CASE STUDIES IN
PEDIATRIC EMERGENCY
AND CRITICAL CARE
ULTRASOUND

Edited by

DAVID J. MCLARIO, DO, MS, FAAP, FACEP
Associate Professor, Department of Pediatrics,
University of Louisville School of Medicine;
Director of Emergency Ultrasound,
Division of Pediatric Emergency Medicine,
Kosair Children's Hospital, Louisville, KY, USA

JOHN L. KENDALL, MD, FACEP
Associate Professor, Department of Emergency Medicine,
University of Colorado School of Medicine;
Director of Emergency Ultrasound and Ultrasound Fellowship,
Denver Health Medical Center, Denver, CO, USA
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Contributors

Srikar Adhikari, MD, MS, RDMS
Associate Professor, Department of Emergency Medicine, University of Arizona School of Medicine, University of Arizona Medical Center, Tucson, AZ, USA

Alexander C. Arroyo, MD, FAAP
Director Pediatric Emergency Medicine, Director Pediatric Emergency Medicine Ultrasound Research, Maimonides Medical Center, New York, NY, USA

Brandon H. Backlund, MD
Co-Director of Emergency Ultrasound, Acting Assistant Professor, University of Washington School of Medicine, Division of Emergency Medicine, Seattle, WA, USA

Katherine Bakes, MD
Director, Denver Emergency Center for Children, Denver Health Medical Center; Associate Professor, Department of Emergency Medicine, University of Colorado School of Medicine, Denver, CO, USA

Alexa Bisinger, MD
Resident, Department of Emergency Medicine, UC-San Francisco School of Medicine, San Francisco, CA, USA

Jason D. Bothwell, MD, RDMS
Program Director, Emergency Medicine Residency, Department of Emergency Medicine, Madigan Army Medical Center, Tacoma, WA, USA

Matthew Buchanan, DO
Attending Physician, Department of Emergency Medicine, Carepoint PC, Presbyterian/St. Luke Medical Center, Denver, CO, USA

Leonard Bunting, MD, FACEP, RDMS
Assistant Professor of Emergency Medicine, Wayne State University School of Medicine; Emergency Ultrasound Director, St. John Hospital and Medical Center, Detroit, MI, USA

Mikaela Chilstrom, MD, RDMS
Assistant Professor of Emergency Medicine, Emory University, Atlanta, GA, USA

Thomas Cook, MD
Program Director, Department of Emergency Medicine, Palmetto Health Richland, Columbia, SC, USA

Thomas Costantino, MD
Director of Emergency Medicine Ultrasound Fellowship, Associate Professor, Emergency Medicine, Temple University Hospital, Philadelphia, PA, USA

Keith Cross, MD, MSc
Assistant Professor, Department of Pediatrics, Division of Pediatric Emergency Medicine, University of Louisville School of Medicine, Kosair Children's Hospital, Louisville, KY, USA

Jeffrey R. Darst, MD
Assistant Professor, Department of Pediatrics, Section of Cardiology, University of Colorado School of Medicine, Children's Hospital Colorado, Denver, CO, USA
List of contributors

Troy Dean, MD
Staff Physician, Department of Emergency Medicine, Director of Emergency Ultrasound, Regional West Medical Center, Scottsbluff, NE, USA

Eitan Dickman, MD, RDMS, FACEP
Vice Chair for Academics, Director, Division of Emergency Ultrasound, Department of Emergency Medicine, Maimonides Medical Center, New York, NY, USA

Swathi Nadindla Doyle, MD
Instructor, Harvard School of Medicine, Associate Director, Emergency Ultrasound Division, Cambridge Health Alliance, Boston, MA, USA

Catherine Erickson, MD
Assistant Professor, Emergency Ultrasound Fellowship Director, Oregon Health and Science University, Portland, OR, USA

Jason W. Fischer, MD, MSc
Assistant Professor, Department of Paediatrics, University of Toronto; Director, Emergency Ultrasound Program, Division of Emergency Medicine, The Hospital for Sick Children, Toronto, ON, Canada

Jeffrey L. Foster, MD
Medical Director of Radiology, Care Core National, Inc., Bluffton, SC, USA; Associate Professor of Radiology, University of Louisville School of Medicine, Louisville, KY, USA

Andrew French, MD
Assistant Professor, Department of Emergency Medicine, University of Colorado School of Medicine, Associate Director of Emergency Ultrasound, Denver Health Medical Center, Denver, CO, USA

Rajesh N. Geria, MD, FACP, RDMS
Assistant Professor, Department of Emergency Medicine, Chief, Division of Emergency and Critical Care Ultrasound; Director, Emergency Ultrasound Fellowship; Chair, ACEP Emergency Ultrasound Section; Staff Attending Physician, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ, USA

Richard D. Gordon, MD
Assistant Professor of Emergency Medicine, Assistant Program Director, Emergency Medicine Residency; Director, Emergency Ultrasound; Assistant Director, Emergency Ultrasound Fellowship, Department of Emergency Medicine, Medical College of Georgia, Georgia Regents University, Augusta, GA, USA

Brunhild Halm, MD, PhD, RDMS, FAAP
Associate Professor of Pediatrics, University of Hawaii John A. Burns School of Medicine; Attending Physician in Pediatric Emergency Medicine, Kapiolani Medical Center for Women and Children, Honolulu, Hawaii, USA

Amanda L. Hauck, MD
Fellow, Pediatric Cardiology, University of Colorado School of Medicine, Children’s Hospital Colorado, Denver, CO, USA

Beatrice Hoffmann, MD, PhD, RDMS
Assistant Professor, Director, Division of Emergency Ultrasound Education; Fellowship, Department of Emergency Medicine, Johns Hopkins University, Baltimore, MD, USA

Russ Horowitz, MD, RDMS
Assistant Professor, Department of Pediatrics, Feinberg School of Medicine, Northwestern University, Director, Emergency Ultrasound, Ann and Robert H. Lurie Children's Hospital of Chicago, Chicago, IL, USA
List of contributors

Nicole Hurst, MD
Assistant Professor, Uniformed Services University of the Health Sciences School of Medicine, Bethesda, MD; Director of Emergency Ultrasound, Naval Medical Center, San Diego, CA, USA

Timothy Jang, MD
Associate Professor of Medicine, Director, Emergency Ultrasound, David Geffen School of Medicine at UCLA, Harbor-UCLA Medical Center, Los Angeles, CA, USA

Amanda Kao, MD
Clinical Instructor Emergency Ultrasound Fellow, Department of Emergency Medicine, University of Colorado School of Medicine, Denver Health Medical Center, Denver, CO, USA

John L. Kendall, MD, FACEP
Associate Professor, Department of Emergency Medicine, University of Colorado School of Medicine; Director of Emergency Ultrasound and the Ultrasound Fellowship at Denver Health Medical Center, Denver, CO, USA

Daniel J. Kim, MD, FRCPC
Clinical Instructor, Department of Emergency Medicine, University of British Colombia; Attending Physician, Department of Emergency Medicine, Vancouver General Hospital, Vancouver, BC, Canada

In K. Kim, MD, MBA
Associate Professor, Department of Pediatrics Fellowship Director, Division of Pediatric Emergency Medicine, University of Louisville School of Medicine, Kosair Children’s Hospital, Louisville, KY, USA

Charisse Kwan, MD, FRCPC
Instructor, Department of Pediatrics, University of Toronto; Paediatric Emergency Medicine Physician, The Hospital for Sick Children, Toronto, ON, Canada

Brooks T. Laselle, MD, FACEP
Fellowship Director, Emergency Ultrasound Director, Emergency Medicine Residency, Department of Emergency Medicine, Madigan Army Medical Center, Tacoma, WA, USA

Jerusha Lev, MD
Clinical Instructor, Department of Pediatrics, University of Colorado School of Medicine, Denver Emergency Center for Children, Denver Medical Health Center, Denver, CO, USA

Marla C. Levine, MD, RDMS
Attending Physician, Division of Emergency Ultrasound, Department of Pediatric Emergency Medicine, Maimonides Medical Center, New York, NY, USA

Resa E. Lewiss, MD, RDMS
Assistant Clinical Professor of Medicine, Columbia University College of Physicians and Surgeons, St. Luke’s Roosevelt Hospital Center, New York, NY, USA

Matthew Lyon, MD
Professor of Emergency Medicine, Vice Chairman of Academic Programs, Director, Section of Emergency and Clinical Ultrasound; Director, Observation; Acute Care Unit; Director, Emergency Ultrasound Fellowship, Department of Emergency Medicine, Medical College of Georgia, Georgia Regents University, Augusta, GA, USA

Jennifer R. Marin, MD, MSc
Assistant Professor of Pediatrics and Emergency Medicine, Director of Emergency Ultrasound, Division of Pediatric Emergency Medicine, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA
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<tr>
<td>Conor McKaigney, MD</td>
<td>Senior Resident, Emergency Medicine, Queen's University, Kingston, Ontario, Canada</td>
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<tr>
<td>David J. McLario, DO, MS, FAAP, FACEP</td>
<td>Associate Professor, Department of Pediatrics, University of Louisville School of Medicine; Director of Emergency Ultrasound, Division of Pediatric Emergency Medicine, Kosair Children's Hospital, Louisville, KY, USA</td>
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<tr>
<td>Lisa D. Mills, MD</td>
<td>Associate Professor, Director of Emergency Medicine Ultrasound, Department of Emergency Medicine, University of California Davis School of Medicine, Sacramento, CA, USA</td>
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<tr>
<td>Veena A. Modayil, MD RDMS</td>
<td>Assistant Director, Emergency Ultrasound Fellowship, North Shore University Hospital, Manhasset, NY, USA</td>
</tr>
<tr>
<td>Matthew Monson, DO</td>
<td>Assistant Professor of Radiology, University of Colorado School of Medicine, Pediatric Radiologist, Department of Radiology, Denver Health Medical Center, Denver, CO, USA</td>
</tr>
<tr>
<td>Lorraine Ng, MD</td>
<td>Assistant Professor, Department of Pediatrics, Divisions of Pediatric Emergency and Pediatric Emergency Ultrasound, Columbia University College of Physicians and Surgeons, New York Presbyterian Morgan Stanley Children's Hospital of New York, New York, NY, USA</td>
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<td>Laura Nolting, MD</td>
<td>Emergency Physician, Department of Emergency Medicine, Palmetto Health Richland, Columbia, SC, USA</td>
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<td>Pradeep Padmanabhan, MD, MSc</td>
<td>Assistant Professor, Department of Pediatrics, Division of Pediatric Emergency Medicine, University of Louisville School of Medicine; Associate Medical Director, Emergency Department, Kosair Children's Hospital, Louisville, KY, USA</td>
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<tr>
<td>Joni E. Rabiner, MD</td>
<td>Assistant Professor, Department of Pediatrics, Division of Pediatric Emergency Medicine, Albert Einstein College of Medicine/Children’s Hospital at Montefiore, Bronx, NY, USA</td>
</tr>
<tr>
<td>Christopher C. Raio, MD MBA RDMS FACEP</td>
<td>Associate Professor of Emergency Medicine, Associate Chairman, Department of Emergency Medicine, Director of Emergency Ultrasound, North Shore University Hospital, Hofstra North Shore-LIJ School of Medicine, Hempstead, NY, USA</td>
</tr>
<tr>
<td>Cliff Rice, MD</td>
<td>Co-Director of Emergency Ultrasound, NorthShore University Health System, Clinical Educator, Pritzker School of Medicine, Chicago, IL, USA</td>
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<tr>
<td>Annie Heffernan Rominger, MD, MPH, MSc</td>
<td>Assistant Professor, Department of Pediatrics, Associate Research Director, Division of Pediatric Emergency Medicine, University of Louisville, Louisville, KY, USA</td>
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<tr>
<td>Geoffrey Sanz, MD, FRCPC</td>
<td>Clinical Instructor, University of British Columbia Medical School, Attending Physician, Department of Emergency Medicine, Kelowna General Hospital, Kelowna, British Columbia, Canada</td>
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<td>Nicole Seleno, MD</td>
<td>Resident Physician, Emergency Medicine, University of Colorado School of Medicine, Denver Health Medical Center, Denver, CO, USA</td>
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List of contributors

Lekha Shah, MD
Assistant Professor of Emergency Medicine, Emory University School of Medicine,
Attending Physician, Emory University Hospital, Atlanta, GA, USA

Tanya Solano, MD
Instructor, Department of Pediatrics, University of Toronto; Pediatric Emergency Medicine
Physician, The Hospital for Sick Children, Toronto, ON, Canada

Zachary Soucy, DO
Assistant Professor, Department of Emergency Medicine, University of California Davis
School of Medicine, Sacramento, CA, USA

Michael B. Stone, MD
Assistant Professor Harvard Medical School, Chief, Division of Emergency Ultrasound,
Department of Emergency Medicine, Brigham & Women’s Hospital, Boston, MA, USA

Steven J. Tanksley, MD
Staff Physician, Department of Emergency Medicine, Madigan Army Medical Center,
Tacoma, WA, USA

Nathan Teismann, MD
Assistant Professor, Department of Emergency Medicine, UC-San Francisco School of
Medicine, San Francisco, CA, USA

Jonathan Theoret, MD, CM, FRCPC
Clinical Assistant Professor of Emergency Medicine, University of British Columbia;
Clinical Ultrasound Fellowship Director, Attending Emergency Physician, St-Paul’s
Hospital, Vancouver, British Columbia, Canada

Molly Thiessen, MD, FACEP
Assistant Professor, Department of Emergency Medicine, University of Colorado School of
Medicine; Assistant Emergency Ultrasound Director, Denver Medical Center, Denver,
Denver, CO, USA

James W. Tsung, MD, MPH
Associate Professor of Emergency Medicine and Pediatrics, Director, Pediatric Emergency
Ultrasound, Department of Emergency Medicine, Mount Sinai School of Medicine, New
York, NY, USA

Fred Warkentine, MD, MSc
Associate Professor, Department of Pediatrics, Division of Pediatric Emergency Medicine,
University of Louisville School of Medicine, Kosair Children’s Hospital, Louisville, KY,
USA
Abbreviations

ABCDE  Airway–Breathing–Cardiac/Circulation–Disability–Exposure
ACLS  Advanced Cardiovascular Life Support
ALS  advanced life support
ALT  alanine aminotransferase
ARDS  Acute Respiratory Distress Syndrome
AST  aspartate aminotransferase
ATLS  Advanced Trauma Life Support
CBC  complete blood count
CBD  common bile duct
CHF  congestive heart failure
CRP  c-reactive protein
CSD  cat scratch disease
CSF  cerebrospinal fluid
CT  computed tomography
CVP  central venous pressure
DIC  disseminated intravascular coagulation
DVT  deep vein thrombosis
ECMO  extra-corporeal membrane oxygenation
ED  emergency department
EEG  electroencephalogram
EKG  electrocardiograms
EMD  electromechanical dissociation
EMS  emergency medical service
EOMI  extra-ocular movements intact
ESR  erythrocyte sedimentation rate
ET  endotracheal
FAST  focused assessment with sonography for trauma
FEER  Focused Echocardiographic Evaluation in Resuscitation (study)
HEENT  head, ears, eyes, nose, and throat
ICP  intracranial pressure
I&D  incision and drainage
IHPS  idiopathic hypertrophic pyloric stenosis
IO  intrasosseous
IPH  intraperitoneal hemorrhage
IUP  intrauterine pregnancy
IV  intravenous
IVC  inferior vena cava
IVH  intraventricular hemorrhage
KUB  kidney, ureters, and bladder
LV  left ventricle
MCI  multi-casualty incidents
MDI  metered dose inhaler
MLF  main lobar fissure
MRI  magnetic resonance imaging
MRSA  methicillin-resistant Staphylococcus aureus
MWT  muscle wall thickness
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<td>NSAID</td>
<td>non-steroidal anti-inflammatory drug</td>
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<td>ONSD</td>
<td>optic nerve sheath diameter</td>
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<tr>
<td>ORT</td>
<td>oral rehydration therapy</td>
</tr>
<tr>
<td>PA</td>
<td>posteroanterior</td>
</tr>
<tr>
<td>PAE</td>
<td>posterior acoustic enhancement</td>
</tr>
<tr>
<td>PE</td>
<td>pulmonary embolism</td>
</tr>
<tr>
<td>PEA</td>
<td>pulseless electrical activity</td>
</tr>
<tr>
<td>PERRL</td>
<td>pupils equal, round, and reactive to light</td>
</tr>
<tr>
<td>PID</td>
<td>pelvic inflammatory disorder</td>
</tr>
<tr>
<td>PMI</td>
<td>point of maximal impulse</td>
</tr>
<tr>
<td>PMN</td>
<td>polymorphonuclear leukocyte</td>
</tr>
<tr>
<td>POCE</td>
<td>point-of-care echocardiography</td>
</tr>
<tr>
<td>PPD</td>
<td>purified protein derivative</td>
</tr>
<tr>
<td>PSLA</td>
<td>parasternal–long-axis</td>
</tr>
<tr>
<td>PTA</td>
<td>peritonsillar abscess</td>
</tr>
<tr>
<td>SBP</td>
<td>spontaneous bacterial peritonitis</td>
</tr>
<tr>
<td>SCFE</td>
<td>slipped capital femoral epiphysis</td>
</tr>
<tr>
<td>SCM</td>
<td>sternocleidomastoid</td>
</tr>
<tr>
<td>SMA</td>
<td>superior mesenteric artery</td>
</tr>
<tr>
<td>SMV</td>
<td>superior mesenteric vein</td>
</tr>
<tr>
<td>SSTI</td>
<td>skin and/or soft tissue infections</td>
</tr>
<tr>
<td>TLS</td>
<td>thoracic, lumbar, sacral</td>
</tr>
<tr>
<td>TM</td>
<td>tympanic membrane</td>
</tr>
<tr>
<td>TOA</td>
<td>tubo-ovarian abscess</td>
</tr>
<tr>
<td>TPN</td>
<td>total parenteral nutrition</td>
</tr>
<tr>
<td>UPJ</td>
<td>ureteropelvic junction</td>
</tr>
<tr>
<td>URI</td>
<td>upper respiratory infection</td>
</tr>
<tr>
<td>UTI</td>
<td>urinary tract infection</td>
</tr>
<tr>
<td>UTVJ</td>
<td>ureterovesical junction</td>
</tr>
<tr>
<td>VP</td>
<td>ventriculoperitoneal</td>
</tr>
<tr>
<td>VPP</td>
<td>visceral–parietal pleura</td>
</tr>
<tr>
<td>VTE</td>
<td>venous thromboembolic disease</td>
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Preface

David J. McLario and John L. Kendall

Evaluating the unborn child, observing the extraordinary synchrony of the heart as it both accommodates and propels blood, and viewing various adjacent organs that perform unique functions in almost perfect choreography. These are among the almost infinite opportunities provided by ultrasound that should cause us, as scientists, to, first and foremost, enjoy this rapidly developing technology.

Heartened by the progress of our colleagues in radiology, cardiology and, more recently, emergency medicine, pediatric providers have expressed interest in the application of ultrasound on behalf of their patients. We believe such providers, by virtue of their highly developed clinical judgment, are well-suited for the development and addition of ultrasound skill to their bedside armamentarium.

It would be difficult to argue that the sage practitioner’s use of all possible sources of information does not improve his or her clinical acumen. An appreciation of the acetone odor of diabetic ketoacidosis, the unique palpable nature of the scarlatiniform rash, the audible stridor of croup, and the characteristic movements of dystonia not only facilitates good judgment, but also elevates the level of clinical scholarship and communication within a medical community. Even with the development of increasingly sophisticated diagnostic testing, the benefit of pattern-recognition in making an immediate diagnosis remains a quintessential component of the art of medicine.

As pediatric practitioners across the globe confront issues of limited time and resources relative to the increasing numbers and needs of the children entrusted to us, the provision of safe, efficient, and cost-effective care will be of increasing priority. In addition to its benefits in diagnostic efforts, ultrasound has been increasingly recognized as an imperative to ensure the accuracy of various invasive procedures. Moreover, ultrasound puts the clinician back in the presence of the child and his or her family, where they are able to share and discuss information revealed on the display screen.

From the perspective of the medical educator, ultrasound recaptures physiologic and anatomic concepts often not appreciated since cadaver-lab in medical school, providing a bridge to a more integrated application of the knowledge we worked so diligently to acquire.

Pediatric bedside ultrasound is not, however, without its challenges. One such challenge is the definition of what are termed “core applications.” Our emergency medicine colleagues have been successful in developing a consensus of requisite ultrasound proficiencies for their trainees, which, in turn, has provided emergency medicine residency graduates outstanding technical skills and knowledge. In addition to the use of ultrasound in the evaluation of the trauma patient, other consensus emergency medicine applications include abdominal aortic aneurysm, gall-bladder disease, first-trimester pregnancy, and deep venous thrombosis. Clearly, these applications will be less commonly utilized in children. It is likely that the absence of consensus applications provides at least a partial explanation for the relative lack of development of ultrasound in pediatric acute care.

In response to this disparity, our text purposes to illustrate a considerable variety of ultrasound applications that can be performed in children. In so doing, we hope to provide useful instruction that will aid practitioners in providing the best possible care and facilitate the conversation that we must have regarding basic and advanced applications.

We have been fortunate to recruit a variety of outstanding authors who have produced case-vignette chapters in their respective areas of expertise in emergency ultrasound. Most of the chapters in this text, although intended to be hypothetical, draw from real-life patient encounters where ultrasound effected significant improvement in patient care.
Of our 59 chapters, most involve “diagnostic” scenarios where bedside ultrasound was useful in reaching a correct diagnosis. Other case chapters illustrate the use of ultrasound to guide or assist various important procedures performed in children. Our final chapter provides strategies intended to make pediatric ultrasound easier for sonographers and their patients.

We have chosen to use a case-based format, presenting the case and minimally-captioned figures on the first page, concluding with a question: “What is your diagnosis?” and/or “How will you proceed?” Our hope is that review of the first page will cause our readers to contemplate their usual practice in anticipation of benefits that may result from the addition of ultrasound.

On page 2, we will normally re-present the image or images provided on page 1 with the answer to the questions posed, an explanation of the images provided, and a conclusion of the hypothetical case.

The duration of each chapter will provide additional information regarding the illness or intervention in question and how ultrasound can be used to facilitate diagnosis and/or procedural success and safety.

Not all practitioners will utilize bedside ultrasound as presented in our 59 case studies. It is possible that additional ultrasound applications not mentioned in this text will become popular in the future, while some of the applications mentioned may fall out of favor. However, we believe it is our obligation, in good faith, to advocate what we believe are future possibilities for this exciting technology.

We are hopeful that the ideas presented in this text will serve as an impetus for a variety of research efforts in clinician-performed ultrasound. We believe the opportunities may include the following:

- Supplementation and/or modification of traditional diagnostic strategies
- Evaluations of the possible influence of ultrasound on cost- and time-efficiency
- Establishment of anatomic and physiologic norms
- Procedural ultrasound
- Optimal teaching and learning strategies
- Usefulness of ultrasound within basic science curricula
- Studies of possible novel ultrasound uses
- Novel settings where ultrasound might be useful

Many of our authors have been remarkably innovative as they expand the horizons. One of our authors found she had little else but ultrasound available to her in the aftermath of Hurricane Katrina. She and her heroic colleagues developed a variety of unique ultrasound applications as they faced the near-overwhelming needs of their community.

Other authors have utilized ultrasound on the mission field: some on the playing field; while still others as physicians responsible for those in the battlefield. To all of you, we offer both our gratitude and admiration.

In conclusion, it is our hope that the material in this text will both expand and improve the standard of clinician-performed ultrasound and be a source of professional development and satisfaction for our readers, who aspire to a most worthy goal – the best possible care of ill and injured children.
Acknowledgments

First and foremost, I want to thank God for his astonishing provision, the “fearfully and wonderfully made” human body. As a Pediatric Emergency Physician, I am privileged to have had the opportunity to study and protect his extraordinary creation on behalf of my patients and their families. My hope is that this textbook honors God, whose brilliance is matched only by his goodness in providing his one and only son as a reconciling sacrifice for undeserving persons like myself.

Daniel and Marguerite McLario. On the day I was accepted to medical school, your first words were, “God has done a miracle.” You were right. Thank you for your unwavering faith.

Jim and Charlene Walker. You have exemplified incredible selflessness, steadfast encouragement and quiet strength during the 17 years since you adopted me as your surrogate son. Thank you.

Fred Neasham. Thank you for your conviction and the courage to tell me what I needed to hear.

John Kendall, Chris Colwell, Katie Bakes, Jody Maes, Blaine Allen and my former physician, nurse and staff colleagues at the Denver Health Medical Center. You combine academic and clinical excellence while also being among the most gracious and pleasant people with whom I have ever worked. Thank you John, for allowing me to be part of an extraordinary emergency ultrasound fellowship.

Lee Shockley. Your encouragement and example caused me to believe a text like ours was possible.

Ronald Paul and my extraordinary partners in the University of Louisville Division of Pediatric Emergency Medicine. I am immensely grateful for your support, encouragement and considerable patience.

Kendra. The order you lent to the closing months of the project was indispensable to its completion.

Our case study authors. You have provided riveting and instructive vignettes that have surpassed even my very high expectations. I am grateful for your ability and knowledge as well as your willingness to add this undertaking to your already-busy schedules. Many of you endured and persisted despite significant physical, personal, and professional challenges. You have provided our readers a special reference that combines your skill in emergency ultrasound with practical and hard-earned wisdom. I believe children and their families will benefit tremendously from your efforts. Thank you.

Our editors, Deb Russell and Joanna Chamberlin, and the Cambridge staff. Thank you for this opportunity and the lesson that high standards and amicability can coexist. It has been an education and a privilege.

My wonderful and kind-hearted parents-in-law, Bill and Paula. I am very grateful for your support during this challenging process.

My children, Greg, Ashleigh, and Abby. You are three miracles. I love you.

My beautiful wife and best friend, Sherri. This would mean far less if I were not able to share it with you. I love you.

David J. McLario
Acknowledgments

To my fellow authors: your expertise is entirely the reason this book came to fruition. Thank you.

To Dave and Kendra: No one will really know the sacrifices you made to make this book possible. Thank you for your dedication and perseverance.

To my fellows and residents: your passion and enthusiasm for ultrasound is infectious and motivates me to continue to explore new frontiers for its application.

To my wife, Kwai, whose patience, love, and support is immeasurable, and to our children, Oliver and Maya, who make my life richer and more fulfilling than I could have ever imagined.

John L. Kendall