD
Professor of Medicine
University of Bari Medical School, Policlinico Hospital, Bari, Italy

David O. Prichard, MB, BCh, PhD
Gastroenterologist
Mayo Clinic College of Medicine, Rochester, MN, USA

Krish Ragunath, MD, DNB, MPhil, FRCP, FRACP, FASGE, FJGES
Professor and Director of Research (Medicine)
Programme Lead
Curtin Medical School, Curtin Health Innovation Research Institute, Curtin University, Bentley Campus, Perth, WA, Australia; University of Nottingham, Nottingham, UK

David S. Raiford, MD
Chief, Medical Staff
Vanderbilt University Medical Center, Nashville, TN, USA

Aashish Rajesh, MD, MBBS
General Surgery Resident
University of Texas Health Science Center, San Antonio, TX, USA

Siva P. Raman, MD
Assistant Professor of Radiology
Johns Hopkins University, Baltimore, MD, USA

Mitchell L. Ramsey, MD
Fellow
Division of Gastroenterology, Hepatology, and Nutrition, The Ohio State University Wexner Medical Center, Columbus, OH, USA

Jean-Pierre Raufman, MD
Division Head
Gastroenterology and Hepatology, University of Maryland School of Medicine, and Veterans Affairs Maryland Health Care System, Baltimore, MD, USA

Craig C. Reed, MD, MSCR
Assistant Professor of Medicine
Department of Medicine, Division of Gastroenterology and Hepatology, School of Medicine, University of North Carolina, Chapel Hill, NC, USA

Douglas K. Rex, MD
Distinguished Professor Emeritus
Division of Gastroenterology and Hepatology, Indiana University School of Medicine, Indianapolis, IN, USA

Mona Rezapour, MD, MHS
Gastroenterologist
University of California Los Angeles, Los Angeles, CA, USA

Nicole E. Rich, MD
Assistant Professor
Internal Medicine, University of Texas Southwestern Medical Center, Dallas, TX, USA

Don C. Rockey, MD
Professor
Digestive Disease Research Center, Department of Internal Medicine, Medical University of South Carolina, Charleston, SC, USA

Marc E. Rothenberg
Director
Division of Allergy and Immunology, Cincinnati Children's Hospital Medical Center and University of Cincinnati College of Medicine, Cincinnati, OH, USA

Stephen E. Rubesin, MD
Emeritus Professor CE of Radiology
Hospital of the University of Pennsylvania, Philadelphia, PA, USA

Deborah C. Rubin, MD, AGAF
Professor
Washington University School of Medicine, St Louis, MO, USA

Anil K. Rustgi, MD
Professor of Medicine
Herbert Irving Comprehensive Cancer Center, Columbia University Irving Medical Center, New York, NY, USA

Arun J. Sanyal, MD
Professor
Department of Internal Medicine, Division of Gastroenterology, Hepatology and Nutrition, Virginia Commonwealth University, Richmond, VA, USA

Antonia R. Sepulveda, MD, PhD
Professor of Pathology
George Washington University, Washington, DC, USA

Zarine K. Shah, MD
Department of Radiology, The Ohio State University Wexner Medical Center, Columbus, OH, USA

Nicholas J. Shaheen, MD, MPH
Chief
Department of Medicine, Division of Gastroenterology and Hepatology, School of Medicine, University of North Carolina, Chapel Hill, NC, USA

Neal Shahidi, MD
Gastroenterologist
Department of Medicine, St. Paul's Hospital, University of British Columbia, Vancouver, British Columbia, Canada;
Department of Gastroenterology and Hepatology, Westmead Hospital, Sydney, New South Wales, Australia

Nizamuddin Shaikh, MD, MBBS
General Surgeon
Mayo Clinic, Rochester, MN, USA

Fergus Shanahan, MD
Professor and Chairman
Department of Medicine, University College Cork, Cork, Ireland

Bo Shen, MD
Professor of Medicine
Columbia University Irving Medical Center, New York Presbyterian Hospital, New York, NY, USA

Nicole T. Shen, MD
Fellow
Department of Gastroenterology and Hepatology, New York Presbyterian Weill Cornell Medical Center, New York, USA

Yuto Shimamura, MD
Assistant Professor
Digestive Diseases Center, Showa University Koto Toyosu Hospital, Tokyo, Japan

Mohammad S. Siddiqui, MD
Associate Professor
Division of Gastroenterology, Hepatology and Nutrition, Virginia Commonwealth University, Richmond, VA, USA

Siddharth Singh, MD, MS
Assistant Professor of Medicine
Division of Gastroenterology, Department of Medicine, University of California San Diego, La Jolla, CA, USA

Phillip D. Smith, MD
Professor of Medicine
Division of Gastroenterology and Hepatology, University of Alabama at Birmingham, Birmingham, AL, USA

Sergei A. Sobolevsky, MD, MBA
Managing Physician
Modern Vascular Hospital, Mesa, AZ, USA

Amin K. Soltani
Gastroenterology Clinical Fellow
Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA

Louis-Michel Wong Kee Song, MD
Associate Professor
Mayo Clinic College of Medicine and Science, Rochester, MN, USA

Scott D. Stevens, MD, FACR
Associate Professor of Radiology
Division of Abdominal Radiology, University of Kentucky, Lexington, KY, USA

Neil Stollman, MD, FACP, FACG, AGAF
Associate Clinical Professor
Alta Bates Summit Medical Center,
East Bay Center for Digestive Health, Oakland, CA, USA

Debra Sudan, MD
Professor of Surgery
Duke University Medical Center, Durham, NC, USA

Kazuki N. Sugahara, MD, PhD
Assistant Professor
Surgical Sciences, Columbia University Irving Medical Center, New York, NY, USA

Garima Suman, MD
Fellow
Mayo Clinic School of Medicine, Mayo Clinic, Rochester, MN, USA

Seth Sweetser, MD
Associate Professor
Division of Gastroenterology and Hepatology,
Department of Medicine, Mayo Clinic College of Medicine, Rochester, MN, USA

Lawrence Szarka, MD
Gastroenterologist
Mayo Clinic College of Medicine, Rochester, MN, USA

Andrew W. Tai, MD
Gastroenterologist
University of Michigan and VA Ann Arbor Healthcare System, Ann Arbor, MI, USA

Phillip I. Tarr, MD
Division Chief, Gastroenterology, Hepatology and Nutrition Co-Leader Pathobiology Research Unit,
Department of Pediatrics, Melvin E. Carnahan Professor of Pediatrics, Professor of Molecular Microbiology
Washington University, St Louis, MO, USA

Richard Taubert, MD
Gastroenterologist
Hannover Medical School, Hannover, Germany

Gabriella Torres, MD
Research Fellow
Pan American Center for Oncology Trials, San Juan, Puerto Rico;
Internal Medicine, Municipal Hospital, San Juan, Puerto Rico

Jerrold R. Turner, MD, PhD
Professor
Laboratory of Mucosal Barrier Pathobiology, Department of Pathology,
Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA

Travis W. Vandergriff, MD
Associate Professor
Dermatology, University of Texas Southwestern Medical Center, Dallas, TX, USA

Hugo E. Vargas, MD
Gastroenterologist
Mayo Clinic, Scottsdale, AZ, USA

Elizabeth J. Videlock, MD
Clinical Instructor
Division of Digestive Diseases, Department of Medicine,
David Geffen School of Medicine at UCLA,
Los Angeles, CA, USA

Erik C. von Rosenvinge, MD
Associate Professor
University of Maryland School of Medicine,
Baltimore, MD, USA;
Veterans Affairs Maryland Health Care System, Baltimore, MD, USA

Arnold Wald, MD
Professor
Gastroenterology and Hepatology
Department of Medicine
School of Medicine and Public Health
University of Wisconsin-Madison,
Madison, WI, USA

David Q.-H. Wang, MD, PhD
Professor
Department of Medicine and Genetics,
Albert Einstein College of Medicine, New York, USA

M. Kay Washington, MD, PhD
Professor of Pathology
Vanderbilt University Medical Center, Nashville, TN, USA

Irving Waxman, MD
Professor of Medicine and Surgery
Department of Medicine and Surgery; Division of Digestive Diseases & Nutrition;
Digestive Disease Service Line for Rush University System for Health,
Chicago, IL, USA

Joel V. Weinstock, MD
Professor
Medicine, Tufts Medical Center, Boston, MA, USA

Theodore H. Welling, MD
Director
Liver Tumor Program, NYU Langone Health, New York, USA

Maria Westerhoff, MD
Associate Professor
Gastrointestinal and Hepatobiliary Pathology,
Department of Pathology,
Michigan Medicine, University of Michigan,
Ann Arbor, MI, USA

David C. Whitcomb, MD, PhD
Professor of Medicine
Giant Eagle Foundation Professor of Cancer Genetics, Department of Medicine,
Cell Biology & Molecular Physiology, and Human Genetics,
Division of Gastroenterology,
Hepatology and Nutrition, University of Pittsburgh and University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA

Jonathan R. White, MBChB, MRCP
NIHR Nottingham Biomedical Research Centre,
Nottingham University Hospitals NHS Trust and
University of Nottingham, Nottingham, UK

Jennifer M. Whittington, MD, PhD
Assistant Attending of Surgical Oncology
NYU Long Island Surgical Oncology Associates
Assistant Professor in the Department of Surgery,
NYU Long Island School of Medicine, NYU Langone Health,
Mineola, NY, USA

C. Mel Wilcox, MD
Professor Emeritus
University of Alabama at Birmingham, Birmingham, AL, USA

Grace L.H. Wong, MD, FRCP
Professor
Institute of Digestive Disease, The Chinese University of
Hong Kong, Hong Kong Special Administrative Region, China

Andrew W. Yen, MD
Gastroenterologist
Sacramento VA Medical Center, VA Northern California Health Care System,
Mather, CA, USA;
University of California Davis School of Medicine, Sacramento, CA, USA

Harvey A. Ziessman, MD
Professor
Johns Hopkins University, Baltimore, MD, USA

Yael Haberman Ziv, MD
Pediatric Gastroenterologist
Cincinnati Children's Hospital Medical Center and
University of Cincinnati College of Medicine,
Cincinnati, OH, USA

Preface

Gastroenterology and hepatology remain highly visual specialties, in part because of the tremendous accessibility of the luminal gastrointestinal tract and the variety of other internal organs as well as advanced imaging modalities. Thus, in addition to standard views of cross-sectional imaging and histopathological analysis used in many disorders, the field encompasses multimodal endoscopic imaging, which has continued to advance over the last decade. This sixth edition of *Yamada's Atlas of Gastroenterology* continues to offer diverse images that provide an overview of the digestive field, but the objective is to achieve an overview through pictures and illustrations rather than through text. Consequently, this Atlas is designed to complement and accompany the primary textbook in the field, the seventh edition of *Yamada's Textbook of Gastroenterology*.

This sixth edition of the *Atlas* and the seventh edition of the *Textbook* represent the transition from the previous Editor-in-Chief, Dr Daniel K. Podolsky, to a new set of Editors-in-Chief and a new team of Associate Editors. This new editorial team has made changes to and updated both the main *Textbook* and the *Atlas*. Changes to the former have been much more substantial, and included a greater focus on the human microbiome, obesity, bariatric endoscopy and aging, along with consolidation of many older chapters. In contrast, changes to the *Atlas* have focused on updating chapters from prior editions, and the addition of several new *Atlas* chapters. Nevertheless, the *Atlas*, like the *Textbook*, continues to cover most aspects of gastroenterology and hepatology with a broad, global perspective.

This newest edition of the *Atlas*, a compendium to the *Textbook*, includes key figures as well as supplementary images designed to provide a highly informative snapshot of major gastrointestinal diseases covered in the *Textbook*. The *Atlas* starts with anatomy and development, then covers each of the key gastrointestinal organs and their diseases, along with miscellaneous disorders, and ends with several chapters on diagnostic and therapeutic modalities in gastroenterology. Thus, it follows roughly the organizational structure of the newest edition of the *Textbook*, but with a much greater focus on images, including gross and microscopic anatomy, and the full range of imaging modalities, including endoscopy, spanning many newer technologies.

The *Atlas* is designed for a wide spectrum of readers, including students, residents, fellows and other trainees, practicing clinicians, professors, and related specialists. For a busy trainee or clinician seeking a quick introduction to the spectrum of GI diseases, the *Atlas* represents a practical and useful introduction to important disorders, building on the notion that in some instances, a "picture is worth a thousand words" and that images can often communicate complex ideas more effectively. We are hopeful that the pictorial reproductions and representations will bring to life the salient points accurately and comprehensively detailed in the *Textbook*.

This *Atlas*, as with the *Textbook*, would not have been possible without the effort of many individuals. We would like to thank all of our Editors, our teachers and mentors, our patients, and our partners and publishers at Wiley. In particular, we would like to thank our authors for procuring from their practice the many outstanding, supplementary images that have served as the foundation for this *Atlas*.

On behalf of all the Editors, we are excited to present to our readers this sixth edition of the *Atlas*, which we hope will be a resource for all students and practitioners of gastroenterology and hepatology.

Timothy C. Wang, MD
Michael Camilleri, MD

About the companion website

This book is accompanied by a companion website:

www.yamadagastro.com/atlas6e 

The website includes:

- Videos
- Figures from the book as downloadable PowerPoint slides

PART 1

Anatomy and development

CHAPTER 1

Esophagus: anatomy and structural anomalies

Ikuo Hirano
Northwestern University Feinberg School of Medicine, Chicago, IL, USA

An understanding of the normal and abnormal histology and structure is essential to the clinical care of patients with esophageal disorders. Esophageal biopsies obtained during endoscopy sample the squamous mucosa and, less commonly, the lamina propria of the esophageal wall. The histological evaluation of submucosal glands, Meissner and myenteric ganglia, and the muscularis propria depicted in Figure 1.1 traditionally requires surgical biopsy. Endoscopic ultrasonography (EUS) can evaluate the structural integrity and anomalies of deeper structures, including the muscularis propria. Endoscopic mucosal resection and per oral esophageal myotomy allow for histological evaluation of deeper mural structures. Extrinsic compression of the esophagus by adjacent mediastinal structures as shown in Figure 1.2 is better appreciated on radiographic barium examination, EUS, or cross-sectional imaging than endoscopy. Feline esophagus is depicted in Figure 1.3 and can be mistaken for esophageal rings in eosinophilic esophagitis. The feline pattern is transient plications visualized during retching and esophageal shortening and may represent contraction of the muscularis mucosa. Upon relaxation of the esophageal musculature and luminal distension with air insufflation, the plications disappear.

Esophageal developmental anomalies include vascular lesions, duplications, and heterotopic gastric mucosa. Congenital esophageal stenosis is caused by tracheobronchial cartilaginous remnants, fibromuscular wall hypertrophy, and membranous web formation. While typically presenting in childhood, delayed presentation in adults occurs as shown in Figure 1.4. Dysphagia lusoria is caused by extrinsic compression of the thoracic esophagus by congenital anomalies of the aortic arch, most commonly by an aberrant take-off of the right subclavian artery from the left side of the aortic arch (Figure 1.5). Congenital venous malformations illustrated in Figure 1.6 represent another vascular anomaly and are distinct from esophageal varices as vascular obstruction or portal hypertension is not present in the former. Congenital esophageal duplications assume both tubular (Figure 1.7) and cystic (Figures 1.8 and 1.9) forms. While most are apparent before the age of 1 year, 25% can present in adults with symptoms of dysphagia. Heterotopic gastric mucosa (inlet patch) shown in Figure 1.10 is a common congenital anomaly detected with a prevalence of 4% based on an autopsy series. Infrequently, this anomaly is associated with cervical esophageal stricture (Figure 1.11) and web formation (Figure 1.12). Other uncommon developmental anomalies include esophageal atresia, congenital esophageal stenosis, and bronchopulmonary foregut malformations.

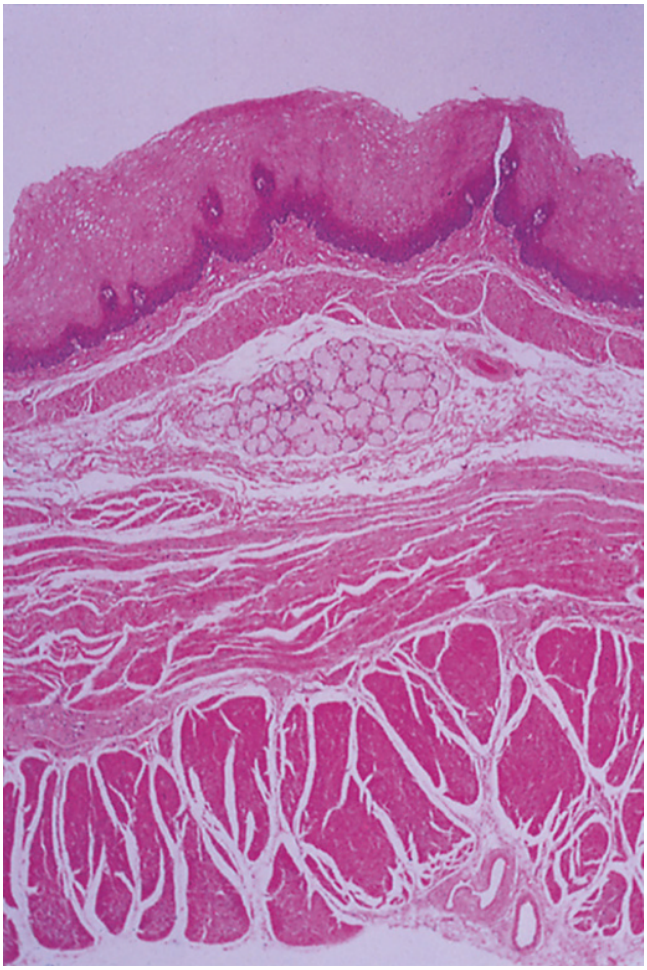
Structural esophageal anomalies include esophageal rings and webs, cricopharyngeal bar, pharyngoesophageal diverticula, and diffuse idiopathic skeletal hyperostosis of the cervical spine. The most widely recognized structural anomaly is the lower esophageal mucosal or Schatzki ring that is found in about 10% of adults. It is one of the most common causes of dysphagia and food impaction, although the majority of Schatzki rings are asymptomatic. The inner diameter of the ring is a critical determinant for dysphagia and can be assessed on endoscopic retroflexed view (Figure 1.13) or ingestion of a barium tablet of known diameter. A cricopharyngeal bar is found in 5–19% of radiographic studies of the pharynx (Figure 1.14). Like Schatzki rings, the majority are not associated with dysphagia.

Figure 1.15 illustrates progressive enlargement of a Zenker diverticum with normalization of the pharyngeal outpouching following surgery. Therapeutic options for symptomatic cricopharyngeal bars and Zenker diverticula include both endoscopic and surgical approaches. Epiphrenic diverticula arise from the distal esophagus and are often associated with an underlying spastic esophageal motility disorder. With time, the diverticula can increase in size, resulting in food retention, bezoar formation, and symptoms of regurgitation (Figures 1.16–1.18).

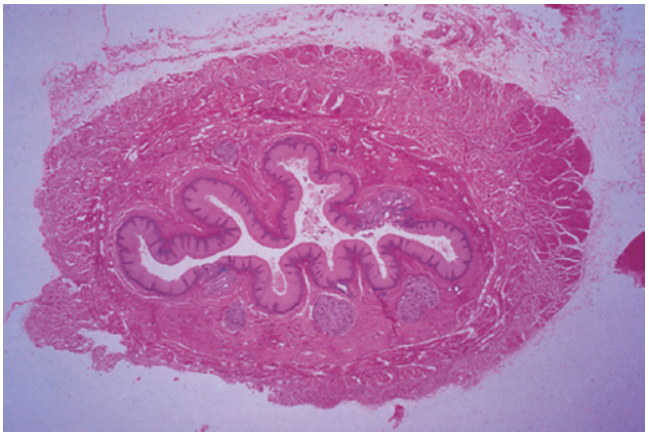
Treatment for large or symptomatic epiphrenic diverticula is most commonly surgical and includes not only a diverticulectomy but also treatment of the underlying motility disorder. Intramural pseudodiverticulosis is a rare finding best appreciated on barium esophagram rather than upper endoscopy. The

Yamada's Atlas of Gastroenterology, Sixth Edition. Edited by Timothy C. Wang, Michael Camilleri, Benjamin Lebwohl, Anna S. Lok, William J. Sandborn, Kenneth K. Wang, and Gary D. Wu.

Companion website: www.yamadagastro.com/atlas6e



(a)



(b)

Figure 1.1 **(a)** This cross-section (×2.5) from the middle third of the esophagus has a mixture of skeletal and predominantly smooth muscle in the muscularis propria. The submucosal glands are clearly shown. An esophageal cardiac gland in which a small focus of glandular epithelium interrupts the squamous mucosa is a normal finding, seen in at least 1% of all esophagi. **(b)** Longitudinal section of esophageal wall (×10). Source: Courtesy of Rodger C. Haggitt, MD, Seattle, WA.

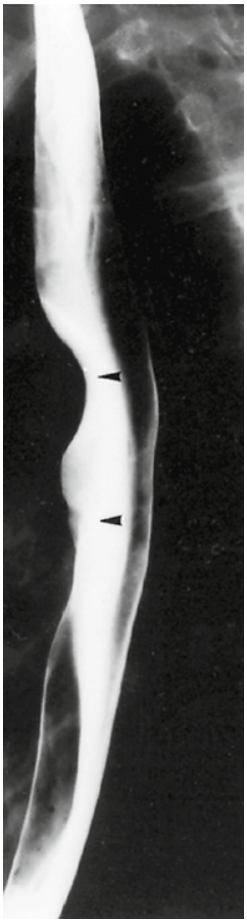
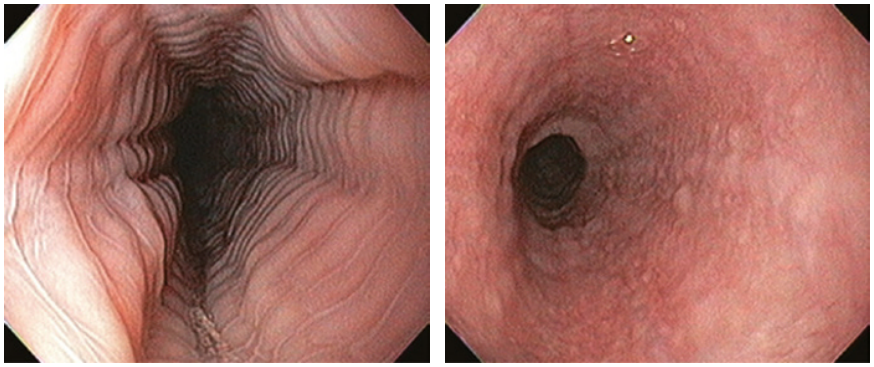


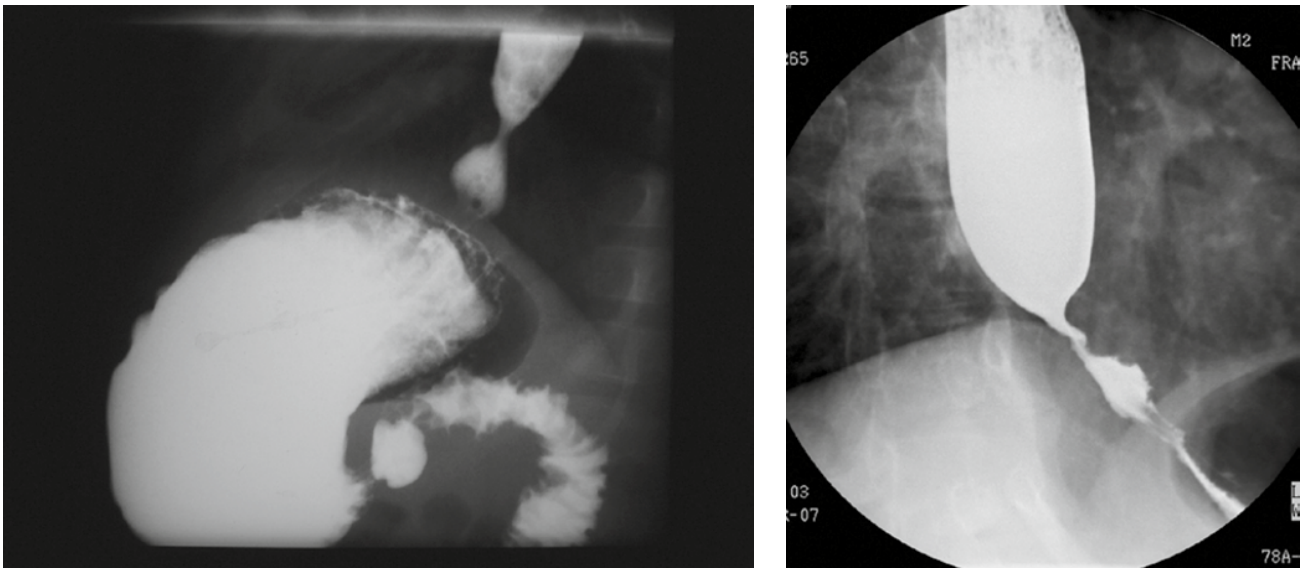
Figure 1.2 Barium esophagram shows normal indentation of the esophageal lumen by the aorta (top arrow) and left mainstem bronchus (bottom arrow).

disorder results from dilation of the excretory ducts of submucosal esophageal glands and is associated with proximal esophageal strictures and esophageal candidiasis. Diffuse idiopathic skeletal hyperostosis (DISH) of the cervical spine leads to ossification of the anterolateral ligaments and enthuses. Dysphagia may result from extrinsic compression of the cervical esophagus (Figure 1.19).



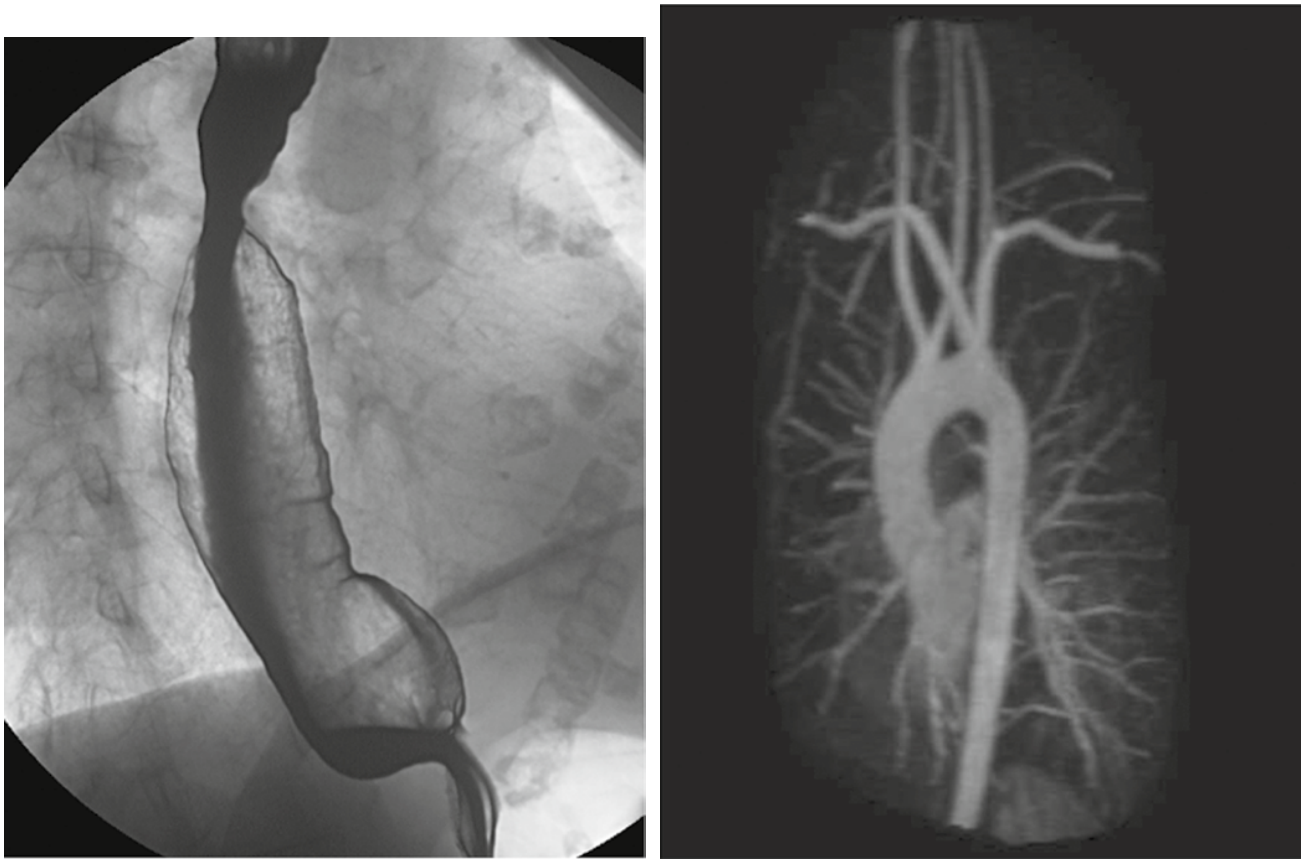
(a) (b)

Figure 1.3 **(a)** Feline esophagus demonstrating rippling or plications of the esophageal mucosa. This is a transient occurrence and disappears with continued observation as shown in the left panel. **(b)** Eosinophilic esophagitis can present with a similar appearance but the rings persist with air insufflation and are less tightly spaced apart.



(a) (b)

Figure 1.4 Barium esophagram of a patient with congenital esophageal stenosis. Initial study at age 1 **(a)** with subsequent image at age 20 **(b)** showing a persistent distal esophageal stricture.



(a) (b)

Figure 1.5 Dysphagia lusoria represents symptomatic esophageal compression by a vascular anomaly of the aortic arch, most commonly by an aberrant right subclavian artery. **(a)** Barium esophagram in a patient reveals thoracic esophageal compression by an aberrant right subclavian artery posterior to the esophagus. **(b)** Magnetic resonance angiography reveals an aberrant right subclavian artery arising from the aortic arch.

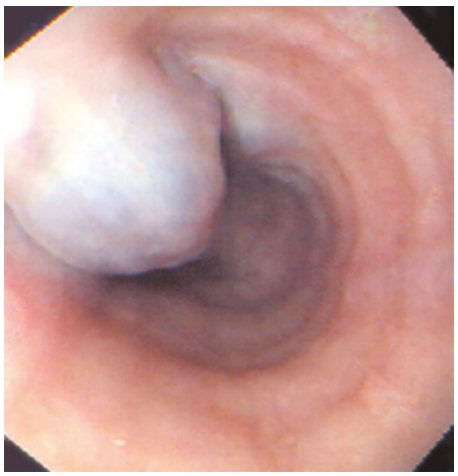
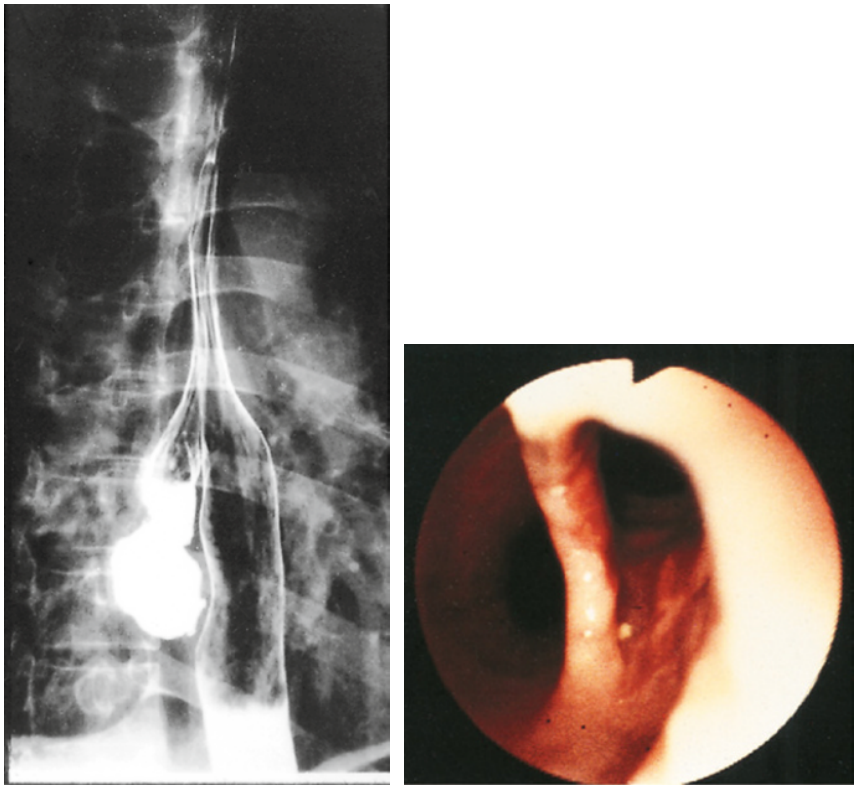
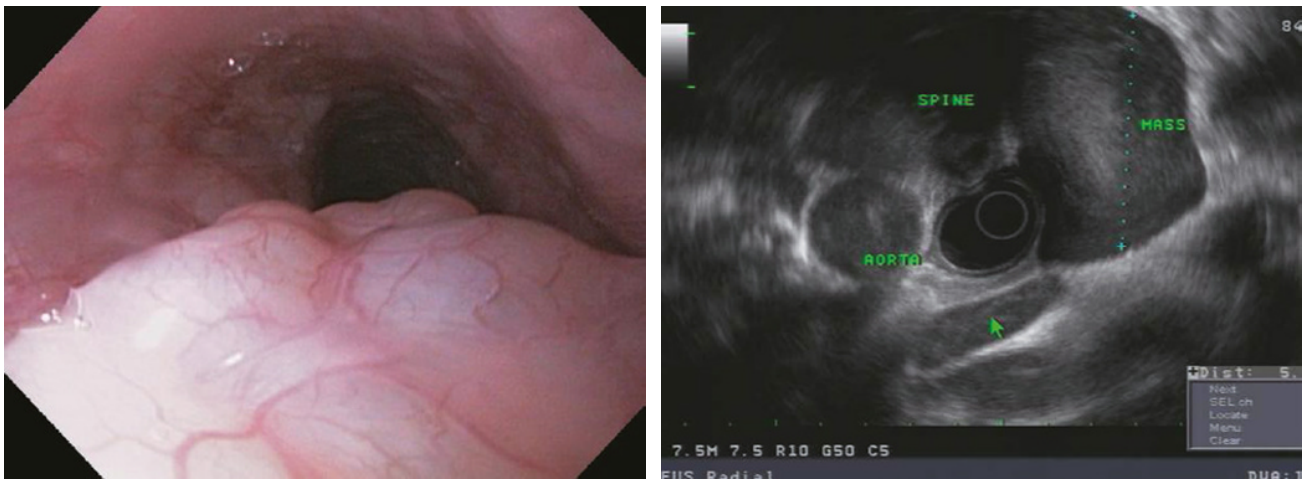


Figure 1.6 Congenital venous malformations as depicted may also be referred to as primary esophageal varices when no secondary cause such as portal hypertension can be identified. These venous structures rarely bleed spontaneously. Endosonography confirmed a conglomerate of venous channels in this case.



(a) (b)

Figure 1.7 **(a)** Radiograph showing a large, congenital, tubular duplication of the esophagus. **(b)** Endoscopic view showing the opening to the tubular duplication (right) and esophageal lumen (left). Congenital esophageal duplications may be tubular or cystic.



(a) (b)

Figure 1.8 Congenital esophageal duplication cysts may be present as submucosal lesions on upper endoscopy **(a)**. **(b)** Endoscopic ultrasonographic image of a large duplication cyst. Duplication cysts are the second most common benign esophageal submucosal lesion with stromal tumors being more common. Source: Images courtesy of Sri Komanduri, MD.

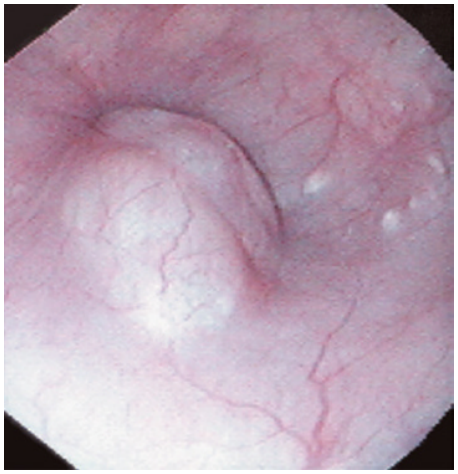


Figure 1.9 Small intramural cysts such as the bilobate type shown here are not symptomatic and are typically identified on barium esophagram or endoscopy for another indication. The cystic nature of the lesion can be confirmed using endoscopic ultrasonography. The differential diagnosis includes submucosal esophageal lesions and esophageal varices.

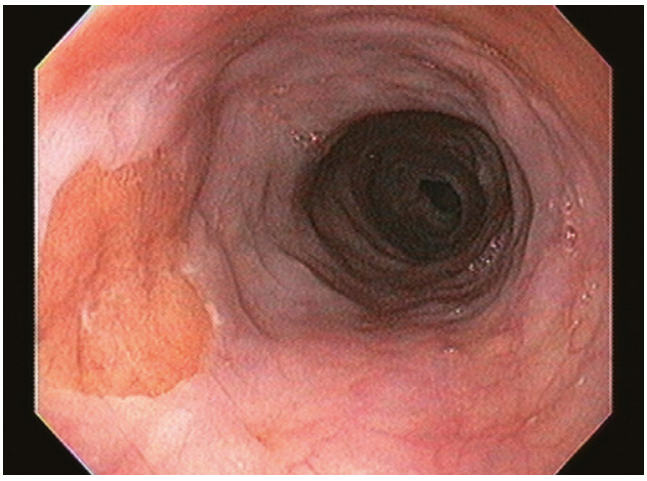


Figure 1.10 Heterotopic gastric mucosa (inlet patch) in the cervical esophagus. The reported prevalence approximates 4%. The lesions can be unifocal, as in the case illustrated, multifocal or circumferential.

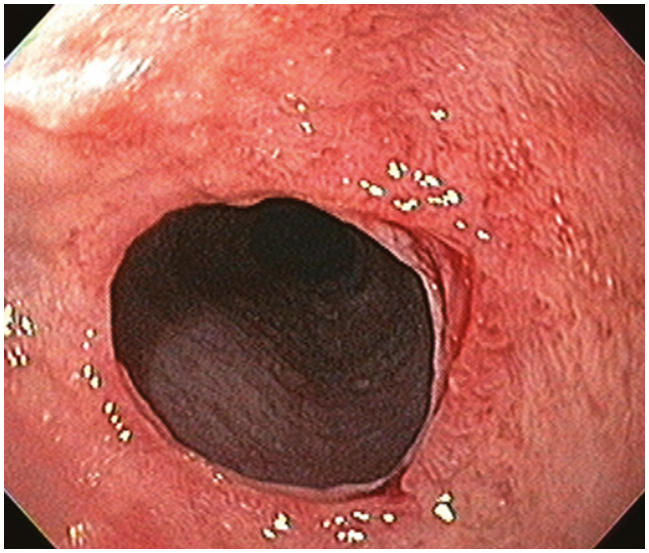
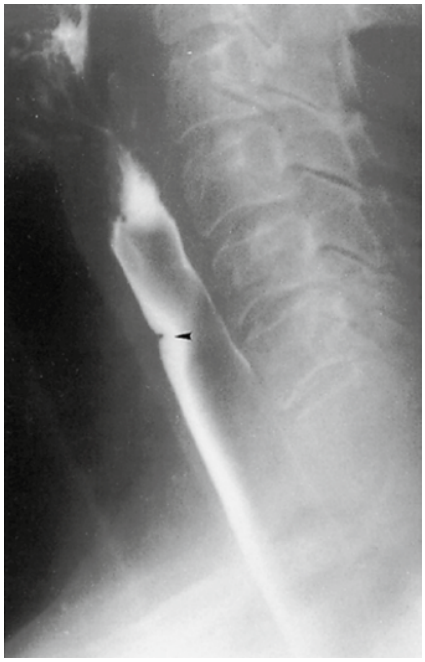
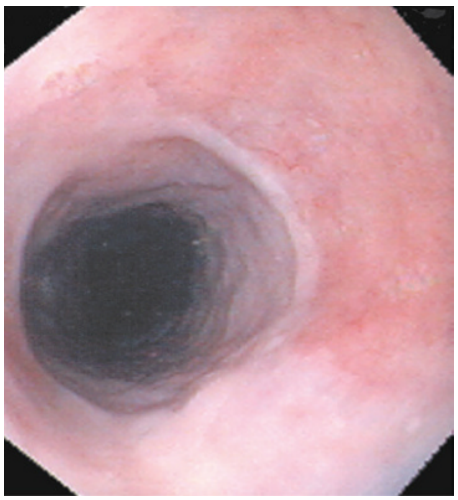


Figure 1.11 A large, circumferential focus of heterotopic gastric mucosa in the cervical esophagus associated with a circumferential mucosal web immediately distally. The web in this case likely represents a form of peptic stricture related to acid secretion from parietal cells within the inlet patch.

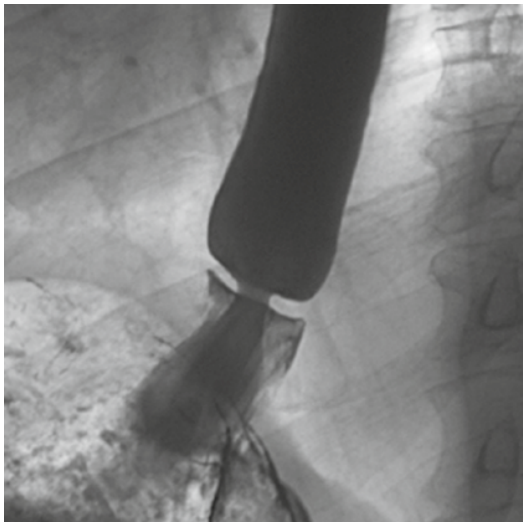


(a)

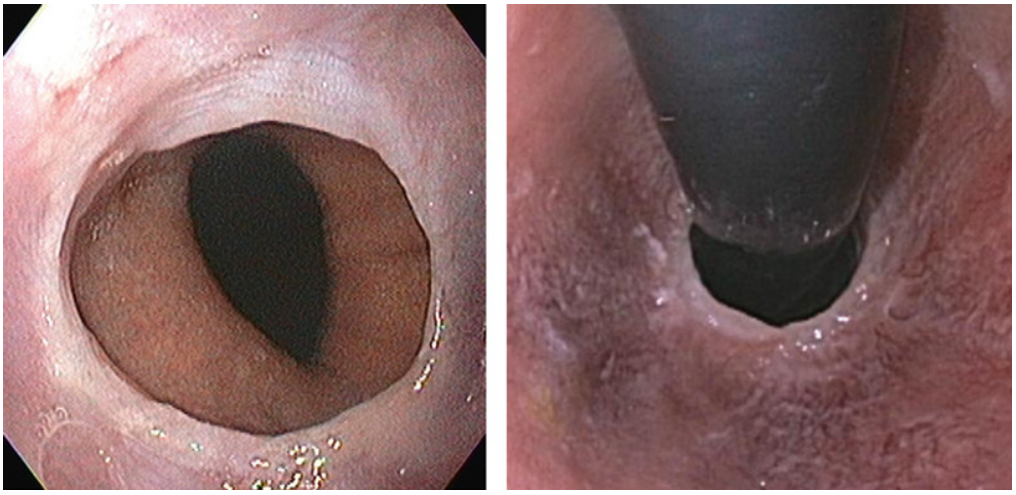


(b)

Figure 1.12 **(a)** Barium contrast radiograph showing a mucosal web in the cervical esophagus, often an incidental finding. **(b)** Corresponding endoscopic view of the cervical web from (a) demonstrates a proximal gastric inlet patch with web creating a shelf or lip at the distal aspect of the heterotopic gastric mucosa.



(a)



(b)

Figure 1.13 **(a)** A high-grade stenosis from a Schatzki ring located at the esophagogastric junction on a barium esophagram. **(b)** Anterograde and retrograde endoscopic views of a Schatzki ring. Schatzki rings are almost invariably seen in association with hiatal hernia as in the cases here. The inner ring diameter of a Schatzki ring is an important determinant of whether the ring is associated with dysphagia.

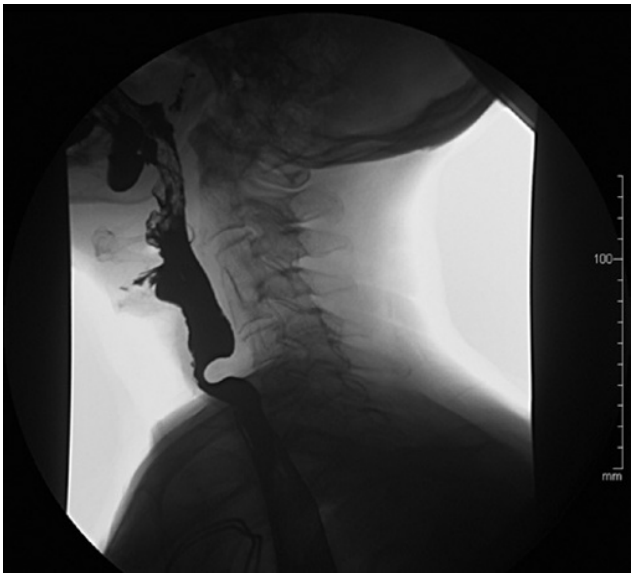


Figure 1.14 Barium esophagram depicting a cricopharyngeal bar in an elderly patient presenting with dysphagia. The bar is a posterior indentation arising from the cricopharyngeus muscle.