

Diagnostic Radiology

1987



Edited by

ALEXANDER R. MARGULIS, M.D.

Professor and Chairman, Department of Radiology
University of California School of Medicine
San Francisco, California

CHARLES A. GOODING, M.D.

Professor of Radiology and Pediatrics
Executive Vice-Chairman, Department of Radiology
University of California School of Medicine
San Francisco, California



Distributed by

The C.V. Mosby Company • Saint Louis • Toronto • London

The C.V. Mosby Company • Saint Louis • Toronto • London

North American and worldwide sales and distribution by:

The C.V. Mosby Company, Limited

11830 Westline Industrial Drive

Saint Louis, Missouri 63146

In Canada: **The C.V. Mosby Company, Limited**

120 Melford Drive

Scarborough, Ontario M1B2X5

Department of Radiology
University of California, San Francisco,
and the Radiology Research and Education Foundation
1987

Printed in the United States of America
by the University of California Printing Services

DEDICATION

“Each honest calling, each walk of life, has its own elite, its own aristocracy, based on excellence of performance.”

JAMES BRYANT CONANT
Harvard Baccalaureate Sermon
June 16, 1940

This book is dedicated to the physicians who are residents and fellows
in Radiology at the University of California, San Francisco.

Preface

The Department of Radiology of the University of California Medical Center in San Francisco is proud to present this synopsis of the state of the art in the field of radiology. The challenge for us was to select stimulating topics and authorities who could offer both expert commentary on the newest radiologic technologies and critical commentary on their effectiveness. The topics presented are pragmatically oriented; they have been chosen with the intent of aiding clinical radiologists in their medical practice.

The editors thank Mrs. Renee Sauers, Victoria Babcock, and the Postgraduate Education Section of the Department of Radiology of the University of California Medical Center in San Francisco for all the time and effort that they have contributed to ensure the success of this book. We extend our thanks to Al Averbach and Susan Averbach for editing the chapters, to Charlie Scribner and the University of California Printing Services, whose expertise and cooperation made this publication possible, and to Anne Poirier and Wendy Neale for administrative assistance. We would also like to express our sincere thanks to the authors for their contributions to this work.

ALEXANDER R. MARGULIS, M.D.
CHARLES A. GOODING, M.D.

San Francisco, California
March, 1987



Contributors

WALTER E. BERDON, M.D., Professor of Radiology; Director of Pediatric Radiology, Babies Hospital, Columbia-Presbyterian Medical Center, New York, New York

MICHAEL E. BERNARDINO, M.D., Professor of Radiology; Director, Abdominal Radiology and Magnetic Resonance Imaging, Emory University Hospital, Atlanta, Georgia

ELIAS H. BOTVINICK, M.D., Professor of Medicine and Radiology; Co-Director, Adult Noninvasive Cardiac Laboratory, Cardiology Division and Nuclear Medicine Section, University of California School of Medicine, San Francisco

ROBERT C. BRASCH, M.D., Professor of Radiology and Pediatrics; Director, Contrast Media Laboratory, University of California School of Medicine, San Francisco

ERIK CARLSSON, M.D., Professor of Radiology; Chief, Cardiac Section; Senior Staff Member, Cardiovascular Research Institute, University of California School of Medicine, San Francisco

NEIL CHAFETZ, M.D., Associate Clinical Professor of Radiology, University of California School of Medicine, San Francisco

LAWRENCE E. CROOKS, Ph.D., Professor of Electrical Engineering, Radiological Imaging Laboratory, South San Francisco, University of California School of Medicine, San Francisco

MICHAEL W. DAE, M.D., Assistant Professor of Radiology and Medicine, University of California School of Medicine, San Francisco

BARRY L. ENGELSTAD, M.D., Associate Professor of Radiology and Medicine, University of California School of Medicine, San Francisco

JOHN T. FALLON, M.D., Ph.D., Associate Professor of Pathology, Cardiac Pathologist, Massachusetts General Hospital, Boston, Massachusetts

MICHAEL P. FEDERLE, M.D., Professor of Radiology, University of California School of Medicine, San Francisco; Chief, Radiology Department, San Francisco General Hospital

STEPHEN A. FEIG, M.D., Professor of Radiology; Chief, Division of Breast Imaging, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania

IRWIN M. FEUERSTEIN, M.D., Clinical Instructor of Radiology, University of California School of Medicine, San Francisco

ROY A. FILLY, M.D., Professor of Radiology, Obstetrics, Gynecology, and Reproductive Medicine; Chief, Diagnostic Ultrasound, University of California School of Medicine, San Francisco

PATRICK C. FREENY, M.D., Clinical Associate Professor of Radiology, University of Washington Medical Center, The Mason Clinic, Seattle, Washington

GORDON GAMSU, M.D., Professor of Radiology; Chief, Pulmonary Section, University of California School of Medicine, San Francisco

HARRY K. GENANT, M.D., Professor of Radiology, Medicine, and Orthopaedic Surgery; Chief, Skeletal Section, University of California School of Medicine, San Francisco

HENRY I. GOLDBERG, M.D., Professor and Vice-Chairman, Department of Radiology; Chief, Computed Tomography and Gastrointestinal Sections, University of California School of Medicine, San Francisco

RUTH B. GOLDSTEIN, M.D., Assistant Professor of Radiology, University of California School of Medicine, San Francisco

CHARLES A. GOODING, M.D., Professor of Radiology and Pediatrics; Executive Vice-Chairman, Department of Radiology; Chief, Pediatric Section, University of California School of Medicine, San Francisco

GRETCHEN A. W. GOODING, M.D., Professor of Radiology, University of California School of Medicine, San Francisco; Assistant Chief, Radiology; Chief, Ultrasound, Veterans Administration Medical Center, San Francisco

PHILIP C. GOODMAN, M.D., Associate Clinical Professor of Radiology and Medicine, San Francisco General Hospital, University of California School of Medicine, San Francisco

BARBARA B. GOSINK, M.D., Professor of Radiology; Chief, Ultrasound Division, University of California, San Diego, California

- ROBERT G. GOULD, Ph.D., Associate Professor of Radiology, University of California School of Medicine, San Francisco
- VAN V. HALBACH, M.D., Assistant Professor of Radiology and Neurological Surgery, University of California School of Medicine, San Francisco
- ROBERT S. HATTNER, M.D., Vice-Chairman and Associate Professor of Radiology; Chief, Nuclear Medicine Section, University of California School of Medicine, San Francisco
- MARCUS W. HEDGCOCK, JR., M.D., Assistant Professor of Radiology, Veterans Administration Medical Center, University of California School of Medicine, San Francisco
- CLYDE A. HELMS, M.D., Associate Professor of Radiology, University of California School of Medicine, San Francisco
- GRANT B. HIESHIMA, M.D., Professor of Radiology, Neurology, and Neurological Surgery, University of California School of Medicine, San Francisco
- RANDALL T. HIGASHIDA, M.D., Assistant Professor of Radiology and Neurological Surgery, University of California School of Medicine, San Francisco
- CHARLES B. HIGGINS, M.D., Professor of Radiology and Vice-Chairman for Research; Chief, Magnetic Resonance Imaging Section, University of California School of Medicine, San Francisco
- HEDVIG HRICAK, M.D., Professor of Radiology and Urology; Co-Chief, Uradiology Section, University of California School of Medicine, San Francisco
- R. BROOKE JEFFREY, JR., M.D., Associate Professor of Radiology, San Francisco General Hospital, University of California School of Medicine, San Francisco
- JAY A. KAISER, M.D., Assistant Clinical Professor of Radiology, University of California School of Medicine, San Francisco
- LEON KAUFMAN, Ph.D., Professor of Physics; Director, Radiologic Imaging Laboratory, South San Francisco, University of California School of Medicine, San Francisco
- KAREN KIMBRELL-WILMOT, M.D., Captain, United States Army Medical Corps, Letterman Army Medical Center, San Francisco
- DAVID M. KRAMER, Ph.D., Adjunct Associate Professor of Physics, Radiologic Imaging Laboratory, South San Francisco, University of California School of Medicine, San Francisco
- FAYE C. LAING, M.D., Professor of Radiology; Chief, Ultrasound Section, San Francisco General Hospital, University of California School of Medicine, San Francisco
- DAVID C. LEVIN, M.D., Professor and Chairman, Department of Radiology, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania
- MARTIN J. LIPTON, M.D., Professor of Radiology and Medicine; Chief, Cardiovascular Imaging Section, University of California School of Medicine, San Francisco
- JAY C. MALL, M.D., Associate Clinical Professor of Radiology, University of California School of Medicine, San Francisco
- ALEXANDER R. MARGULIS, M.D., Professor and Chairman, Department of Radiology, University of California School of Medicine, San Francisco
- TIMOTHY P. MARONEY, M.D., Assistant Professor of Radiology, University of California School of Medicine, San Francisco
- SHEILA G. MOORE, M.D., Clinical Instructor in Radiology, University of California School of Medicine, San Francisco
- STEVEN H. OMINSKY, M.D., Associate Clinical Professor of Radiology; Chief, Clinics Section, University of California School of Medicine, San Francisco
- DAVID C. PRICE, M.D., Professor of Radiology, Nuclear Medicine, and Medicine, University of California School of Medicine, San Francisco
- DAVID J. SARTORIS, M.D., Assistant Professor of Radiology, University of California, San Diego, California
- EDWARD A. SICKLES, M.D., Associate Professor of Radiology; Chief, Breast Imaging Section, University of California School of Medicine, San Francisco
- RICHARD A. SOLLITTO, M.D., Assistant Clinical Professor of Radiology, University of California School of Medicine, San Francisco
- DAVID B. SPRING, M.D., Associate Clinical Professor of Radiology, University of California Medical Center, San Francisco
- MARK G. STEIN, M.D., Assistant Professor of Radiology; Chief, Thoracic Imaging, Veterans Administration Medical Center, University of California School of Medicine, San Francisco

LYNNE STEINBACH, M.D., Assistant Professor of Radiology, University of California School of Medicine, San Francisco

DAVID W. STOLLER, M.D., Clinical Instructor in Radiology, University of California School of Medicine, San Francisco

FONG Y. TSAI, M.D., Professor and Chairman, Department of Radiology, University of Missouri, Kansas City, School of Medicine, Truman Medical Center, Kansas City, Missouri

SUSAN D. WALL, M.D., Assistant Professor of Radiology, Veterans Administration Medical Center, University of California School of Medicine, San Francisco

W. RICHARD WEBB, M.D., Associate Professor of Radiology, University of California School of Medicine, San Francisco

WILLIAM N. WEBER, M.D., Clinical Instructor of Radiology, University of California School of Medicine, San Francisco

ELIAS A. ZERHOUNI, M.D., Associate Professor of Radiology; Co-Director, Magnetic Resonance Imaging; Co-Director, Computed Tomography, Johns Hopkins University School of Medicine, Baltimore, Maryland

Contents

Gastrointestinal Radiology

Imaging and Intervention in Acute Appendicitis	3
R. Brooke Jeffrey, Jr., M.D.	
Computed Tomography of the Postoperative Abdomen	9
Irwin M. Feuerstein, M.D.	
Susan D. Wall, M.D.	
Magnetic Resonance Imaging of the Alimentary Tract	19
Alexander R. Margulis, M.D.	
Susan D. Wall, M.D.	
Abdominal Computed Tomography in Acquired Immune Deficiency Syndrome	23
Michael P. Federle, M.D.	

Mammography

A Current Assessment of the Benefits and Risks of Screening Mammography	33
Stephen A. Feig, M.D.	
Use of Grids in Mammography.	41
Edward A. Sickles, M.D.,	
William N. Weber, M.D.	
Comparison of Xeromammography and Screen-Film Mammography	45
Stephen A. Feig, M.D.	
How to Conduct an Audit of Your Mammography Practice . . .	55
David B. Spring, M.D.	
Karen Kimbrell-Wilmot, M.D., Capt., U.S. Army Medical Corps	
Methods for Localizing Nonpalpable Breast Lesions Prior to Biopsy.	61
Stephen A. Feig, M.D.	

Uroradiology

Role of Magnetic Resonance Imaging in Pelvic Malignancies	71
Hedvig Hricak, M.D.	
Magnetic Resonance Imaging of the Adrenal Glands	79
Marcus W. Hedgcock, Jr., M.D.	

Advances in Magnetic Resonance Instrumentation

- Limitations of High-Field Magnetic Resonance Imaging** 101
David M. Kramer, Ph.D.
- Advances in Radiofrequency Coil Technology** 109
Leon Kaufman, Ph.D.
- Speeding Up the Magnetic Resonance Study** 115
Lawrence E. Crooks, Ph.D.

Hepatobiliary Radiology

- Advanced Contrast Techniques in Hepatic Computed Tomography** 123
Michael E. Bernardino, M.D.
- Hepatic Hemangiomas: Porta Hepatis Lesions** 131
Henry I. Goldberg, M.D.
- Advanced Imaging Techniques in Hepatic Magnetic Resonance** 145
Michael E. Bernardino, M.D.
- Guided Biopsy Techniques** 151
Michael E. Bernardino, M.D.
- Tumors of the Bile Ducts and Gallbladder: Radiologic Diagnosis, Tumor Staging, and Interventional Treatment** . . . 159
Patrick C. Freeny, M.D.
- Transhepatic Chemoembolization Techniques** 173
Timothy P. Maroney, M.D.
- Acute and Chronic Pancreatitis: Current Concepts of Diagnosis** 179
Patrick C. Freeny, M.D.
- Pancreatic Ductal Adenocarcinoma: Diagnosis, Staging, and Results of Treatment** 195
Patrick C. Freeny, M.D.

Pediatric Radiology

- Acquired Gastrointestinal Disease in Children** 207
Walter E. Berdon, M.D.
- Magnetic Resonance Imaging in the Assessment of the Pediatric Patient: Current Status** 211
Charles A. Gooding, M.D.
- Neonatal Hepatobiliary Diseases** 223
Walter E. Berdon, M.D.
- Magnetic Resonance Imaging of Bone Marrow** 227
Sheila G. Moore, M.D.

Ultrafast Computed Tomography for Pediatric Diagnosis	233
Robert C. Brasch, M.D.	
Polycystic Kidney Disease	247
Walter E. Berdon, M.D.	

Ultrasound

Everything You Need to Know about Women	253
Barbara B. Gosink, M.D.	
Ultrasonography during First-Trimester Pregnancy	257
Faye C. Laing, M.D.	
Polyhydramnios	263
Roy A. Filly, M.D.	
Doppler Evaluation of the Abdomen	271
Barbara B. Gosink, M.D.	
Carotid Duplex Evaluation: A Practical Approach	279
Barbara B. Gosink, M.D.	
Ultrasound of Venous Dynamics	285
Gretchen A. W. Gooding, M.D.	
Neonatal Cranial Sonography: Intracranial Hemorrhage and Periventricular Leukomalacia	293
Ruth B. Goldstein, M.D.	

Interventive Radiology

Percutaneous Transluminal Angioplasty of Brachiocephalic Vessels	303
Randall T. Higashida, M.D.	
Van V. Halbach, M.D.	
Fong Y. Tsai, M.D.	
Grant B. Hieshima, M.D.	
Diagnosis and Treatment of Dural Arteriovenous Fistulae	309
Van V. Halbach, M.D.	
Randall T. Higashida, M.D.	
Grant B. Hieshima, M.D.	
<i>The Walter W. Herbert Memorial Lecture</i> Treatment of Intracranial Aneurysms by Balloon Embolization Therapy	315
Grant B. Hieshima, M.D.	

Chest Radiology

- Another Look at the Lateral Chest View** 323
Steven H. Ominsky, M.D.
- Computed Tomography and Magnetic Resonance Imaging
of the Mediastinum** 327
Elias A. Zerhouni, M.D.
- Radiographic Diagnosis of Pulmonary Embolus.** 335
Mark G. Stein, M.D.
- Computed Tomographic Characterization
of Focal Pulmonary Lesions** 349
Elias A. Zerhouni, M.D.
- High-Resolution Computed Tomography of the Lung** 359
W. Richard Webb, M.D.
- Asbestos-Related Disease** 367
Gordon Gamsu, M.D.
- Role of Magnetic Resonance Imaging
in the Management of Lymphoma** 375
Elias A. Zerhouni, M.D.
- Computed Tomography of Complex Pleuropulmonary Disease** 385
Philip C. Goodman, M.D.

Nuclear Medicine

- New Radiopharmaceuticals** 397
Barry L. Engelstad, M.D.
- Acute Inflammation—Gallium-67 or Indium-111-Labeled
Leukocyte Scintigraphy?** 409
David C. Price, M.D.
- Gallium Imaging in Acquired Immune Deficiency Syndrome** 423
Richard A. Sollitto, M.D.
Robert S. Hattner, M.D.
- Radionuclide Assessment of Biochemical Markers:
Evaluation of Cardiac Adrenergic Function** 427
Michael W. Dae, M.D.
Elias H. Botvinick, M.D.

Cardiovascular Radiology

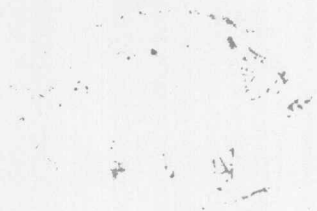
- Noncardiac Interventional Angiography in the Thorax.** 435
David C. Levin, M.D.

Magnetic Resonance Imaging of Thoracic Vascular Disease . . .	439
Charles B. Higgins, M.D.	
Magnetic Resonance Imaging and Computed Tomography of the Heart	447
Martin J. Lipton, M.D.	
Robert G. Gould, Ph.D.	
Principles of Interpretation of Coronary Arteriograms	453
David C. Levin, M.D.	
Significance of the Angiographic Morphology of Localized Coronary Stenoses: Histopathologic Correlations	459
David C. Levin, M.D.	
John T. Fallon, M.D., Ph.D.	
Impact of New Cardiac Imaging Techniques	467
Erik Carlsson, M.D.	

Skeletal Radiology

Current and Future Approaches to Assessment of Osteoporosis	473
David J. Sartoris, M.D.	
Radiologic Diagnosis of Internal Derangements of the Temporomandibular Joint	487
Clyde A. Helms, M.D.	
Modern Diagnostic Imaging Approach to Rheumatologic Disorders	495
David J. Sartoris, M.D.	
Magnetic Resonance Imaging of Articular Abnormalities . . .	509
Lynne Steinbach, M.D.	
Magnetic Resonance Imaging of the Knee	517
David W. Stoller, M.D.	
Three-Dimensional Imaging of the Musculoskeletal System . . .	525
David J. Sartoris, M.D.	
Magnetic Resonance Imaging in Low Back Pain Syndromes	535
Harry K. Genant, M.D.	
Computed Tomography of the Lumbar Spine	545
Neil Chafetz, M.D.	
Jay A. Kaiser, M.D.	
Jay C. Mall, M.D.	
INDEX	553

Gastrointestinal Radiology



11

Gastrophysiology

Imaging and Intervention in Acute Appendicitis

R. Brooke Jeffrey, Jr., M.D.



Acute Appendicitis

Although acute appendicitis remains the most common indication for emergency laparotomy, its diagnosis is often based on imprecise clinical criteria. Surgeons generally agree that negative appendectomy rates on the order of 20 percent are justified to avoid misdiagnosis. Diagnostic inaccuracy is highest in ovulating women, for whom negative appendectomy rates of 35 to 45 percent are commonly quoted in the surgical literature.^{1,2} The main factors contributing to this high negative appendectomy rate have been the nonspecific clinical features of acute appendicitis, which broadly overlap a variety of other acute abdominal disorders, and the inability to directly image the appendix with a readily available noninvasive technique. Although conventional radiologic methods such as plain abdominal radiographs and contrast enemas have been widely used in the evaluation of patients with suspected appendicitis, they are frequently insensitive and nonspecific. This paper focuses on the role of high-resolution sonography and computed tomography (CT) in the diagnosis of appendicitis and its complications.

Puylaert³ has recently described a graded compression technique using high-resolution real-time sonography in evaluating patients with suspected uncomplicated acute appendicitis. The technique employs a linear array transducer (5–7.5 MHz) that can directly image an inflamed appendix after all of the gas and fluid have been gradually compressed out of the cecum and ascending colon. In normal patients the appendix is not routinely visualized. The main sonographic criteria for acute appendicitis include the visualization of a non-compressible appendix with a thickened wall (3 mm or greater). The presence of appendicoliths, periappendiceal abscess, mesenteric adenopathy, and mural thickening of the cecum can be readily discerned by this method. In Puylaert's study there were no nondiagnostic examinations and no false-positive examinations. A small number of false-negatives were encountered in patients with surgically proven acute appendicitis but no sonographically visible appendix.

We recently completed a study at San Francisco General Hospital evaluating the diagnostic efficacy of graded compression real-time sonography in evaluating 90 patients with suspected acute appendicitis (Fig. 1). Although our overall accuracy (93%) suggested that this is a very promising new method, several important limitations of sonography were encountered in our series

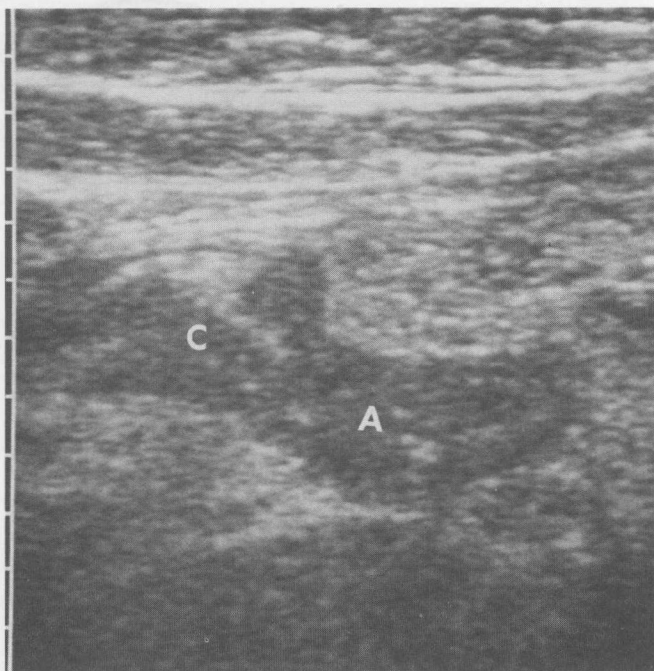
that had not been noted by Puylaert.³ In three patients (3%) the study was nondiagnostic owing to an inability to adequately compress the cecum and right lower quadrant. The normal bowel is quite distensible and easily collapses with moderate degrees of pressure. However, the distended inflamed appendix does not collapse when compressed. Two of the three patients had marked peritoneal findings in the right lower quadrant and could not cooperate to complete the study. Both had proven appendicitis (one with a ruptured appendix) at surgery. A third patient had tense abdominal ascites that precluded adequate compression of the right lower quadrant.

Three patients in our series had a sonographically visible appendix compatible with acute appendicitis, but their symptoms resolved and they did not require surgery. The exact explanation for this is unclear; however, "chronic appendicitis" has been referred to in the surgical literature, and it is possible that in some patients appendiceal inflammation may be reversible.^{4,5}

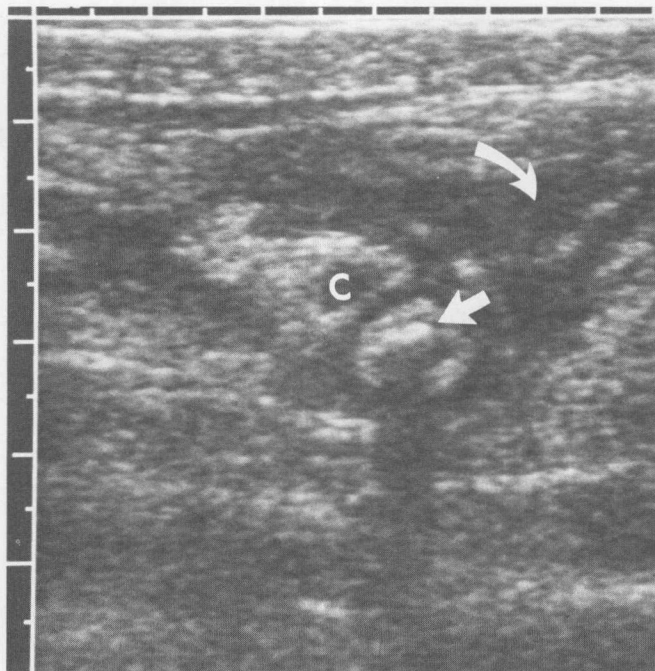
In our clinical series a very low percentage of women (only 6 of 49, or 12%) had proven appendicitis. Often their clinical symptomatology overlapped with acute gynecologic disorders such as ovarian cysts and pelvic inflammatory disease. However, routine scanning of the pelvis with a 3.5-MHz transducer using a full-bladder technique did not significantly improve the diagnostic specificity in patients without sonographic evidence of acute appendicitis. Nonetheless, it is likely that one of the main impacts of sonography will be in the evaluation of appendicitis in women, in whom clinical criteria often result in a disturbingly high negative appendectomy rate.

Periappendiceal Abscess

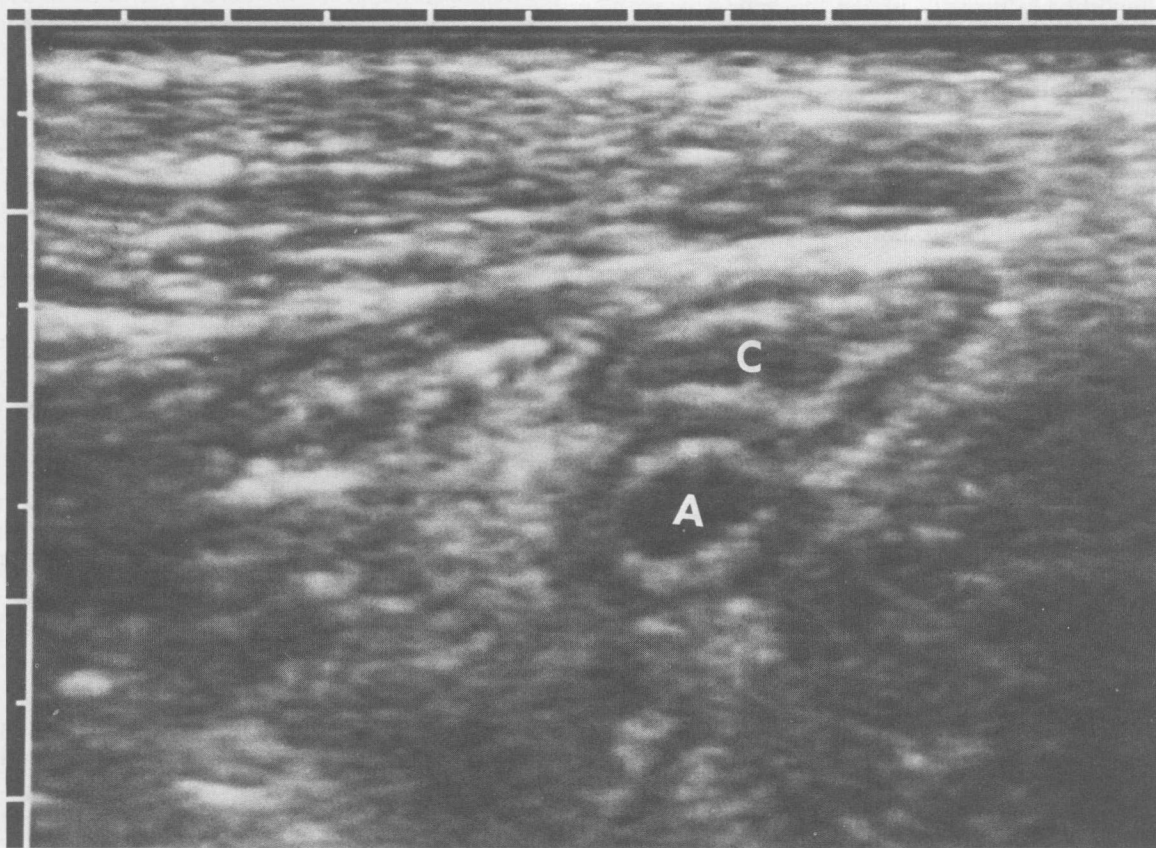
Patients with periappendiceal abscesses often present with longer-lasting symptoms, a palpable right lower quadrant mass, pain, fever, and leukocytosis. In this subset of patients, CT appears to be of considerable clinical value in differentiating pericecal phlegmon from a liquified periappendiceal abscess (Fig. 2).⁶ In patients with a well-localized liquified abscess, percutaneous catheter drainage is often the therapeutic method of choice and has a high degree of success. Over the past 3 years, 24 of 26 patients with periappendiceal abscesses have been successfully managed by percutaneous drainage at San Francisco General Hospital (Fig. 3).



A.



B.



C.

Figure 1. Sonographic diagnosis of acute appendicitis.

- A. Longitudinal scan of noncompressible appendix with distended lumen and edematous wall. (A, appendix; C, cecum)
- B. Transverse scan of calcified appendicolith (straight arrow). (C, cecum; curved arrow, mesenteric edema)
- C. Transverse scan of retrocecal appendix (A). (C, cecum)