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Aims of the Series
Evidence-Based Imaging: Improving the Quality of Imaging in Patient Care series presents the radiologist and clinician with a user-friendly guide to the evidence-based science and the merit behind the diagnostic imaging performed in medicine. This ideal reference gathers contributions by internationally renowned specialists in the field. The series provides a systematic framework for understanding the best imaging choices for patient care. Chapters highlight key points that support the clinical applications, allowing fast access to pertinent information. Topics include patient selection, imaging, strategies, test performance, cost-effectiveness, and applicability.

By offering a clear understanding of the science behind the evidence, the book fills a void for radiologists, clinicians, physician assistants, nurse practitioners, residents, fellows, students and others with an interest in medical imaging and a desire to implement an evidence-based approach.
Evidence-Based Neuroimaging Diagnosis and Treatment

Improving the Quality of Neuroimaging in Patient Care

With 143 Figures and 123 Tables
To our patients, who are our best teachers,
and to the researchers, who made this book possible.
To our families, friends, and mentors

To my loving family past, present, and future, Jorge, Susana, Olga, Camila, and Isabela – LSM

To my loving and supportive husband, George, and our three children, Isabella, Sophia, and Nicholas, who are truly our pride and joy – PCS

To my children, Ella, Leah, and Ethan, who make it all worthwhile, and to my wife, Gail, who makes it all possible – JGJ
We are in the midst of a health-care transformation that has accelerated the need for providers to be able to defend the consequences of their decisions. The costs of care in the United States and in many other countries continue to escalate at unsustainable paces. With health care already consuming over 17% of our GDP, the rate of increase frightens those who appreciate that we are approaching the limits of economic tolerance.

Superimposed on the affordability conundrum is an urgency to deal with health issues associated with an aging population. Congress and governmental agencies are bent on removing costs and imposing barriers to limit expenses. The clear mantra in health care is to do more with less. How to provide quality care and improve the health of our country becomes a formidable challenge in such a demanding environment.

A particular component of this struggle is the focus on imaging. Its success in the past 30-plus years has dramatically improved the lives of millions. When I began my career in 1973, it was common to perform exploratory neurosurgery, myelography, direct carotid puncture angiography, and pneumoencephalography. Today, cross-sectional imaging has obviated such painful and frequently fruitless procedures, while also enabling remarkable increases in diagnostic acumen.

The imaging revolution has also created much consternation, however. I have been on a number of health-care panels where media and government functionaries have railed at “unnecessary” imaging and its associated costs. Of course, it is more difficult to actually define what is “unnecessary.” A case in point was my exposure to triage for CT (then a scarce resource) in the 1970s. It was about 10 pm when I was asked by a neurology resident to do an emergency CT on a patient with headache, slight fever, and normal neurologic examination – with only a hunch that there was a significant intracranial problem. He was concerned about a brain abscess, but with a normal exam it was difficult to imagine there was a developing emergency. It seemed to me that the case could wait to the following morning, which it did, with the subsequent scan revealing a large brain abscess pointing to the ventricle. So much for triaging!

Yet today, the concept of triage in the proper use of valuable resources looms larger than ever. And while, arguably, nothing will ever replace the intuition of the gifted physician, there is an unquestionable need to counter the practice of “defensive medicine” – the widespread ordering of tests that serve not to elucidate, but merely to document. Whether the impetus is the
The physician’s quest for self-protection or the patient’s insistence on “proof,” the only antidote to unnecessary imaging studies is evidence-based medicine.

A major stumbling block to embracing evidence-based approaches is the common assumption that patient well-being and the exigencies of the “bottom line” are intrinsically at odds. On the contrary, employing the most appropriate diagnostic algorithm is cost effective and patient centered simultaneously. There are innumerable examples of imaging examinations that provide virtually the same information. CT and MR examinations of the brain for this or that generally duplicate findings. There are instances, however, where one study may perhaps be more sensitive, e.g., the superiority of CT for the detection of calcification in a tumor or the detection of acute subarachnoid hemorrhage. Mastery of these nuances enables the neuroradiologist to be a worthy consultant.

Of course, the value of evidence-based medicine hinges above all on the quality of the evidence itself, leading to the fundamental question of how much evidence is truly available. There must be not only reliable, significant data but an accompanying interpretation of that information in the actual clinical context. One must diagnose the potential stroke, for instance, and then request the appropriate imaging study, a prerequisite that – however obvious it sounds – in many cases fails to occur.

Evidence is also a dynamic that changes as discoveries are made and additional knowledge is acquired. The essential need to incorporate the latest knowledge into the guidelines has lagged. In many instances, this is related to studies and results that are underpowered. In other circumstances, it is linked to the reluctance on the part of groups that have a particular interest or bias to participate in well-controlled large clinical trials.

Such disinclination is going to dissipate as payers demand real data. With an underpinning of robust economic incentives, CMS and insurance payers are signaling that they will not accept ad hoc decision making, necessitating institutions and providers to demand proper evidence for particular diagnostic and therapeutic decisions. It is baffling that so little incontrovertible evidence, including data on major and expensive medical conditions, exists today. There are many obvious examples of this issue, but the one that perhaps most dramatically demonstrates the point is the treatment of prostate cancer. First, what is the appropriate therapy for definite prostate cancer: watchful waiting, prostatectomy, radioactive seeds, external radiation, proton beam therapy, high frequency ultrasound, etc.? Even if one decides on surgery, is the costlier robotic surgery that much better than standard surgery? The discussion is further complicated by the PSA test itself, which lacks specificity, leading to the recent recommendation by the US Preventive Services Task Force that widespread PSA testing did not save enough lives to justify the considerable medical consequences of treatment. Even for such a common condition, in other words, there is disturbingly little data available.

An equally crucial yet less recognized and more difficult problem is the inability to effect change in the face of strong evidence. This failure – attributable to inertia and lack of knowledge on the part of both physicians and institutions – is bound to improve, at least in part, with the
implementation of the electronic health record, where evidence-based medicine will be embedded in alerts and accountability for decisions will be demanded.

This book will play a major positive role by informing clinicians about the quality of information they can depend on to enable evidence-based decision making. Neuroclinicians should welcome its publication. Strong outcome measures provide happy ways of doing things. Vigorous outcome measures support the value and utility of imaging. This is essential in the face of the increasing scrutiny by payers: the more available the information is, the easier the justification for the expense of imaging and the role of imagers will be.

Evidence-Based Neuroimaging Diagnosis and Treatment presents its readers with a logical introduction to understanding the foundation of evidence in medicine and then focuses on specific issues related to neuroradiology. It will begin an obligatory confrontation with the data that clinicians must gather in order to facilitate value-based decisions. Readers will gain significant appreciation of the data as it exists today, making the case for particular algorithms as well as the precise role of imaging. This is a major accomplishment and one that will benefit neuroradiologists, neurologists, neurosurgeons, and others with interests in clinical neuroscience.

Hats off to the authors who have presciently identified a need and who, with solid expertise and trenchant analysis, have produced a most worthy and requisite addition to the literature. This book will be the beginning of an ever-increasing torrent of texts and manuscripts focused on value and evidence. The era of evidence-based medicine has arrived – thank goodness!

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Preface

All is flux, nothing stays still.
Nothing endures but change.
Heraclitus, 540–480 B.C.

Medical imaging has grown exponentially in the last three decades with the development of many promising and often noninvasive diagnostic studies and therapeutic modalities. In no other area have these changes been more dramatic than in neuroimaging. The corresponding medical literature has also exploded in volume and can be overwhelming to physicians. In addition, the literature varies in scientific rigor and clinical applicability. The purpose of this book is to employ stringent evidence-based medicine criteria to systematically review the evidence defining the appropriate use of medical imaging and to present to the reader a concise summary of the best medical imaging choices for patient care.

The initial book chapters discuss the principles of evidence-based imaging and critical assessment of the literature. This book also includes important chapters on the economic impact, regulatory impact, and medicolegal implications of evidence-based imaging. Given the increased awareness and concern of radiation exposure from medical imaging, a dedicated chapter discussing the current evidence and its implications is presented. The rest of this book covers the most prevalent central nervous system, spine, and neck diseases in developed countries. Most of the chapters have been written by radiologists and imagers in close collaboration with clinical physicians and surgeons to provide a balanced perspective of the different medical topics. In addition, we address in detail both adult and pediatric issues. We cannot answer all questions – medical imaging is a delicate balance of science and art, often without adequate data for guidance – but we can empower the reader with the current evidence supporting medical imaging.

To make this book user friendly and to enable fast access to pertinent information, we have organized all of the chapters in the same format. The chapters are framed around important and provocative clinical questions relevant to the physician’s daily practice. A short table of contents at the beginning of each chapter helps three different tiers of users: (1) the busy physician searching for quick guidance, (2) the physician seeking deeper understanding, and (3) the medical-imaging researcher requiring a comprehensive resource. Key points and summarized answers to the important clinical issues are provided at the beginning of the chapters, so the busy
clinician can understand the most important evidence-based imaging data in seconds. Each important question and summary is followed by a detailed discussion of the supporting evidence so that the physician seeking greater depth can have a clear understanding of the science behind the evidence.

In each chapter, the evidence discussed is presented in tables and figures that provide an easy review in the form of summary tables and flowcharts. The imaging case series highlights the strengths and limitations of the different imaging studies with vivid examples. Toward the end of the chapters, the best imaging protocols are described to ensure that the imaging studies are well standardized and done with the highest available quality. The final section of the chapters is Future Research, in which provocative questions are raised for physicians and nonphysicians interested in advancing medical imaging.

Not all research and not all evidence are created equal. Accordingly, throughout this book, we use a four-level classification detailing the strength of the evidence based on the Oxford criteria: level I (strong evidence), level II (moderate evidence), level III (limited evidence), and level IV (insufficient evidence). The strength of the evidence is presented in parenthesis throughout the chapter, and so the reader gets immediate feedback on the weight of the evidence behind each topic.

Finally, we had the privilege of working with a group of outstanding contributors from major medical centers and universities in North America, Europe, Asia, and Australia. We believe that the authors’ expertise, breadth of knowledge, and thoroughness in writing the chapters provide a valuable source of information and can guide decision making for physicians and patients. In addition to guiding practice, the evidence summarized in the chapters may have policy-making and public health implications. We hope that this book highlights key points and generates discussion, promoting new ideas for future research. Finally, regardless of the endless hours spent researching the multiple topics in depth, evidence-based imaging remains a work in progress. We value your suggestions and comments on how to improve this book. Please email them to us and the authors so that we can bring you the best of the evidence over the years.

February 2013
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Dr. Santiago Medina is a pediatric radiologist and neuroradiologist at Miami Children’s Hospital, Miami, Florida, USA. Currently, he is codirector of the Division of Neuroradiology and cofounder and director of the International Health Outcomes, Policy and Economics Center (HOPE) and clinical professor of radiology at Florida International University (FIU). Dr. Medina is board certified in diagnostic radiology, pediatric radiology, and neuroradiology by the American Board of Radiology. He graduated from the Institute of Health Sciences, CES University, Medellin, Colombia. Dr. Medina completed his radiology residency in the Mallinckrodt Institute of Radiology, Washington University Medical Center, St. Louis, Missouri. He completed both fellowships for pediatric radiology and pediatric neuroradiology at Children’s Hospital, Harvard Medical School, Boston, Massachusetts in 1997. Dr. Medina has received numerous prestigious awards including the Scientific Exhibit Cum Laude Award from the Radiological Society of North America (RSNA), the Roentgen Fellow Research Award from the Radiological Society of North America (RSNA) Research and
Education Fund, Outstanding Researcher and Professor from the U.S. Immigration and Naturalization Service, General Electric-Association of University Radiologists Fellow, and the American Society of Neuroradiology (ASNR) Health Services and Outcomes Scholar. He has also a master’s degree in public health with concentration in health care management from the Harvard School of Public Health. Dr. Medina has received multiple grants, including grants from the U.S. Department of Defense. He is an expert on evidence-based imaging and research on functional MRI and advanced neuroimaging. Dr. Medina has held various visiting professorships in Children’s Hospital Medical Center in Cincinnati, Ohio; Columbia University; Boston University; Malaysia; Hospital for Sick Children, Toronto, Canada; and South Africa. He was the invited/named lecturer of the Dr. Donald Altman Annual Lecture in the Miami Children’s Hospital Pediatric Course. Dr. Medina has written more than 50 peer-reviewed scientific manuscripts. He is the author of four books and co-series editor of Springer’s *Evidence-Based Imaging*.

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Pina C. Sanelli, M.D., M.P.H., is an associate professor of radiology and public health at the Weill Cornell Medical College. She also serves as the associate chairman for Practice Quality Improvement and director of the Fellowship Training Program in Neuroradiology at the NewYork-Presbyterian Hospital.

Dr. Sanelli obtained her medical degree from SUNY at Buffalo School of Medicine and Biomedical Sciences. She completed residency training in diagnostic radiology at North Shore University Hospital and fellowship training in neuroradiology at the Massachusetts General Hospital. She is board certified by the American Board of Radiology with Certificate of Added Qualifications in Neuroradiology. Dr. Sanelli obtained a Masters degree in Public Health from Harvard University School of Public Health. She was awarded the GE-AUR Radiology Research Academic Fellowship (GERRAF) and the Scholar’s Award from the American Society of Neuroradiology (ASNR).
Her research focused on technology assessment of CT perfusion imaging in aneurysmal subarachnoid hemorrhage and its clinical effectiveness. Dr. Sanelli has also been awarded several private foundation grants for her work and is currently the principal investigator on an NIH-funded prospective clinical trial in the neuro-intensive care unit for outcomes research on CT perfusion imaging in aneurysmal subarachnoid hemorrhage.

Dr. Sanelli is well known in the field of health services and comparative effectiveness research. Her currently funded NIH grant includes performing a cost-effectiveness analysis of CT perfusion imaging in aneurysmal subarachnoid hemorrhage to assess its added value in this population. Dr. Sanelli serves on the executive board for the Radiology Alliance for Health Services Research (RAHSR). She also serves on the research committee and grant reviewer for the American Society of Neuroradiology (ASNR), Radiological Society of North America (RSNA), and the American Roentgen Ray Society (ARRS). She is currently the chairperson of the evidence-based medicine and research committees of the ASNR. She has been an invited speaker and author on the topic of evidence-based imaging. Dr. Sanelli now serves as the health care and socioeconomics editor of the American Journal of Neuroradiology (AJNR).

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Dr. Jarvik is a professor of radiology and neurological surgery as well as adjunct professor of health services in the School of Public Health and adjunct professor of pharmacy in the School of Pharmacy at the University of Washington. He also serves as director of the Comparative Effectiveness, Cost and Outcomes Research Center (CECORC).

Dr. Jarvik attended the University of California, San Diego, for both undergraduate education and medical schooling. He then did his residency in diagnostic radiology and fellowship in neuroradiology at the Hospital of the University of Pennsylvania. He obtained his M.P.H. from the University of Washington in health services while a Robert Wood Johnson Clinical Scholar. His studies in the RWJ Clinical Scholars Program focused on
the evaluation of diagnostic and therapeutic technologies related to low back pain, with Richard A. Deyo, M.D., M.P.H., as his primary mentor. Dr. Jarvik is a former recipient of the GE-AUR Radiology Research Academic Fellowship (GERRAF), a career development award.

Dr. Jarvik is an internationally recognized expert in MR imaging of the spine as well as in the field of health services and comparative effectiveness research as it relates to radiology. As the director of CECORC, he has led or collaborated on multiple technology assessments using multidisciplinary teams involving a wide variety of medical and surgical specialties as well as nonclinical disciplines of biostatistics, economics, epidemiology, and health services. He has extensive practical experience in the conduct of both observational as well as randomized controlled trials of devices and procedures. He has published studies focused on technology assessment and back pain in numerous prestigious journals including JAMA, The Lancet, and the New England Journal of Medicine.

Dr. Jarvik is the only radiologist to be selected as a principal investigator (PI) for the NIH Collaboratory, an initiative that is part of the NIH Director’s fund to foster pragmatic clinical trials. He was also the PI of the Back pain Outcomes using Longitudinal Data (BOLD) project, a $10 million project funded by the Agency for Healthcare Research and Quality that established a large registry to investigate diagnostic and therapeutic interventions in seniors with low back pain.
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