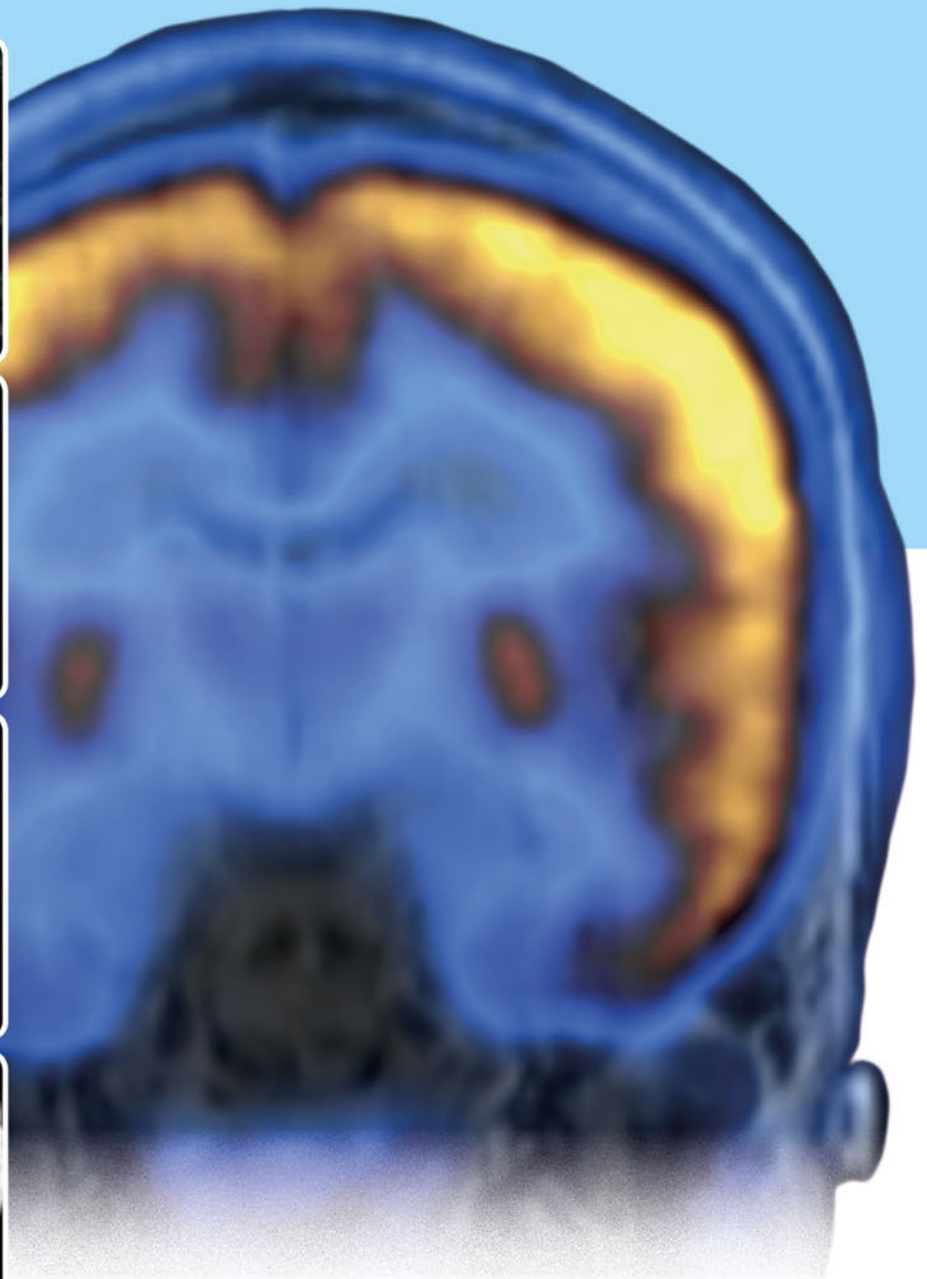
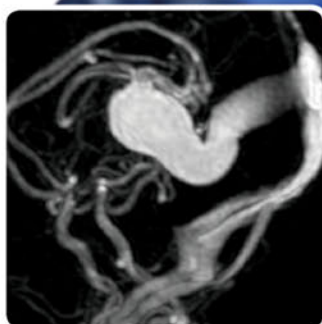
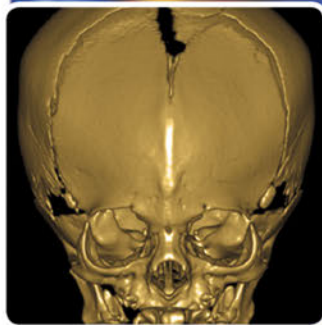
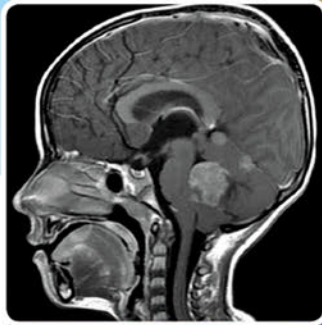
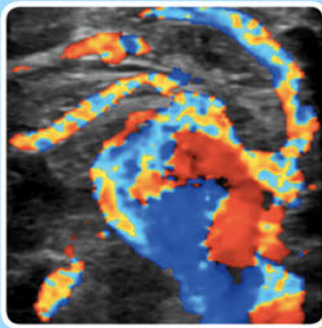


Pediatric Neuroradiology

Clinical Practice Essentials

Asim F. Choudhri



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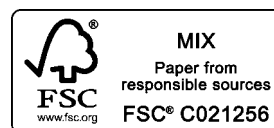
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This book is dedicated to all children with neurologic disorders, and to their families.

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Foreword

It is said, “Everyone has a book within them”. The key is to write one that fulfills a niche and tells a good story. In this volume by Asim Choudhri, *Pediatric Neuroradiology: Clinical Practice Essentials*, one has the book that has been needed for a long time and that tells a good story. Let’s face it, Jim Barkovich’s *Pediatric Neuroimaging* is one of the bibles of Neuroradiology, but is not something that anyone can read cover to cover. It’s more of a reference book that you consult, and it fulfills that niche. It is outstanding. What Dr. Choudhri has done is to write a book that captures 95% of what you will actually see in your clinical practice, distills it to an appropriate depth, and moves on to the next entity. The writing style is engaging and Asim’s fund of knowledge is exceptional. He is a good “story-teller.”

The book was designed with a carefully thought out table of contents, with 28 manageable chapters divided into sections for brain, head and neck, and spine. High quality images are supplemented with descriptive figure legends to allow the reader to extract maximum information. Beyond learning the information, it is important to clinically apply this knowledge, which is often the most difficult aspect to glean from a textbook. This is where the three appendices come in handy. An entire appendix is dedicated to protocolling studies, to allow the reader to learn how best (and when) to acquire the images that are most useful. A second appendix focuses on how to report studies, presenting templates and

guidance for providing clinically helpful and consultative interpretations. The third appendix is a quick-reference for common pediatric neuroradiology indications/presentations, including condition-specific pertinent positive and negative studies for interpretation. It’s all there!

I recommend this book to all trainees and practitioners that see a fair number of pediatric neuroradiology cases and/or patients. If you want an outstanding, practical, efficient read that does not get mired in the minutiae, buy this book.

I have known Dr. Choudhri since his year as a neuroradiology fellow at Johns Hopkins. In the time since his graduation from our program I have corresponded with him, collaborated with him, and also invited him to serve as a teacher at the American College of Radiology Education Center for its Neuroradiology Course. Asim has done a super job as a clinician, a researcher, and as an educator. I think that you are really going to enjoy this book from one of Neuroradiology’s Triple Threats, Asim Choudhri. I tip my hat to him.

David M. Yousem, MD, MBA

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Preface

The idea for this book arose during my first few years of practice as a neuroradiologist in a pediatric hospital. During daily interactions with residents and fellows, as well as faculty members of various specialties, I was frequently asked to recommend a good resource for an individual to learn and review the fundamentals of pediatric neuroradiology. Extensive, and therefore appropriately expensive, resources exist, which are well served for the neuroradiologist and for reference libraries; however, there was no book which was light enough to carry around, practical enough to be used on a regular basis, detailed enough to be helpful while remaining accessible to those junior in training, and priced so that residents in radiology, neurology, and neurosurgery would consider it worth owning (not to mention residents and staff in otolaryngology and neck surgery, ophthalmology, orthopaedics, neurosurgery, genetics, pediatrics, and other areas).

So from this came my working outline, which I added to and modified over several years. It became clear why the giants of the field wrote giant textbooks on this topic, and I realized that a 50-page all-encompassing text is not possible. I nevertheless believe that the book you are holding remains appropriately focused for the individual who wishes to learn the foundations of pediatric neuroradiology.

The content of this book come from cases I have seen during my first five years of practice. There are indeed many rare diseases I have seen that are not included in this book (e.g. melanocytic neuroectodermal tumor of infancy, methylmalonic academia, and others). I performed the imaging workup and preoperative planning for over 750 pediatric brain tumors while at Le Bonheur, but this is not meant to be a pediatric neuro-oncology textbook, therefore many of the esoteric entities I have encountered are not discussed. I also have performed a large volume of advanced imaging, including over 250 functional MRIs in children, and multi-delay ASL perfusion in dozens of children with moyamoya vasculopathy; however, this is not intended to be a textbook in advanced imaging techniques in neuroradiology.

This book is deliberately not kitchen-sink comprehensive, but is instead meant to be practical and focused on fundamentals. I am less concerned that the reader can identify a disease that has only been reported a few dozen times than I am to make sure they can confidently and safely interpret the common disorders of childhood. This book is meant to help

reduce the over-diagnosis of normal pediatric conditions (such as mistaking a calvarial suture for a fracture), and reduce the under-diagnosis of conditions that present differently in children than in adults (such as mistaking a fracture for a calvarial suture). Another area of significant confusion I hope to clarify is the dandy-walker spectrum of malformations, and normal variants without pathologic significance that are confused with dandy-walker spectrum malformations. Accordingly, disease processes that I couldn't readily find examples of in my teaching files (and thus that I haven't knowingly encountered in the last five years) have been excluded, with rare exceptions. A few diseases I have not definitely encountered during my time at Le Bonheur Children's Hospital have been included some because they are common in other geographic locations, such as Lyme disease (which I saw multiple times when training on the East Coast), some because they have a very characteristic imaging appearance, despite their rarity, and others that are not commonly evaluated by radiologists today due to advances in clinical evaluation yet have historic importance, such as Coats disease, which is now confidently differentiated from retinoblastoma by ophthalmologists without the need for CT or MRI. Additionally, topics that have significant overlap with findings in adult neuroradiology are not covered in as comprehensive a manner as a general neuroradiology textbook does, in particular with entities that are much less common in children such as glioblastoma and acute stroke. Where possible, suggested readings are provided to learn more on given areas, typically review articles that further delve into a given topic. Many review articles arise from publications such as Radiographics, Neurographics, and the American Journal of Neuroradiology.

This book will not replace comprehensive reference texts in the field of pediatric neuroradiology, and it is not intended to do so. This book will serve as a foundation for a broader audience to understand the imaging appearance of neurologic diseases of childhood. With this foundation, readers may be in a position to further explore the details in sources such as reference textbooks and the peer-reviewed scientific literature. I hope and trust that the book has been structured to appropriately achieve this goal, and I look forward to feedback from readers about the impact this book has on your education and clinical care.

Acknowledgments

This book would not be possible without the guidance of my parents, Drs. Fiaz and Saleem Choudhri, who served as personal and professional role models. Each was the first physician in their families, showing a dedication to patient care that inspired my siblings and numerous cousins to pursue careers in medicine. My brothers, Drs. Haroon and Tanvir Choudhri, followed my father's footsteps into neurosurgery, and kept me apprised of their clinical thought processes along the way. They have served as a constant source of challenging consults and clinical feedback. To my loving wife Lauren, an academic pediatric neuro-ophthalmologist who is my collaborator, my supporter, and my perpetual cheering section. To my beautiful son Hilo, who joined us just as this book was going to print. To all of my in-laws, who are truly family members and supporters.

After family, I must acknowledge the significant efforts regarding proofreading this manuscript and serving as a source of ideas for improvement, often on exceedingly short deadlines, provided by Dr. Adeel Siddiqui and Dr. Zachary Abramson.

Thank you to my mentors within medicine, including Mehmet Oz who taught me to think critically, and helped me early in my career prior to entering medical school. To the memory of Theodore Keats, a spectacular radiologist, educator, and person. To Michael Dake, Bruce Hillman, Doug Phillips, Kiran Nandalur and other mentors and role models from my time at the University of Virginia. David Yousem, Thierry Huisman, Aylin Tekes, Ari Blitz, Dheeraj Gandhi, Nafi Aygun, Sachin Gujar, Jay Pillai, Bruce Wasserman, Mike Kraut, Izlem Isbudak, Dorris Lin, Marty Radvany, Philippe Gailloud, among other stellar physicians who trained me at Johns Hopkins.

Thank you to Harris Cohen who allowed me to convince him to hire a neuroradiologist to work at a pediatric hospital, and who throughout the last four and a half years has been a supportive Chairman, mentor, colleague, and friend. To James Wheless, Frederick Boop, Paul Klimo, and my collaborators at the Le Bonheur neuroscience institute, including Amy McGreggor, Stephen Fulton, Sarah Weatherspoon, Paras Bhattarai, Elena Caron, Ehab Dayyat, Masanori Igarashi, Swati Karmarker, Kathryn McVicar, Robin Morgan, Basan Mudigoudar, Namrata Shah, Stephanie Einhaus, Michael Muhl-bauer, Lucas Elijovich, as well as Andy Papanicolaou, Roozbeh Rezaie, Shalini Narayana, and Abbas Babajani-Feremi. To Bruce MacDonald for giving me direct clinical feedback on skull base and temporal bone cases, and Jerome Thompson and Jennifer McLevy for their clinical collaborations on complex otolaryngology cases. To Dr. Chris Fleming of the department of Ophthalmology for his clinical collaborations and leadership. To Dr. Barrett Haik, a world class Ophthalmologist and role model in academic medicine, who has also been an

important research and academic collaborator. To Zoltan Patay and the team at St. Jude, with whom we collaborate on pediatric neurooncology, not to mention Dr. Patay's ability to serve as the definitive resource on metabolic disorders.

Thank you to all of my radiology colleagues over the last four and a half years in at UTHSC and Le Bonheur; especially Matt Whitehead, a friend and stellar neuroradiologist who I have been lucky enough to work with at several stages of my career, and Adeel Siddiqui who has more recently joined our practice. To the team of pediatric radiologists who serve as colleagues, collaborators, and mentors, including Chandra Smothers, Lynn Magill, Louis Parvey, Jeff Scrugham, Clint Teague, Nana Sintim-Damoa, Steve Miller (not *that* Steve Miller), Webster Riggs, and Thomas Boulden. To the many additional collaborators and teammates at Le Bonheur, including John Bissler, a collaborator on tuberous sclerosis as well as a leader in clinical and basic research, Eniko Pivnick, Karen Lakin, Jason Johnson, Nadeem Shafi, Regan Williams, Jie Zhang, and Royce Joyner. To the team of pediatric emergency specialists who I work with on a daily basis, led by Dr. Barry Gilmore, and the anesthesiologists who help us take care of patients, who work under the guidance of Dr. Joel Salzman.

Thank you to Tom Naidich, who has given me support and advice since I was in medical school, and served as an inspiration for how to develop as a pediatric neuroradiologist. Similarly, to Jeff Stone who has given me guidance since the start of medical school. To Mauricio Castillo, who served as an outstanding and inspiring leader and mentor during my AJNR editorial fellowship. To Jiro Ono, who has demonstrated that the pursuit of perfection is a never-ending goal requiring dedication, patience, and building an outstanding team. To Grant Achatz, for showing that effective use of technology can augment creativity and artistic expression.

Thank you to my classmates and co-residents throughout this process, in particular Eric von Johnson and Aaron Morrison (the other two musketeers). To Alan Levy, Gustavo Lozada, and others from medical school. To Trey Carr, Rourke Stay, Jimi Obembe, James Stone, Mike Meuse, and Chris Ho, a wonderful set of co-residents (with honorable mention to Jen Marler). To my co-fellows Muzammil Shafi, Sonia Ghei, Dan Hawley, Juan Gomez, Alper Acka, George Kuo, and Anna Nidecker, who helped make my time at Johns Hopkins such an eye-opening and life-changing experience. To all of the students and residents I have had the privilege to work with, teach, and also learn from, including Eric Chin, Chris Oh, and Zachary Abramson. To the technologists who I work with on a daily basis, who allow me to do the work that I do, including (but not limited to!) Will Boon, Lisa McAfee, Ratana Laurie, Megan Carroll, Stacy Pennington, Becky Cooper, Anita Young, Lori Bledsoe, Shawn Holliday, and Jeff Jenkins as well as the