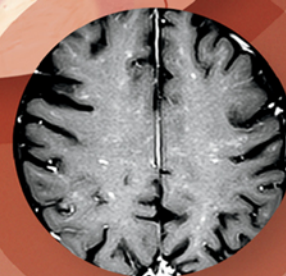
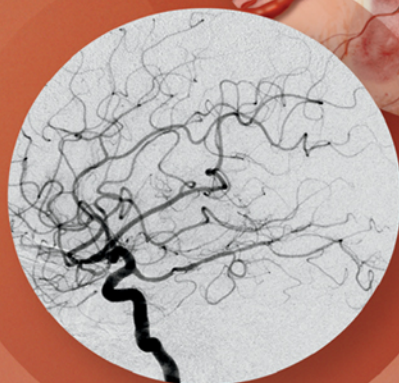
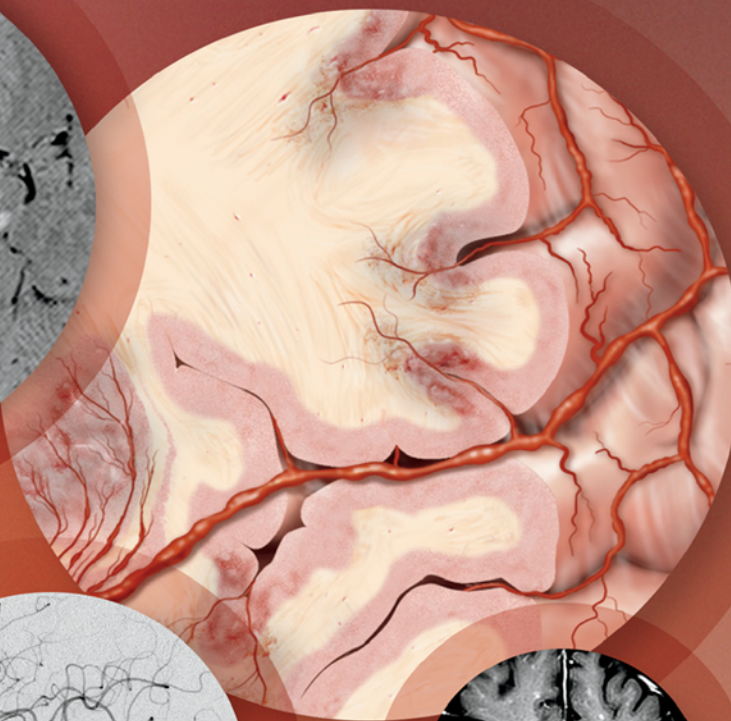
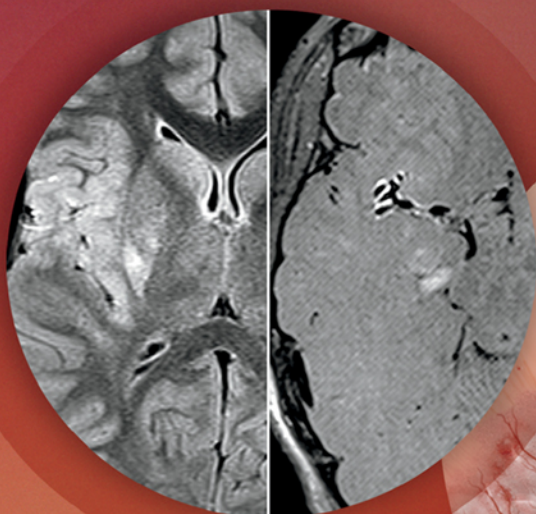


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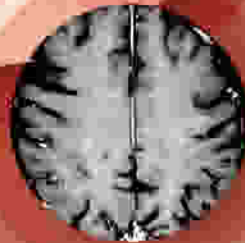
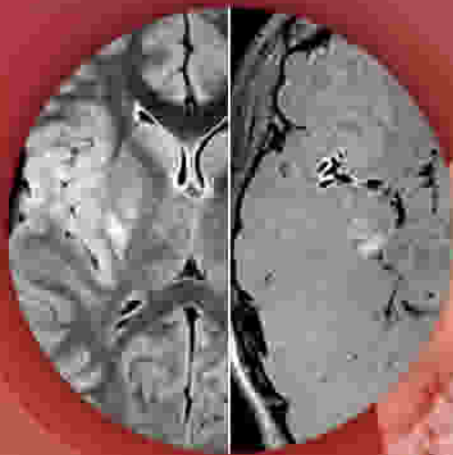
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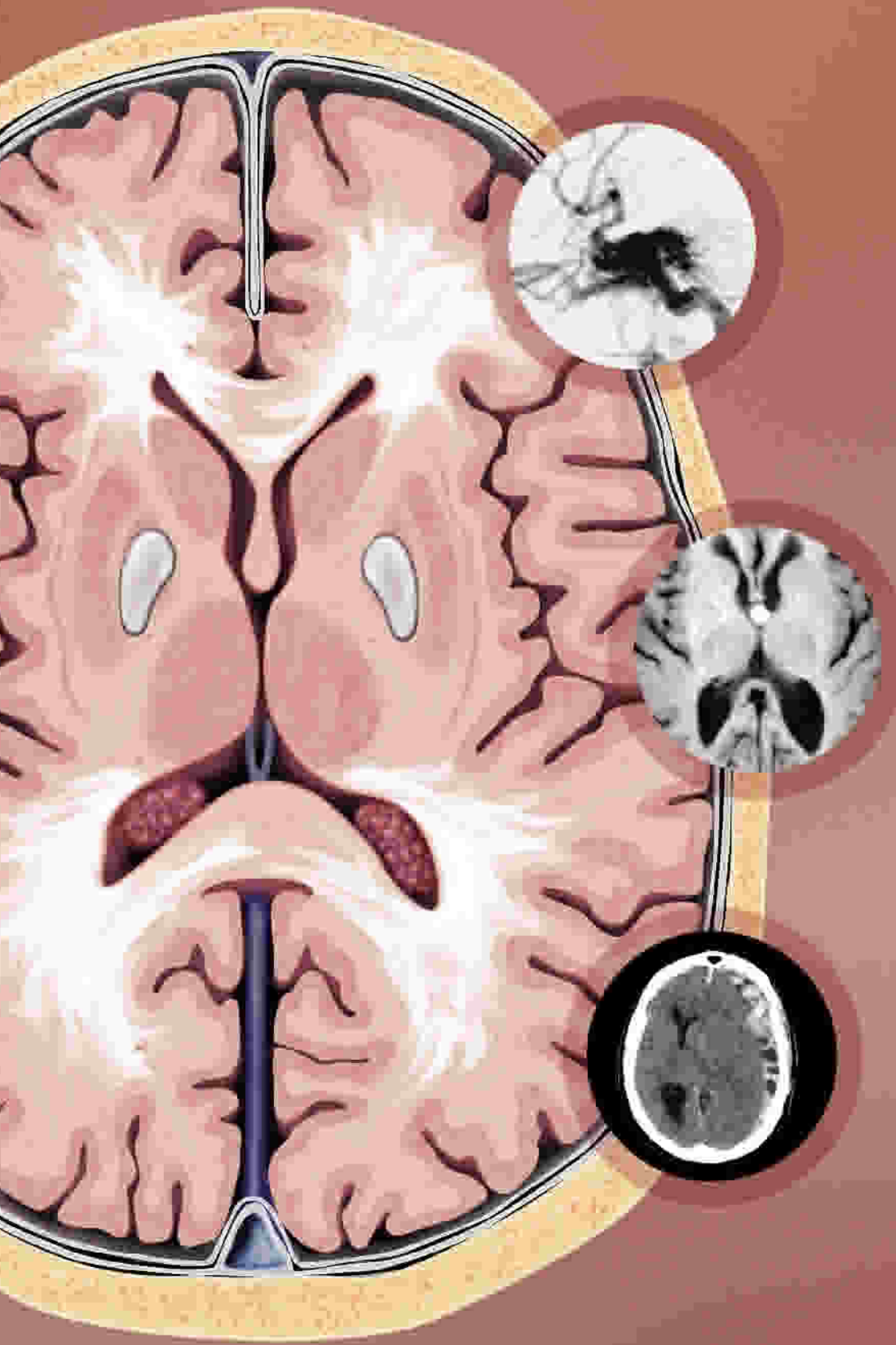
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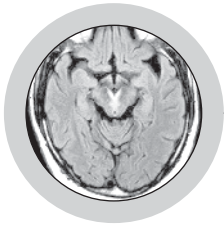
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## Anne G. Osborn, MD, FACR

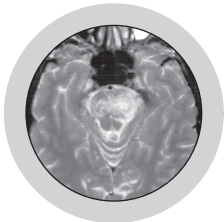
University Distinguished Professor  
William H. and Patricia W. Child Presidential Endowed Chair  
University of Utah School of Medicine  
Salt Lake City, Utah



---

## Kathleen B. Digre, MD

Professor of Neurology, University of Utah School of Medicine  
Chief, Division of Headache and Neuro-Ophthalmology  
John A. Moran Eye Center  
Salt Lake City, Utah



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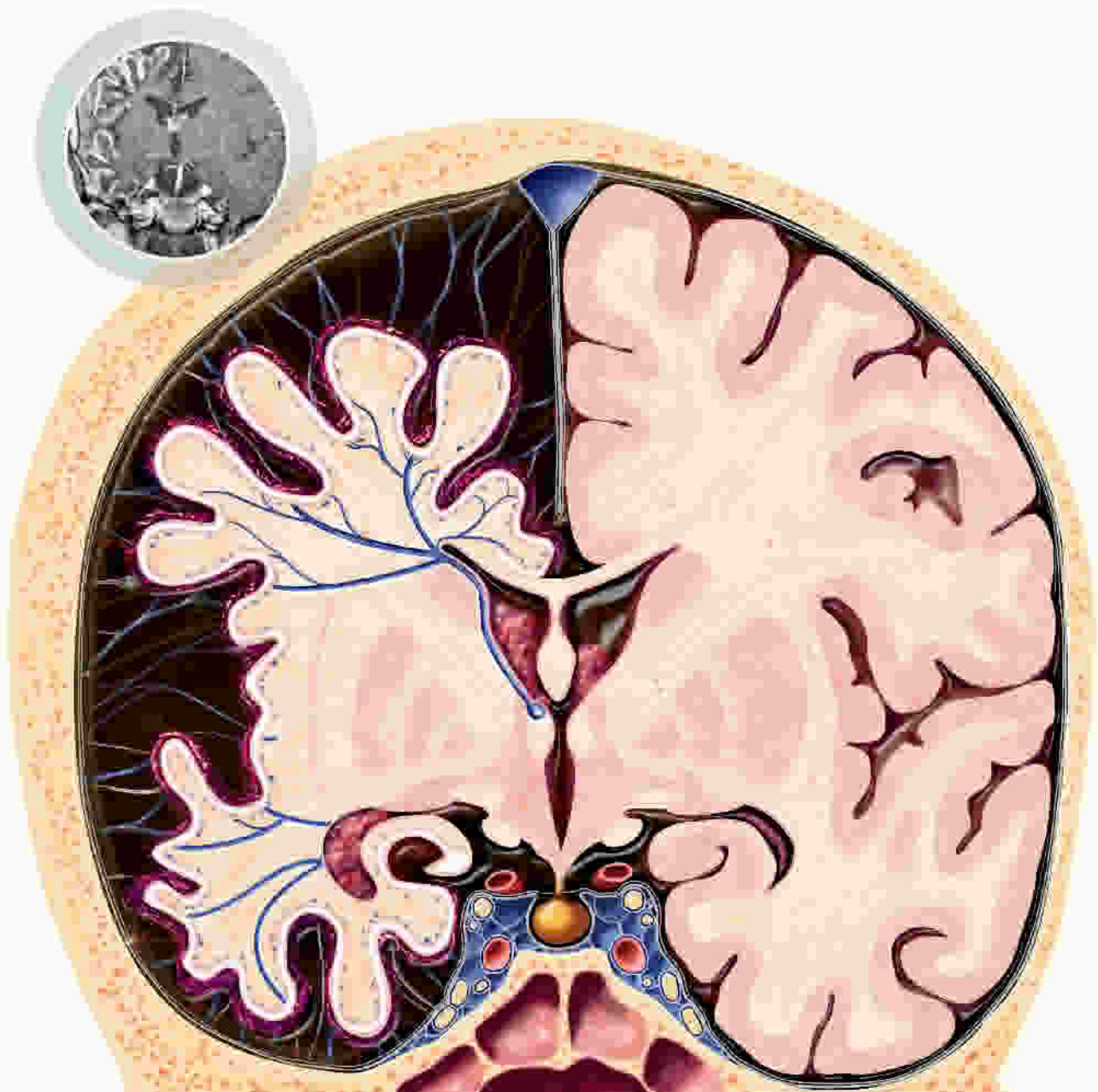
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# Dedication

*To my husband, Michael Varner, for his  
neverending love and encouragement.*

**KBD**



# Contributing Authors

**Miral D. Jhaveri, MD**

Associate Professor  
Director of Neuroradiology  
Department of Diagnostic Radiology & Nuclear Medicine  
Rush University Medical Center  
Chicago, Illinois

**Karen L. Salzman, MD**

Professor of Radiology  
Leslie W. Davis Endowed Chair in Neuroradiology  
University of Utah School of Medicine  
Salt Lake City, Utah

**Jeffrey S. Ross, MD**

Senior Associate Consultant  
Neuroradiology Division  
Department of Radiology  
Mayo Clinic Arizona  
Professor of Radiology  
Mayo Clinic College of Medicine  
Phoenix, Arizona

**Kevin R. Moore, MD**

Pediatric Neuroradiologist  
Primary Children's Hospital  
Salt Lake City, Utah

**Lubdha M. Shah, MD**

Associate Professor of Radiology  
Division of Neuroradiology  
University of Utah School of Medicine  
Salt Lake City, Utah

**James M. Provenzale, MD**

Professor of Radiology  
Duke University Medical Center  
Durham, North Carolina

**H. Ric Harnsberger, MD**

R.C. Willey Chair in Neuroradiology  
Professor of Radiology and Otolaryngology  
University of Utah School of Medicine  
Salt Lake City, Utah

**Bryson Borg, MD**

Fairfield, California

**Gregory L. Katzman, MD, MBA**

Professor, Neuroradiology  
Vice Chair, Radiology Operations  
Chief Quality Officer  
Chief Business Development Officer  
Department of Radiology  
University of Chicago Medicine  
Chicago, Illinois

**Susan I. Blaser, MD, FRCPC**

Staff Neuroradiologist  
The Hospital for Sick Children  
Professor of Neuroradiology  
University of Toronto  
Toronto, Ontario, Canada

**Bronwyn E. Hamilton, MD**

Professor of Radiology  
Oregon Health & Science University  
Portland, Oregon

**Perry P. Ng, MBBS (Hons), FRANZCR**

Adjunct Associate Professor, Department of Radiology  
University of Utah School of Medicine  
Salt Lake City, Utah  
Interventional Neuroradiologist  
Centura Health Physician Group  
Denver, Colorado

**A. James Barkovich, MD**

Professor of Radiology and Biomedical Imaging, Neurology,  
Pediatrics and Neurological Surgery  
UCSF-Benioff Children's Hospital  
University of California, San Francisco  
San Francisco, California

**Julia R. Crim, MD**

Chief of Musculoskeletal Radiology  
Professor of Radiology  
University of Missouri at Columbia  
Columbia, Missouri

**Laurie A. Loevner, MD**

Chief, Division of Neuroradiology  
Director, Head and Neck Radiology  
Professor of Radiology, Otorhinolaryngology: Head and  
Neck Surgery, and Neurosurgery  
University of Pennsylvania Health System Perelman School  
of Medicine at the University of Pennsylvania  
Philadelphia, Pennsylvania

**Gilbert Vézina, MD**

Director, Program in Neuroradiology  
Children's National Medical Center  
Professor of Radiology and Pediatrics  
The George Washington University School of Medicine  
and Health Sciences  
Washington, DC

**Sheri L. Harder, MD, FRCPC**

Assistant Professor of Radiology  
Division of Neuroradiology  
Loma Linda University Medical Center  
Loma Linda, California

**Chang Yueh Ho, MD**

Assistant Professor of Radiology  
Director of Pediatric Neuroradiology  
Program Director, Pediatric Neuroradiology Fellowship  
Riley Hospital for Children  
Indiana University School of Medicine  
Indianapolis, Indiana

**Majda M. Thurnher, MD**

Associate Professor of Radiology  
Medical University of Vienna  
Department of Biomedical Imaging and Image-Guided Therapy  
Vienna, Austria

**H. Christian Davidson, MD**

Professor of Radiology  
University of Utah School of Medicine  
Salt Lake City, Utah

**Yoshimi Anzai, MD, MPH**

Professor of Radiology  
Associate Chief Medical Quality Officer  
University of Utah  
Salt Lake City, Utah

**Anna Illner, MD**

Pediatric Neuroradiologist  
Texas Children's Hospital  
Assistant Professor of Radiology  
Baylor College of Medicine  
Houston, Texas

**Ulrich Rassner, MD**

Associate Professor of Radiology  
Division of Neuroradiology  
University of Utah School of Medicine  
Salt Lake City, Utah

**Charles Raybaud, MD, FRCPC**

Derek Harwood-Nash Chair in Medical Imaging  
Division Head of Neuroradiology  
The Hospital for Sick Children  
Professor of Radiology  
University of Toronto  
Toronto, Ontario, Canada

**John H. Rees, MD**

Chief of Neuroradiology: Partners Imaging  
Sarasota, Florida  
Assistant Professor of Radiology  
Georgetown University  
Previously: Visiting Scientist  
Armed Forces Institute of Pathology  
Washington, DC

**Jeffrey S. Anderson, MD, PhD**

Associate Professor of Radiology and Bioengineering  
University of Utah School of Medicine  
Salt Lake City, Utah

**P. Ellen Grant, MD**

Associate Professor in Radiology, Harvard Medical School  
Founding Director, Center for Fetal-Neonatal Neuroimaging  
and Developmental Science  
Director of Fetal and Neonatal Neuroimaging Research  
Boston Children's Hospital Endowed Chair in Neonatology  
Boston Children's Hospital  
Boston, Massachusetts

**Gary L. Hedlund, DO**

Adjunct Professor of Radiology  
University of Utah School of Medicine  
Pediatric Neuroradiologist  
Department of Medical Imaging  
Primary Children's Hospital  
Salt Lake City, Utah

**Blaise V. Jones, MD**

Associate Director of Radiology  
Neuroradiology Section Chief  
Cincinnati Children's Hospital Medical Center  
Professor of Clinical Radiology and Pediatrics  
University of Cincinnati College of Medicine  
Cincinnati, Ohio

**Luke N. Ledbetter, MD**

Assistant Professor of Radiology  
Division of Neuroradiology  
University of Kansas Medical Center  
Kansas City, Kansas

**Deborah R. Shatzkes, MD**

Professor of Radiology  
Hofstra North Shore-LIJ School of Medicine  
Chief, Head & Neck Radiology  
Lenox Hill Hospital and  
The New York Head & Neck Institute  
North Shore-LIJ Health System  
New York, New York

**Rebecca S. Cornelius, MD, FACR**

Professor of Radiology and Otolaryngology-  
Head and Neck Surgery  
University of Cincinnati College of Medicine  
University of Cincinnati Medical Center  
Cincinnati, Ohio

**Patricia A. Hudgins, MD, FACR**

Professor of Radiology/Otolaryngology  
Director of Head & Neck Radiology  
Department of Radiology and Imaging Sciences  
Emory University School of Medicine  
Atlanta, Georgia

**Nicholas A. Koontz, MD**

Assistant Professor of Clinical Radiology  
Department of Radiology and Imaging Sciences  
Indiana University School of Medicine  
Indianapolis, Indiana

**Gary M. Nesbit, MD**

Professor of Radiology, Neurology, Neurological Surgery  
and the Dotter Interventional Institute  
Oregon Health & Science University  
Portland, Oregon

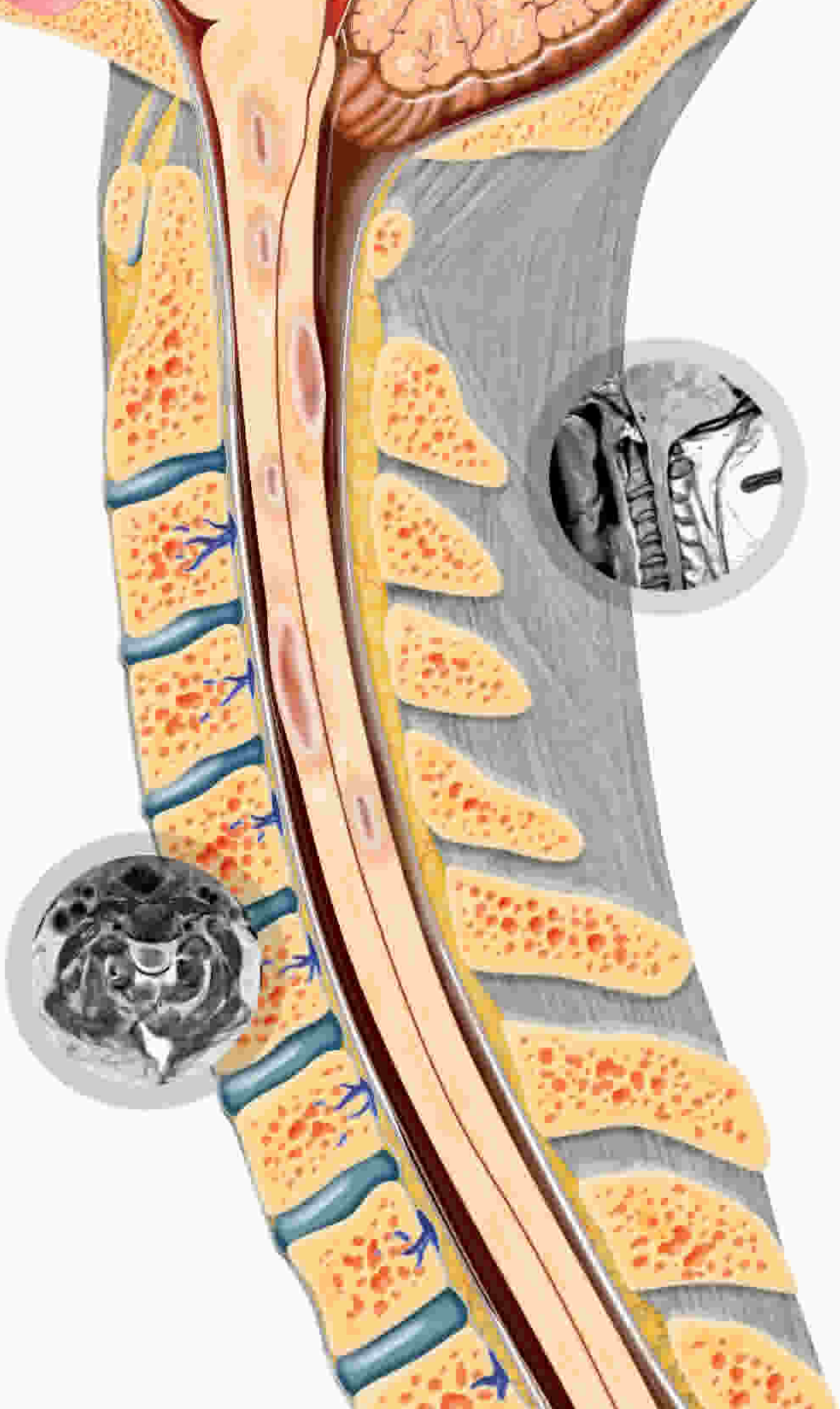
**Edward P. Quigley, III, MD, PhD**

Assistant Professor of Radiology  
Division of Neuroradiology  
University of Utah School of Medicine  
Salt Lake City, Utah

**Palmi Shah, MD**

Assistant Professor  
Rush University Medical Center  
Chicago, Illinois





# Preface

Anne Osborn and I have been colleagues for almost our entire careers. When she approached me about joining her to edit a book for neurologists on imaging, I didn't have to think twice. Neurologists use imaging every day as an extension of the neurological examination. In fact, imaging is critical to making the correct diagnosis and following patients. Yet, the best imaging books are all in neuroradiology. Here was a chance to partner with one of the premier neuroradiologists to produce a book that would be practical and useful to my neurological colleagues around the world. What wasn't to like?!

The book's purpose is to provide key imaging findings to the most common and important neurological disorders in an easy-to-understand format, using typical imaging examples, pathological examples when appropriate, and gorgeous drawings that illustrate key findings. We have also included clinical photos where indicated.

The book is divided into three parts—an introduction to imaging in general, imaging of the brain from pathology-based and anatomic-based diagnoses, and spine imaging. There are overview chapters to difficult subjects like congenital malformations, trauma, vascular anatomy, neoplasms, infectious diseases, and metabolic disorders. There are anatomic overviews of the ventricles, the pituitary, cerebellar pontine angle, and the orbit. The spine section also has a wonderful review of normal anatomy and then develops a complex subject made simple.

Each chapter is written by outstanding neuroradiologists who point out the main imaging findings for each disorder or anatomic area. We then addressed key clinical features. The organization of each chapter makes it really easy for a neurologist to quickly know the key terminology, imaging findings, pathologic underpinnings, and important clinical details. Images were specifically chosen to be classic examples, and Anne Osborn labored for many hours putting arrows on every structure that is described so that all of us neurologists know exactly what the key findings are.

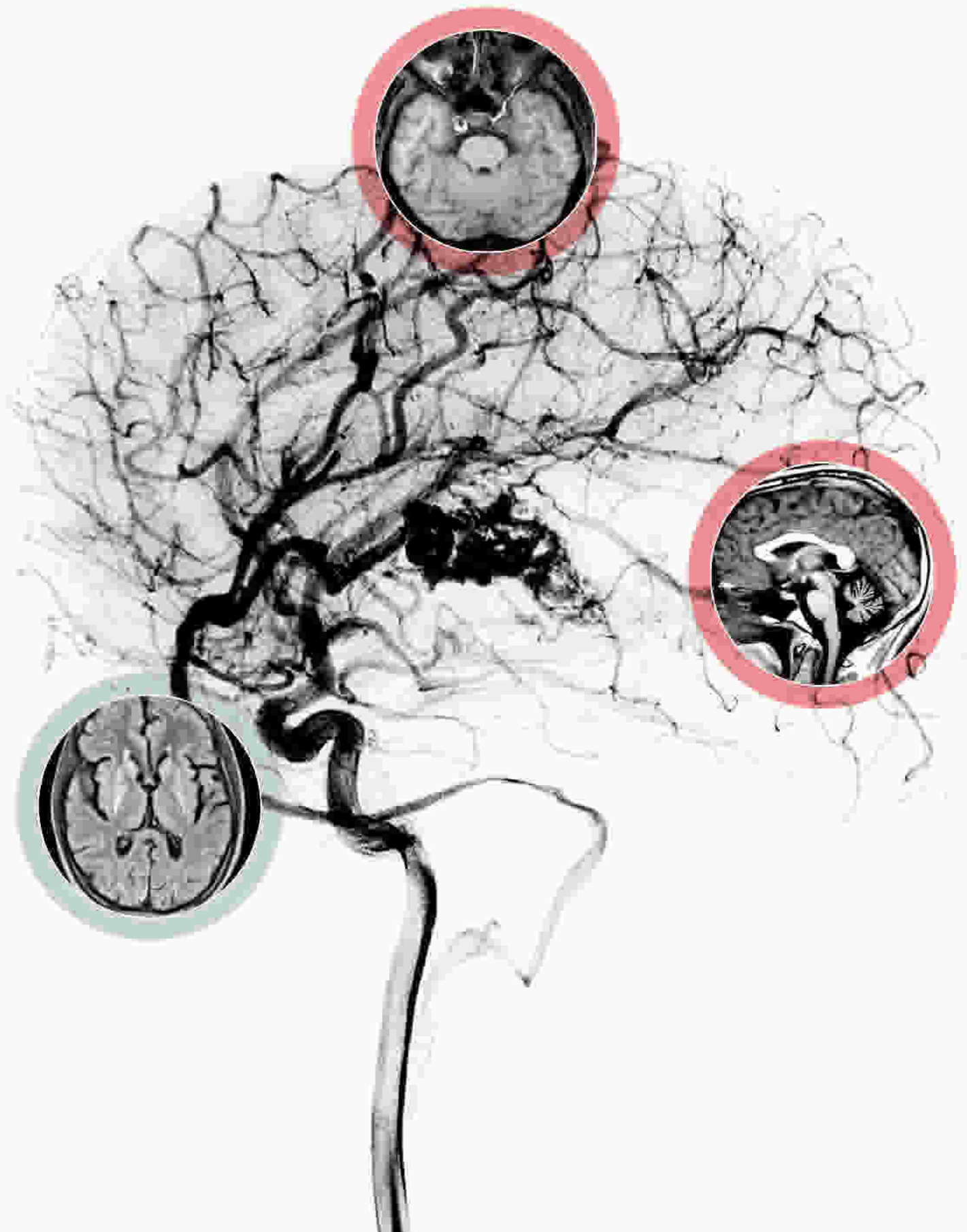
We see this book being of value to every practicing neurologist or physician who sees general neurology patients. In addition, we see residents using this book to study for in-service and board exams.

We have many people to thank in producing this book. First, we relied on two fellows from the University of Utah who completed neurological residencies and are currently in fellowship—Dr. Kelsey Juster-Switlyk and Dr. Reuben Valenzuela. These two highlighted areas that were not clear or key points that were missing. Our fabulous senior editor, Dr. Karen E. Concannon, kept us on schedule.

Finally, we thank our families and colleagues for giving us the time and space to finish the project.

## **Kathleen B. Digre, MD**

Professor of Neurology, University of Utah School of Medicine  
Chief, Division of Headache and Neuro-Ophthalmology  
John A. Moran Eye Center  
Salt Lake City, Utah



# Acknowledgments

## **Text Editors**

Arthur G. Gelsinger, MA  
Nina I. Bennett, BA  
Tricia L. Cannon, BA  
Terry W. Ferrell, MS  
Lisa A. Gervais, BS  
Emily C. Fassett, BA

## **Image Editors**

Jeffrey J. Marmorstone, BS  
Lisa A. M. Steadman, BS

## **Medical Editors**

Kelsey Juster-Switlyk, MD  
Reuben Mari Valenzuela, MD

## **Illustrations**

Laura C. Sesto, MA  
Lane R. Bennion, MS  
Richard Coombs, MS

## **Art Direction and Design**

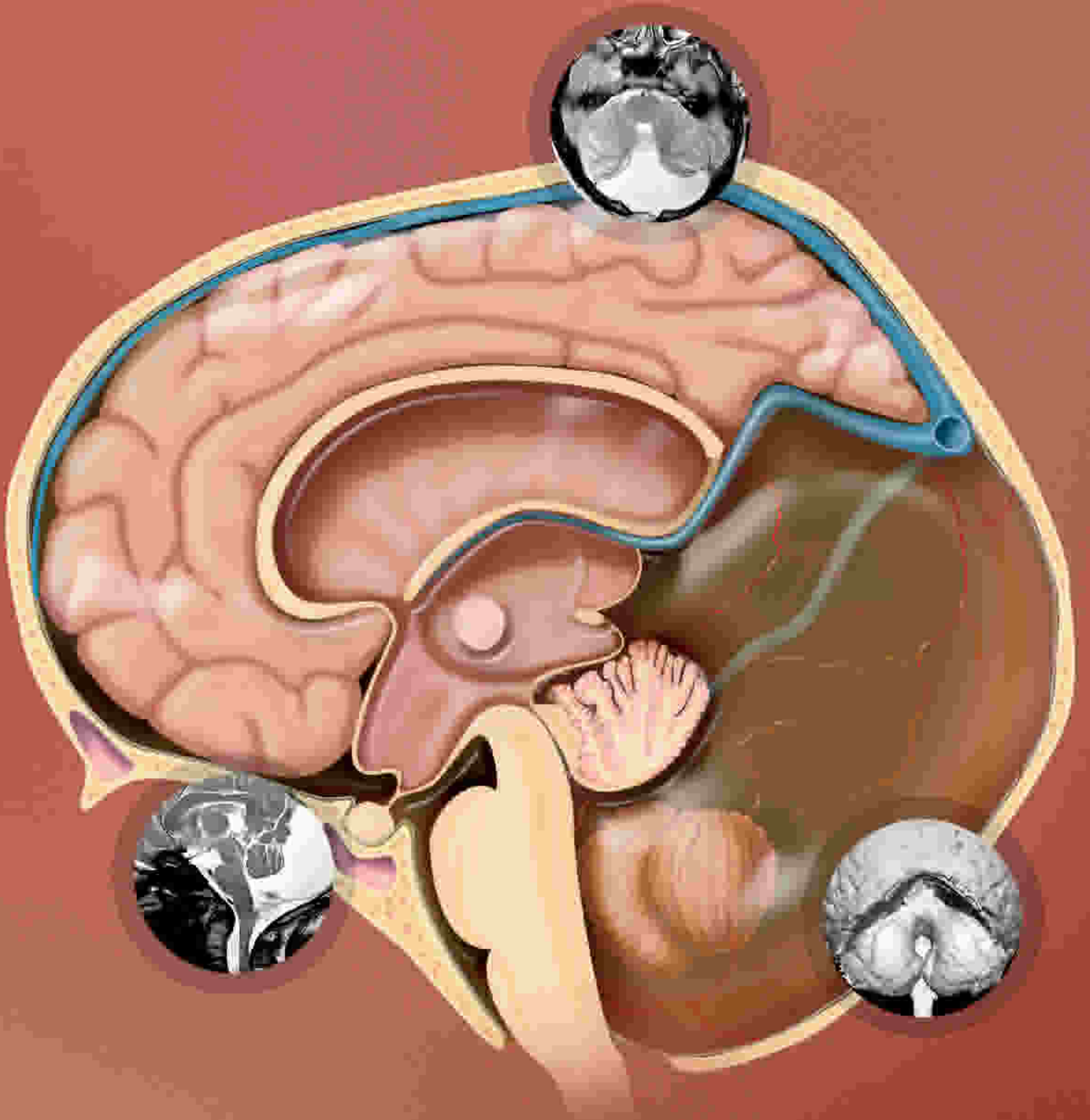
Tom M. Olson, BA  
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## **Lead Editor**

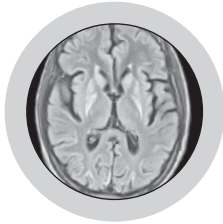
Karen E. Concannon, MA, PhD

## **Production Coordinators**

Angela M. Terry, BA  
Rebecca L. Hutchinson, BA



# Sections



## Part I: Brain

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### **Section 1:**

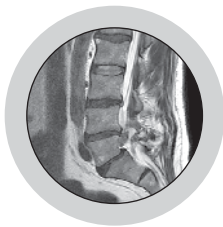
Pathology-Based Diagnoses:  
Malformations, Trauma, and Stroke

### **Section 2:**

Pathology-Based Diagnoses:  
Neoplasms, Cysts, and Disorders

### **Section 3:**

Anatomy-Based Diagnoses



## Part II: Spine

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### **Section 1:**

Normal Anatomy and Congenital Disorders

### **Section 2:**

Trauma and Hemorrhage

### **Section 3:**

Degenerative Diseases and Arthritides

### **Section 4:**

Infection and Inflammatory Disorders

### **Section 5:**

Neoplasms, Cysts, and Other Masses

### **Section 6:**

Peripheral Nerve and Plexi

# TABLE OF CONTENTS

- 2 **Introduction to Imaging**  
*Miral D. Jhaveri, MD and Palmi Shah, MD*

## Part I: Brain

### SECTION 1: PATHOLOGY-BASED DIAGNOSES: MALFORMATIONS, TRAUMA, AND STROKE

#### CONGENITAL MALFORMATIONS

- 10 **Congenital Malformations Overview**  
*A. James Barkovich, MD*
- BRAIN MALFORMATIONS**
- 14 **Chiari 1**  
*Susan I. Blaser, MD, FRCPC and Anne G. Osborn, MD, FACR*
- 15 **Chiari 2**  
*Susan I. Blaser, MD, FRCPC and Kevin R. Moore, MD*
- 16 **Callosal Dysgenesis**  
*Charles Raybaud, MD, FRCPC and Anne G. Osborn, MD, FACR*
- 17 **Lipoma**  
*A. James Barkovich, MD*
- 18 **Dandy-Walker Continuum**  
*Susan I. Blaser, MD, FRCPC*
- 19 **Septo-optic Dysplasia**  
*A. James Barkovich, MD*
- 20 **Heterotopic Gray Matter**  
*Charles Raybaud, MD, FRCPC*
- 21 **Polymicrogyria**  
*A. James Barkovich, MD*
- 22 **Schizencephaly**  
*Blaise V. Jones, MD*
- NEUROCRANIAL SYNDROMES**
- 23 **von Hippel-Lindau Syndrome**  
*Anne G. Osborn, MD, FACR and Gilbert Vézina, MD*
- 24 **Neurofibromatosis Type 1**  
*Gilbert Vézina, MD and Anne G. Osborn, MD, FACR*
- 25 **Neurofibromatosis Type 2**  
*Gilbert Vézina, MD*
- 26 **Tuberous Sclerosis Complex**  
*Gilbert Vézina, MD and Anne G. Osborn, MD, FACR*
- 27 **Sturge-Weber Syndrome**  
*Gilbert Vézina, MD and Anne G. Osborn, MD, FACR*
- 28 **Hereditary Hemorrhagic Telangiectasia**  
*Anne G. Osborn, MD, FACR and Charles Raybaud, MD, FRCPC*

- 29 **Lhermitte-Duclos Disease**  
*Anne G. Osborn, MD, FACR and P. Ellen Grant, MD*

- 30 **Li-Fraumeni Syndrome**  
*Gilbert Vézina, MD*

#### TRAUMA

- 31 **Introduction to CNS Imaging, Trauma**  
*Anne G. Osborn, MD, FACR*

#### PRIMARY EFFECTS OF CNS TRAUMA

- 37 **Acute Subdural Hematoma**  
*Anne G. Osborn, MD, FACR and Bronwyn E. Hamilton, MD*
- 38 **Subacute Subdural Hematoma**  
*Anne G. Osborn, MD, FACR and Bronwyn E. Hamilton, MD*
- 39 **Chronic Subdural Hematoma**  
*Anne G. Osborn, MD, FACR*
- 40 **Epidural Hematoma, Classic**  
*Anne G. Osborn, MD, FACR and Gregory L. Katzman, MD, MBA*
- 41 **Epidural Hematoma, Variant**  
*Anne G. Osborn, MD, FACR*
- 42 **Abusive Head Trauma**  
*Gary L. Hedlund, DO and Anne G. Osborn, MD, FACR*
- 43 **Traumatic Subarachnoid Hemorrhage**  
*Anne G. Osborn, MD, FACR and Gregory L. Katzman, MD, MBA*
- 44 **Cerebral Contusion**  
*Anne G. Osborn, MD, FACR*
- 45 **Diffuse Axonal Injury**  
*Anne G. Osborn, MD, FACR*
- 46 **Subcortical Injury**  
*Anne G. Osborn, MD, FACR and Gregory L. Katzman, MD, MBA*

#### SECONDARY EFFECTS OF CNS TRAUMA

- 47 **Intracranial Herniation Syndromes**  
*Anne G. Osborn, MD, FACR*
- 48 **Traumatic Cerebral Ischemia/Infarction**  
*Anne G. Osborn, MD, FACR and Gregory L. Katzman, MD, MBA*
- 49 **Brain Death**  
*Anne G. Osborn, MD, FACR*
- 50 **Second Impact Syndrome**  
*Anne G. Osborn, MD, FACR*
- 51 **Traumatic Intracranial Arterial Dissection**  
*Anne G. Osborn, MD, FACR*
- 52 **Traumatic Carotid Cavernous Fistula**  
*Anne G. Osborn, MD, FACR and Perry P. Ng, MBBS (Hons), FRANZCR*

# TABLE OF CONTENTS

- 53 **Chronic Traumatic Encephalopathy**  
*Anne G. Osborn, MD, FACR*

## VASCULAR ANATOMY AND STROKE

### VASCULAR ANATOMY

- 54 **Intracranial Arteries Overview**  
*Anne G. Osborn, MD, FACR*
- 60 **Intracranial Venous System Overview**  
*Anne G. Osborn, MD, FACR*
- 68 **Stroke Overview**  
*Karen L. Salzman, MD*
- 74 **Evolution of Intracranial Hemorrhage**  
*Karen L. Salzman, MD and Ulrich Rassner, MD*
- 75 **Spontaneous Nontraumatic Intracranial Hemorrhage**  
*Karen L. Salzman, MD and Laurie A. Loevner, MD*
- 76 **Hypertensive Intracranial Hemorrhage**  
*Karen L. Salzman, MD and Laurie A. Loevner, MD*

### NONTRAUMATIC INTRACRANIAL HEMORRHAGE

### ATHEROSCLEROSIS AND CAROTID STENOSIS

- 77 **Arteriolosclerosis**  
*Karen L. Salzman, MD*
- 78 **Intracranial Atherosclerosis**  
*Anne G. Osborn, MD, FACR*
- 79 **Extracranial Atherosclerosis**  
*Karen L. Salzman, MD and Bronwyn E. Hamilton, MD*

### NONATHEROMATOUS VASCULOPATHY

- 80 **Moyamoya**  
*Anne G. Osborn, MD, FACR and Anna Illner, MD*
- 81 **Primary Arteritis of the CNS**  
*Anne G. Osborn, MD, FACR*
- 82 **Miscellaneous Vasculitis**  
*Anne G. Osborn, MD, FACR*
- 83 **Reversible Cerebral Vasoconstriction Syndrome**  
*Karen L. Salzman, MD and Perry P. Ng, MBBS (Hons), FRANZCR*
- 84 **Vasospasm**  
*Karen L. Salzman, MD and Perry P. Ng, MBBS (Hons), FRANZCR*
- 85 **Systemic Lupus Erythematosus**  
*Karen L. Salzman, MD and Gary M. Nesbit, MD*
- 86 **Cerebral Amyloid Angiopathy (CAA)**  
*Karen L. Salzman, MD and Bronwyn E. Hamilton, MD*
- 87 **CADASIL**  
*Karen L. Salzman, MD and Ulrich Rassner, MD*
- 88 **Behçet Disease**  
*Karen L. Salzman, MD*
- 89 **Susac Syndrome**  
*Karen L. Salzman, MD and Jeffrey S. Anderson, MD, PhD*
- 90 **Fibromuscular Dysplasia**  
*Karen L. Salzman, MD and Perry P. Ng, MBBS (Hons), FRANZCR*
- 91 **Extracranial Internal Carotid Artery Dissection**  
*Rebecca S. Cornelius, MD, FACR*

- 92 **Extracranial Vertebral Artery Dissection**  
*Lubdha M. Shah, MD*

## CEREBRAL ISCHEMIA AND INFARCTION

- 93 **Adult Hypoxic Ischemic Injury**  
*Karen L. Salzman, MD and Lubdha M. Shah, MD*
- 94 **Hypotensive Cerebral Infarction**  
*Anne G. Osborn, MD, FACR and Bronwyn E. Hamilton, MD*
- 95 **Childhood Stroke**  
*Anne G. Osborn, MD, FACR and Blaise V. Jones, MD*
- 96 **Acute Cerebral Ischemia-Infarction**  
*Anne G. Osborn, MD, FACR and Edward P. Quigley, III, MD, PhD*
- 97 **Subacute Cerebral Infarction**  
*Karen L. Salzman, MD and Sheri L. Harder, MD, FRCPC*
- 98 **Chronic Cerebral Infarction**  
*Sheri L. Harder, MD, FRCPC and Anne G. Osborn, MD, FACR*
- 99 **Multiple Embolic Cerebral Infarctions**  
*Karen L. Salzman, MD*
- 100 **Fat Emboli Cerebral Infarction**  
*Karen L. Salzman, MD*
- 101 **Lacunar Infarction**  
*Karen L. Salzman, MD and Ulrich Rassner, MD*
- 102 **Cerebral Hyperperfusion Syndrome (CHS)**  
*Anne G. Osborn, MD, FACR*
- 103 **Dural Sinus Thrombosis**  
*Anne G. Osborn, MD, FACR*
- 104 **Cavernous Sinus Thrombosis/Thrombophlebitis**  
*Anne G. Osborn, MD, FACR*
- 105 **Cortical Venous Thrombosis**  
*Anne G. Osborn, MD, FACR and Bronwyn E. Hamilton, MD*
- 106 **Deep Cerebral Venous Thrombosis**  
*Anne G. Osborn, MD, FACR and Bronwyn E. Hamilton, MD*

## SUBARACHNOID HEMORRHAGE AND ANEURYSMS

- 107 **Subarachnoid Hemorrhage and Aneurysms Overview**  
*Anne G. Osborn, MD, FACR*
- 109 **Aneurysmal Subarachnoid Hemorrhage**  
*Anne G. Osborn, MD, FACR*
- 110 **Perimesencephalic Nonaneurysmal Subarachnoid Hemorrhage (pnSAH)**  
*Anne G. Osborn, MD, FACR*
- 111 **Convexal Subarachnoid Hemorrhage (cSAH)**  
*Anne G. Osborn, MD, FACR*
- 112 **Saccular Aneurysm**  
*Anne G. Osborn, MD, FACR and Perry P. Ng, MBBS (Hons), FRANZCR*
- 113 **Vertebrobasilar Dolichoectasia**  
*Anne G. Osborn, MD, FACR*
- 114 **Atherosclerotic Vascular Disease (ASVD) Fusiform Aneurysm**  
*Anne G. Osborn, MD, FACR*

## VASCULAR MALFORMATIONS

- 115 **Vascular Malformations Overview**  
*Anne G. Osborn, MD, FACR*



# TABLE OF CONTENTS

- 117 **Arteriovenous Malformation**  
*Anne G. Osborn, MD, FACR and Perry P. Ng, MBBS (Hons), FRANZCR*
- 118 **Dural Arteriovenous Fistula**  
*Anne G. Osborn, MD, FACR and Perry P. Ng, MBBS (Hons), FRANZCR*
- 119 **Developmental Venous Anomaly**  
*Anne G. Osborn, MD, FACR*
- 120 **Cavernous Malformation**  
*Anne G. Osborn, MD, FACR*
- 121 **Capillary Telangiectasia**  
*Anne G. Osborn, MD, FACR*

## SECTION 2: PATHOLOGY-BASED DIAGNOSES: NEOPLASMS, CYSTS, AND DISORDERS

### NEOPLASMS

- 124 **Neoplasms Overview**  
*Anne G. Osborn, MD, FACR*

### ASTROCYTOMAS

- 128 **Low-Grade Diffuse Astrocytoma**  
*Karen L. Salzman, MD*
- 129 **Anaplastic Astrocytoma**  
*Karen L. Salzman, MD*
- 130 **Pilocytic Astrocytoma**  
*Karen L. Salzman, MD and Chang Yueh Ho, MD*
- 131 **Glioblastoma**  
*Karen L. Salzman, MD*
- 132 **Gliomatosis Cerebri**  
*Karen L. Salzman, MD*

### NONASTROCYTIC GLIOMAS

- 133 **Oligodendroglioma**  
*Karen L. Salzman, MD*
- 134 **Anaplastic Oligodendroglioma**  
*Karen L. Salzman, MD*
- 135 **Infratentorial Ependymoma**  
*Anne G. Osborn, MD, FACR and Majda M. Thurnher, MD*
- 136 **Subependymoma**  
*Karen L. Salzman, MD*
- 137 **Typical Choroid Plexus Papilloma**  
*Anne G. Osborn, MD, FACR and Chang Yueh Ho, MD*

### NEURONAL AND MIXED NEURONAL-GLIAL TUMORS

- 138 **Ganglioglioma**  
*Karen L. Salzman, MD*
- 139 **Dysembryoplastic Neuroepithelial Tumor (DNET)**  
*Karen L. Salzman, MD and Laurie A. Loevner, MD*
- 140 **Central Neurocytoma**  
*Karen L. Salzman, MD*

### PINEAL AND GERM CELL TUMORS

- 141 **Pineocytoma**  
*Karen L. Salzman, MD and Laurie A. Loevner, MD*

- 142 **Pineal Parenchymal Tumor of Intermediate Differentiation (PPTID)**  
*Karen L. Salzman, MD and Anne G. Osborn, MD, FACR*
- 143 **Germinoma**  
*Anne G. Osborn, MD, FACR and Majda M. Thurnher, MD*

### MISCELLANEOUS PRIMARY TUMORS

- 144 **Medulloblastoma**  
*Anne G. Osborn, MD, FACR and Majda M. Thurnher, MD*
- 145 **Hemangioblastoma**  
*Karen L. Salzman, MD and John H. Rees, MD*
- 146 **Primary CNS Lymphoma**  
*Karen L. Salzman, MD*
- 147 **Intravascular (Angiocentric) Lymphoma**  
*Karen L. Salzman, MD*
- 148 **Leukemia**  
*Karen L. Salzman, MD and Miral D. Jhaveri, MD*

### METASTATIC TUMORS AND REMOTE EFFECTS OF CANCER

- 149 **Parenchymal Metastases**  
*Anne G. Osborn, MD, FACR*
- 150 **Miscellaneous Intracranial Metastases**  
*Anne G. Osborn, MD, FACR*
- 151 **Metastatic Intracranial Lymphoma**  
*Karen L. Salzman, MD*
- 152 **Paraneoplastic Syndromes and Limbic Encephalitis**  
*Karen L. Salzman, MD*

### TREATMENT-RELATED EFFECTS

- 153 **Radiation and Chemotherapy**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 154 **Pseudoprogression (PsP)**  
*Karen L. Salzman, MD*
- 155 **Pseudoresponse**  
*Karen L. Salzman, MD*

### PRIMARY NONNEOPLASTIC CYSTS

- 156 **Primary Nonneoplastic Cysts Overview**  
*Anne G. Osborn, MD, FACR*
- 160 **Arachnoid Cyst**  
*Anne G. Osborn, MD, FACR*
- 161 **Colloid Cyst**  
*Anne G. Osborn, MD, FACR*
- 162 **Dermoid Cyst**  
*Chang Yueh Ho, MD*
- 163 **Epidermoid Cyst**  
*Anne G. Osborn, MD, FACR and Gregory L. Katzman, MD, MBA*
- 164 **Hippocampal Sulcus Remnant Cysts**  
*Chang Yueh Ho, MD*
- 165 **Enlarged Perivascular Spaces**  
*Anne G. Osborn, MD, FACR*
- 166 **Pineal Cyst**  
*Anne G. Osborn, MD, FACR*
- 167 **Choroid Plexus Cyst**  
*Anne G. Osborn, MD, FACR*

# TABLE OF CONTENTS

- 168 Porencephalic Cyst**  
*Anne G. Osborn, MD, FACR and Gregory L. Katzman, MD, MBA*

## INFECTIOUS, INFLAMMATORY, AND DEMYELINATING DISEASE

### INFECTIONS

- 169 CNS Infectious Disease Overview**  
*Miral D. Jhaveri, MD and Anne G. Osborn, MD, FACR*
- 171 Meningitis**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 172 Abscess**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 173 Ventriculitis**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 174 Empyema**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 175 Herpes Encephalitis**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 176 HHV-6 Encephalitis**  
*Miral D. Jhaveri, MD*
- 177 West Nile Virus Encephalitis**  
*Miral D. Jhaveri, MD and Laurie A. Loevner, MD*
- 178 Miscellaneous Encephalitis**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 179 Cerebellitis**  
*Miral D. Jhaveri, MD*
- 180 Tuberculosis**  
*Miral D. Jhaveri, MD and Sheri L. Harder, MD, FRCPC*
- 181 Neurocysticercosis**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 182 Lyme Disease**  
*Miral D. Jhaveri, MD and Laurie A. Loevner, MD*
- 183 Acquired HIV Encephalitis**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 184 Acquired Toxoplasmosis**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 185 Acquired CMV**  
*Miral D. Jhaveri, MD and Yoshimi Anzai, MD, MPH*
- 186 Fungal Infections**  
*Anne G. Osborn, MD, FACR*
- 187 Cryptococcosis**  
*Yoshimi Anzai, MD, MPH*
- 188 Progressive Multifocal Leukoencephalopathy (PML)**  
*Miral D. Jhaveri, MD and Yoshimi Anzai, MD, MPH*
- 189 Immune Reconstitution Inflammatory Syndrome (IRIS)**  
*Miral D. Jhaveri, MD*
- 190 HIV/AIDS, Miscellaneous Manifestations**  
*Miral D. Jhaveri, MD*
- DEMYELINATING DISORDERS**
- 191 Multiple Sclerosis**  
*Miral D. Jhaveri, MD*
- 192 Neuromyelitis Optica**  
*Miral D. Jhaveri, MD*
- 193 Acute Disseminated Encephalomyelitis (ADEM)**  
*Miral D. Jhaveri, MD and Jeffrey S. Anderson, MD, PhD*

- 194 CLIPPERS**  
*Anne G. Osborn, MD, FACR*

## INHERITED METABOLIC/DEGENERATIVE DISORDERS

- 195 Inherited Metabolic Disorders Overview**  
*A. James Barkovich, MD*
- 199 Leigh Syndrome**  
*A. James Barkovich, MD*
- 200 MELAS**  
*Susan I. Blaser, MD, FRCPC*
- 201 Kearns-Sayre Syndrome**  
*Susan I. Blaser, MD, FRCPC*
- 202 Mucopolysaccharidoses**  
*Susan I. Blaser, MD, FRCPC*
- 203 Metachromatic Leukodystrophy (MLD)**  
*Anna Illner, MD and Anne G. Osborn, MD, FACR*
- 204 Fabry Disease**  
*Miral D. Jhaveri, MD and Anne G. Osborn, MD, FACR*
- 205 X-Linked Adrenoleukodystrophy**  
*Susan I. Blaser, MD, FRCPC and Anne G. Osborn, MD, FACR*
- 206 Canavan Disease**  
*P. Ellen Grant, MD*
- 207 Alexander Disease**  
*Anna Illner, MD*
- 208 Neurodegeneration With Brain Iron Accumulation (NBIA)**  
*Chang Yueh Ho, MD and Anne G. Osborn, MD, FACR*
- 209 Pantothenate Kinase-Associated Neurodegeneration (PKAN)**  
*Anna Illner, MD*
- 210 Huntington Disease**  
*James M. Provenzale, MD*
- 211 Wilson Disease**  
*Anne G. Osborn, MD, FACR and James M. Provenzale, MD*

## ACQUIRED TOXIC/METABOLIC/DEGENERATIVE DISORDERS

- 212 Acquired Toxic/Metabolic Disorders Overview**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- TOXIC, METABOLIC, NUTRITIONAL,  
SYSTEMIC DISEASES WITH CNS  
MANIFESTATIONS**
- 216 Adult Hypoglycemia**  
*Miral D. Jhaveri, MD and John H. Rees, MD*
- 217 Thyroid Disorders**  
*Miral D. Jhaveri, MD*
- 218 Parathyroid Disorders**  
*Miral D. Jhaveri, MD*
- 219 Fahr Disease**  
*Miral D. Jhaveri, MD and Gregory L. Katzman, MD, MBA*
- 220 Alcoholic Encephalopathy**  
*Miral D. Jhaveri, MD*
- 221 Hepatic Encephalopathy**  
*Miral D. Jhaveri, MD*

# TABLE OF CONTENTS

- 222 **Acute Hypertensive Encephalopathy, Posterior Reversible Encephalopathy Syndrome (PRES)**  
*Miral D. Jhaveri, MD and Anne G. Osborn, MD, FACR*
- 223 **Chronic Hypertensive Encephalopathy**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 224 **Idiopathic Intracranial Hypertension**  
*Miral D. Jhaveri, MD*
- 225 **Carbon Monoxide Poisoning**  
*Yoshimi Anzai, MD, MPH*
- 226 **Drug Abuse**  
*Miral D. Jhaveri, MD*
- 227 **Osmotic Demyelination Syndrome**  
*Miral D. Jhaveri, MD and Sheri L. Harder, MD, FRCPC*
- 228 **Mesial Temporal Sclerosis**  
*Miral D. Jhaveri, MD and Kevin R. Moore, MD*
- 229 **Status Epilepticus**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 230 **Transient Global Amnesia (TGA)**  
*Anne G. Osborn, MD, FACR*

## DEMENTIAS AND DEGENERATIVE DISORDERS

- 231 **Normal Aging Brain**  
*Miral D. Jhaveri, MD and Sheri L. Harder, MD, FRCPC*
- 232 **Alzheimer Disease**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 233 **Vascular Dementia**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 234 **Frontotemporal Lobar Degeneration**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 235 **Dementia With Lewy Bodies**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 236 **Creutzfeldt-Jakob Disease (CJD), Classic**  
*Miral D. Jhaveri, MD and Karen L. Salzman, MD*
- 237 **Creutzfeldt-Jakob Disease (CJD), Variants**  
*Anne G. Osborn, MD, FACR*
- 238 **Parkinson Disease**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 239 **Multiple System Atrophy**  
*Miral D. Jhaveri, MD*
- 240 **Posterior Cortical Atrophy**  
*Anne G. Osborn, MD, FACR*
- 241 **Corticobasal Degeneration**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 242 **Progressive Supranuclear Palsy (PSP)**  
*Miral D. Jhaveri, MD and James M. Provenzale, MD*
- 243 **Amyotrophic Lateral Sclerosis (ALS)**  
*Miral D. Jhaveri, MD and Lubdha M. Shah, MD*
- 244 **Wallerian Degeneration**  
*Miral D. Jhaveri, MD and Lubdha M. Shah, MD*
- 245 **Spinocerebellar Ataxias**  
*Anne G. Osborn, MD, FACR*
- 246 **Crossed Cerebellar Diaschisis**  
*Miral D. Jhaveri, MD and Anne G. Osborn, MD, FACR*
- 247 **Hypertrophic Olivary Degeneration**  
*Miral D. Jhaveri, MD and Anne G. Osborn, MD, FACR*

## SECTION 3: ANATOMY-BASED DIAGNOSES

### VENTRICLES AND CISTERNS

- 250 **Ventricles and Cisterns Overview**  
*Miral D. Jhaveri, MD*
- 256 **Cavum Septi Pellucidi (CSP)**  
*Miral D. Jhaveri, MD and Anne G. Osborn, MD, FACR*
- 257 **Intraventricular Obstructive Hydrocephalus**  
*Miral D. Jhaveri, MD*
- 258 **Extraventricular Obstructive Hydrocephalus**  
*Miral D. Jhaveri, MD*
- 259 **Aqueductal Stenosis**  
*Miral D. Jhaveri, MD and Kevin R. Moore, MD*
- 260 **Normal Pressure Hydrocephalus**  
*Miral D. Jhaveri, MD*
- 261 **CSF Shunts and Complications**  
*Miral D. Jhaveri, MD and Kevin R. Moore, MD*

### SELLA AND PITUITARY

- 262 **Sella and Pituitary Overview**  
*Karen L. Salzman, MD and Anne G. Osborn, MD, FACR*
- 266 **Pituitary Anomalies**  
*Karen L. Salzman, MD and Kevin R. Moore, MD*
- 267 **Pituitary Microadenoma**  
*Karen L. Salzman, MD and Anne G. Osborn, MD, FACR*
- 268 **Pituitary Macroadenoma**  
*Karen L. Salzman, MD and Anne G. Osborn, MD, FACR*
- 269 **Pituitary Apoplexy**  
*Karen L. Salzman, MD and Anne G. Osborn, MD, FACR*
- 270 **Rathke Cleft Cyst**  
*Karen L. Salzman, MD and Anne G. Osborn, MD, FACR*
- 271 **Craniopharyngioma**  
*Karen L. Salzman, MD and John H. Rees, MD*
- 272 **Empty Sella**  
*Luke N. Ledbetter, MD and Anne G. Osborn, MD, FACR*
- 273 **Pituitary Hyperplasia**  
*Luke N. Ledbetter, MD and Anne G. Osborn, MD, FACR*
- 274 **Lymphocytic Hypophysitis**  
*Karen L. Salzman, MD*

### CEREBELLOPONTINE ANGLE AND INTERNAL AUDITORY CANAL (CPA-IAC)

- 275 **CPA-IAC Overview**  
*H. Ric Harnsberger, MD*
- 279 **Epidermoid Cyst, CPA-IAC**  
*H. Ric Harnsberger, MD*
- 280 **Arachnoid Cyst, CPA-IAC**  
*H. Ric Harnsberger, MD*
- 281 **Bell's Palsy**  
*H. Ric Harnsberger, MD*
- 282 **Trigeminal Neuralgia**  
*H. Ric Harnsberger, MD*
- 283 **Hemifacial Spasm**  
*H. Ric Harnsberger, MD*
- 284 **Vestibular Schwannoma**  
*H. Ric Harnsberger, MD*

# TABLE OF CONTENTS

- 285 **Nonvestibular Schwannoma**  
*Nicholas A. Koontz, MD and Anne G. Osborn, MD, FACR*
- 286 **Meningioma, CPA-IAC**  
*H. Ric Harnsberger, MD*
- 287 **Metastases, CPA-IAC**  
*H. Ric Harnsberger, MD*

## SKULL, SCALP, AND MENINGES

- 288 **Skull, Scalp, and Meninges Overview**  
*Karen L. Salzman, MD*

## NONNEOPLASTIC DISORDERS

- 292 **Intracranial Hypotension**  
*Anne G. Osborn, MD, FACR*
- 293 **Skull Base CSF Leak**  
*Patricia A. Hudgins, MD, FACR*
- 294 **Intracranial Idiopathic Inflammatory Pseudotumor**  
*H. Ric Harnsberger, MD*
- 295 **IgG4-Related Disease**  
*Anne G. Osborn, MD, FACR*
- 296 **Fibrous Dysplasia**  
*Anne G. Osborn, MD, FACR and Miral D. Jhaveri, MD*
- 297 **Paget Disease**  
*Anne G. Osborn, MD, FACR and Miral D. Jhaveri, MD*
- 298 **Thick Skull**  
*Anne G. Osborn, MD, FACR and Miral D. Jhaveri, MD*
- 299 **Langerhans Cell Histiocytosis, Skull and Brain**  
*Anne G. Osborn, MD, FACR and Gary L. Hedlund, DO*
- 300 **Neurosarcoid**  
*Anne G. Osborn, MD, FACR and Gregory L. Katzman, MD, MBA*
- 301 **Trichilemmal Cyst**  
*Anne G. Osborn, MD, FACR*

## NEOPLASMS

- 302 **Meningioma**  
*Anne G. Osborn, MD, FACR and Majda M. Thurnher, MD*
- 303 **Atypical and Malignant Meningioma**  
*Anne G. Osborn, MD, FACR and Majda M. Thurnher, MD*
- 304 **Calvarial Hemangioma**  
*Anne G. Osborn, MD, FACR and Gregory L. Katzman, MD, MBA*
- 305 **Myeloma**  
*Anne G. Osborn, MD, FACR and Miral D. Jhaveri, MD*
- 306 **Skull and Meningeal Metastases**  
*Anne G. Osborn, MD, FACR and Miral D. Jhaveri, MD*

## EYE, ORBIT, AND OPTIC NERVE

### OVERVIEW

- 307 **Orbit Overview**  
*H. Christian Davidson, MD*

### NONNEOPLASTIC DISORDERS

- 311 **Optic Neuritis**  
*H. Christian Davidson, MD*
- 312 **Thyroid Ophthalmopathy**  
*H. Christian Davidson, MD*

- 313 **Orbital Idiopathic Inflammatory Pseudotumor**  
*H. Christian Davidson, MD*

## NEOPLASMS

- 314 **Optic Pathway Glioma**  
*Deborah R. Shatzkes, MD*
- 315 **Optic Nerve Sheath Meningioma**  
*Deborah R. Shatzkes, MD*

## Part II: Spine

### SECTION 1: NORMAL ANATOMY AND CONGENITAL DISORDERS

#### ANATOMY

- 318 **Normal Spine Anatomy**  
*Jeffrey S. Ross, MD*
- 324 **Approach to Spine and Spinal Cord Development**  
*Kevin R. Moore, MD*

#### MALFORMATIONS, CONGENITAL DISORDERS, AND SCOLIOSIS

- 332 **Myelomeningocele**  
*Kevin R. Moore, MD*
- 333 **Dorsal Dermal Sinus**  
*Kevin R. Moore, MD*
- 334 **Simple Coccygeal Dimple**  
*Kevin R. Moore, MD*
- 335 **Tethered Spinal Cord**  
*Kevin R. Moore, MD*
- 336 **Klippel-Feil Spectrum**  
*Kevin R. Moore, MD*
- 337 **Dural Dysplasia**  
*Kevin R. Moore, MD*
- 338 **Neurofibromatosis Type 1**  
*Kevin R. Moore, MD*
- 339 **Neurofibromatosis Type 2**  
*Jeffrey S. Ross, MD*
- 340 **Achondroplasia**  
*Bryson Borg, MD*
- 341 **Kyphosis**  
*Kevin R. Moore, MD*
- 342 **Scoliosis**  
*Kevin R. Moore, MD*
- 343 **Degenerative Scoliosis**  
*Jeffrey S. Ross, MD*

### SECTION 2: TRAUMA AND HEMORRHAGE

- 346 **Central Spinal Cord Syndrome**  
*Bryson Borg, MD and Jeffrey S. Ross, MD*
- 347 **Posttraumatic Syrinx**  
*Jeffrey S. Ross, MD*
- 348 **Spinal Cord Contusion-Hematoma**  
*Bryson Borg, MD and Jeffrey S. Ross, MD*
- 349 **Spontaneous Epidural Hematoma**  
*Jeffrey S. Ross, MD*
- 350 **Subdural Hematoma**  
*Jeffrey S. Ross, MD*

# TABLE OF CONTENTS

- 351 **Subarachnoid Hemorrhage**  
*Jeffrey S. Ross, MD*

## SECTION 3: DEGENERATIVE DISEASES AND ARTHRITIDES

### SPINE DEGENERATIONS

- 354 **Nomenclature of Degenerative Disc Disease**  
*Jeffrey S. Ross, MD*
- 358 **Degenerative Disc Disease**  
*Jeffrey S. Ross, MD*
- 359 **Disc Bulge**  
*Jeffrey S. Ross, MD*
- 360 **Cervical Intervertebral Disc Herniation**  
*Jeffrey S. Ross, MD*
- 361 **Thoracic Intervertebral Disc Herniation**  
*Jeffrey S. Ross, MD*
- 362 **Lumbar Intervertebral Disc Herniation**  
*Jeffrey S. Ross, MD*
- 363 **Intervertebral Disc Extrusion, Foraminal**  
*Jeffrey S. Ross, MD*
- 364 **Cervical Facet Arthropathy**  
*Jeffrey S. Ross, MD*
- 365 **Lumbar Facet Arthropathy**  
*Jeffrey S. Ross, MD*
- 366 **Schmorl Node**  
*Jeffrey S. Ross, MD and Kevin R. Moore, MD*
- 367 **Scheuermann Disease**  
*Jeffrey S. Ross, MD and Kevin R. Moore, MD*
- 368 **Acquired Lumbar Central Stenosis**  
*Jeffrey S. Ross, MD*
- 369 **Congenital Spinal Stenosis**  
*Jeffrey S. Ross, MD*
- 370 **Cervical Spondylosis**  
*Jeffrey S. Ross, MD*
- 371 **Diffuse Idiopathic Skeletal Hyperostosis (DISH)**  
*Jeffrey S. Ross, MD*
- 372 **Ossification of Posterior Longitudinal Ligament (OPLL)**  
*Jeffrey S. Ross, MD*

### SPONDYLOLISTHESIS AND SPONDYLOLYSIS

- 373 **Spondylolisthesis**  
*Jeffrey S. Ross, MD*
- 374 **Spondylolysis**  
*Jeffrey S. Ross, MD*

### INFLAMMATORY, CRYSTALLINE, AND MISCELLANEOUS ARTHRITIDES

- 375 **Adult Rheumatoid Arthritis**  
*Jeffrey S. Ross, MD*
- 376 **Calcium Pyrophosphate Dihydrate Deposition (CPPD)**  
*Jeffrey S. Ross, MD*
- 377 **Ankylosing Spondylitis**  
*Jeffrey S. Ross, MD*

## SECTION 4: INFECTION AND INFLAMMATORY DISORDERS

### INFECTIONS

- 380 **Pathways of Spread of Infection**  
*Jeffrey S. Ross, MD*
- 384 **Spinal Meningitis**  
*Lubdha M. Shah, MD*
- 385 **Tuberculous Osteomyelitis**  
*Lubdha M. Shah, MD and Jeffrey S. Ross, MD*
- 386 **Paraspinal Abscess**  
*Lubdha M. Shah, MD*
- 387 **Epidural Abscess**  
*Lubdha M. Shah, MD*
- 388 **Subdural Abscess**  
*Lubdha M. Shah, MD and Kevin R. Moore, MD*
- 389 **Viral Myelitis**  
*Lubdha M. Shah, MD and Kevin R. Moore, MD*
- 390 **HIV Myelitis**  
*Lubdha M. Shah, MD*
- 391 **Opportunistic Infections**  
*Lubdha M. Shah, MD and Kevin R. Moore, MD*

### INFLAMMATORY AND AUTOIMMUNE DISORDERS

- 392 **Acute Transverse Myelopathy**  
*Jeffrey S. Ross, MD*
- 393 **Idiopathic Acute Transverse Myelitis**  
*Kevin R. Moore, MD*
- 394 **Multiple Sclerosis**  
*Lubdha M. Shah, MD and Kevin R. Moore, MD*
- 395 **Neuromyelitis Optica**  
*Lubdha M. Shah, MD and Jeffrey S. Ross, MD*
- 396 **Acute Disseminated Encephalomyelitis (ADEM)**  
*Jeffrey S. Ross, MD*
- 397 **Acute Inflammatory Demyelinating Polyradiculoneuropathy (AIDP)**  
*Lubdha M. Shah, MD and Kevin R. Moore, MD*
- 398 **Chronic Inflammatory Demyelinating Polyneuropathy (CIDP)**  
*Jeffrey S. Ross, MD*
- 399 **Sarcoidosis**  
*Lubdha M. Shah, MD and Jeffrey S. Ross, MD*
- 400 **Subacute Combined Degeneration**  
*Lubdha M. Shah, MD*
- 401 **Paraneoplastic Myelopathy**  
*Jeffrey S. Ross, MD*

## SECTION 5: NEOPLASMS, CYSTS, AND OTHER MASSES

### NEOPLASMS

- 404 **Spread of Neoplasms**  
*Jeffrey S. Ross, MD*

### EXTRADURAL

- 408 **Blastic Osseous Metastases**  
*Bryson Borg, MD*

# TABLE OF CONTENTS

- 409 **Lytic Osseous Metastases**  
*Bryson Borg, MD*
- 410 **Hemangioma**  
*Bryson Borg, MD*
- 411 **Lymphoma**  
*Lubdha M. Shah, MD and Jeffrey S. Ross, MD*
- 412 **Leukemia**  
*Lubdha M. Shah, MD*
- 413 **Plasmacytoma**  
*Lubdha M. Shah, MD and Kevin R. Moore, MD*
- 414 **Multiple Myeloma**  
*Lubdha M. Shah, MD*

## INTRADURAL EXTRAMEDULLARY

- 415 **Schwannoma**  
*Bryson Borg, MD and Kevin R. Moore, MD*
- 416 **Meningioma**  
*Bryson Borg, MD and Jeffrey S. Ross, MD*
- 417 **Neurofibroma**  
*Bryson Borg, MD and Kevin R. Moore, MD*
- 418 **Metastases, CSF Disseminated**  
*Bryson Borg, MD*

## INTRAMEDULLARY

- 419 **Astrocytoma**  
*Lubdha M. Shah, MD and Kevin R. Moore, MD*
- 420 **Classic Ependymoma**  
*Kevin R. Moore, MD*
- 421 **Myxopapillary Ependymoma**  
*Kevin R. Moore, MD*
- 422 **Spinal Cord Metastases**  
*Lubdha M. Shah, MD and Jeffrey S. Ross, MD*

## NEOPLASMS AND TREATMENT-RELATED EFFECTS

- 423 **Radiation Myelopathy**  
*Kevin R. Moore, MD*
- 424 **Postirradiation Vertebral Marrow**  
*Kevin R. Moore, MD*
- 425 **Anterior Lumbar Radiculopathy**  
*Kevin R. Moore, MD*

## NONNEOPLASTIC CYSTS AND TUMOR MIMICS

### CYSTS

- 426 **CSF Flow Artifact**  
*Lubdha M. Shah, MD and Kevin R. Moore, MD*
- 427 **Perineural Root Sleeve Cyst**  
*Kevin R. Moore, MD*

## NONNEOPLASTIC MASSES AND TUMOR MIMICS

- 428 **Epidural Lipomatosis**  
*Julia R. Crim, MD*
- 429 **Normal Fatty Marrow Variants**  
*Julia R. Crim, MD*
- 430 **IgG4-Related Disease/Hypertrophic Pachymeningitis**  
*Jeffrey S. Ross, MD*

## VASCULAR AND SYSTEMIC DISORDERS

### VASCULAR LESIONS

- 431 **Vascular Anatomy**  
*Jeffrey S. Ross, MD*
- 437 **Type 1 Vascular Malformation (dAVF)**  
*Jeffrey S. Ross, MD*
- 438 **Spinal Cord Infarction**  
*Jeffrey S. Ross, MD*

### SPINAL MANIFESTATIONS OF SYSTEMIC DISEASES

- 439 **Osteoporosis**  
*Lubdha M. Shah, MD and Jeffrey S. Ross, MD*

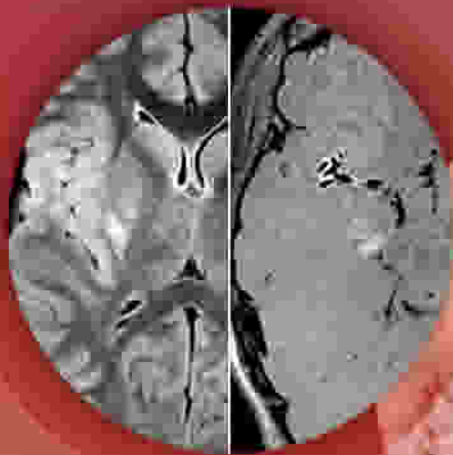
## SECTION 6: PERIPHERAL NERVE AND PLEXI

- 442 **Normal Plexus and Nerve Anatomy**  
*Kevin R. Moore, MD*
- 448 **Superior Sulcus Tumor**  
*Kevin R. Moore, MD*
- 449 **Thoracic Outlet Syndrome**  
*Kevin R. Moore, MD*
- 450 **Muscle Denervation**  
*Julia R. Crim, MD*
- 451 **Brachial Plexus Traction Injury**  
*Kevin R. Moore, MD*
- 452 **Idiopathic Brachial Plexus Neuritis**  
*Julia R. Crim, MD and Kevin R. Moore, MD*
- 453 **Hypertrophic Neuropathy**  
*Kevin R. Moore, MD*
- 454 **Femoral Neuropathy**  
*Kevin R. Moore, MD*
- 455 **Ulnar Neuropathy**  
*Kevin R. Moore, MD*
- 456 **Suprascapular Neuropathy**  
*Julia R. Crim, MD*
- 457 **Median Neuropathy**  
*Kevin R. Moore, MD*
- 458 **Common Peroneal Neuropathy**  
*Kevin R. Moore, MD*
- 459 **Tibial Neuropathy**  
*Julia R. Crim, MD*

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# Imaging in Neurology

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## Introduction

Rapid advancement of medical imaging in the last couple of decades has significantly enhanced the role of imaging in medicine. Imaging plays an integral role in the evaluation of neurological disorders. It is performed for diagnosis, assessing efficacy of therapy, follow-up, and guidance for procedures.

Benign neurological disorders and life-threatening neoplasms may present with similar overlapping symptomatology, which could be relatively nonspecific. Clinical history combined with a good neurological evaluation is often followed by lab investigations, electroencephalography, lumbar puncture, and other investigations. Computed tomography (CT) and magnetic resonance (MR) form the backbone of the imaging work-up of these patients. Neurological disorders tend to be complex, and arriving at a diagnosis involves knowledge of neuroanatomy, pathology, physiology, and diagnostic tools such as neuroimaging.

## Imaging Modalities

In the past, radiography ("plain films" and more recently digital radiography) played a significant role in imaging. With the advent of advanced imaging like CT and MR, the role of radiography has significantly diminished. Currently CT and MR are the most commonly performed imaging modalities for diseases of the brain and spine. In addition to exquisite anatomical detail, advanced MR techniques like MR perfusion, MR spectroscopy (MRS) and functional MR (fMRI) provide physiological information.

Likewise single-photon emission CT (SPECT) and positron emission tomography (PET)-CT imaging have a distinct contribution, as they can also provide structural and functional images of the brain. Ultrasound and color Doppler are useful in evaluating the head and neck vasculature.

## CT

CT technology relies on the same physical principles as x-rays do. The differential absorption of the x-ray beam by different tissues produces varied levels of density in the image, which on CT scans are measured in Hounsfield units (HU). This can be displayed in cross-sectional format or in multiple planes. Multidetector CT (MDCT) has increased the capability of CT with faster scans, greater spatial resolution, and multiplanar reformations.

The ability of CT to image traumatic conditions of brain and spine rapidly has made it invaluable in acute neurotrauma management. Lesions commonly seen on CT include calvarial fractures, acute intraaxial and extraaxial hemorrhage, hemorrhagic contusions, diffuse axonal injury, and spinal fractures.

CT also plays a pivotal role in the management of acute stroke and is the first-line imaging modality. It quickly helps in determining whether the signs and symptoms being observed can be attributed to intracranial hemorrhage, ischemic stroke, or a mass lesion. The biggest contribution of noncontrast CT is excluding intracranial hemorrhage, so that appropriately selected patients can be started on tissue plasminogen activator (tPA). Although CT is less sensitive than MR in detecting acute cerebral ischemia-infarction, detectable changes are present on 50-60% of noncontrast CT (NECT) scans in patients with major territorial (not lacunar) infarcts.

Noncontrast CT is relatively insensitive for detection of neoplastic disease, especially when the tumor burden is small.

A postcontrast CT should always be obtained when evaluating neoplastic conditions using CT.

## CT Angiogram (CTA)

CTA is the study of choice for all emergent and nonemergent neurovascular conditions, including acute stroke. It is fast and less prone to artifact than MR angiography (MRA). A combined CTA of the head and neck, from the aortic arch to the cranial vertex, can be obtained with as little as 70 ml of IV contrast in < 15 seconds. Given the high prevalence of cardiogenic acute strokes, it now is possible to extend the field of coverage of CTA to include the heart in the evaluation.

## CT Venogram (CTV)

CTV is similar to CTA except for an added delay for optimal visualization of the venous system. It is a fast, reliable modality to exclude dural sinus thrombosis in an emergent setting.

## CT Perfusion (CTP)

CTP imaging uses the dynamics of first-pass bolus through the brain parenchyma to derive perfusion maps. Repeated CT scans through a limited region of the brain yield a time-attenuation curve for each pixel that documents the changes in tissue contrast during the bolus contrast passage. CTP software is used to process these images and generate cerebral blood volume (CBV), cerebral blood flow (CBF), mean transit time (MTT), time to peak (TTP), and permeability (kPS) maps. CTP aims to detect the mismatch between the brain already infarcted (ischemic "core") and that at risk of infarction ("penumbra" or potentially salvageable brain). Permeability maps (kPS) are helpful in tumor imaging to grade gliomas and to differentiate between tumor recurrence and radiation necrosis.

## MR

The primary origin of the MR signal used to generate almost all clinical images comes from hydrogen nuclei. Hydrogen nuclei consist of a single proton that is constantly spinning. A radio frequency pulse (RF pulse) emitted from the scanner results in some of the hydrogen protons being "knocked" 180° out of alignment with the static magnetic field. As the energy from the RF pulse is dissipated, the hydrogen protons will return to alignment with the static magnetic field. The MR signal is derived from the hydrogen protons as they move back into alignment with the magnetic field. The MR signal is then broken down and spatially located to produce images.

**T1, T2, and proton density** are the fundamental parameters of MR and determine the contrast between tissues. MR sequences that emphasize tissue differences in T1 relaxation are called T1 weighted, and those that emphasize T2 relaxation are called T2 weighted. Tissues with short T1 relaxation time such as fat, melanin, and protein produce high signal on T1-weighted sequences and appear "bright," whereas cerebrospinal fluid (CSF) is relatively dark. CSF has a long T2 relaxation time and appears bright on T2-weighted sequences.

Spin echo and gradient echo are 2 basic sequences in MR. All other sequences are variations of 1 of these sequences and are used to better characterize specific tissue types. MPRAGE is a 3-dimensional, thin-section T1-weighted volumetric acquisition that is increasingly utilized for evaluating a broad spectrum of brain disorders.

**Fluid-attenuation inversion recovery (FLAIR)** sequence is used to eliminate the signal from CSF, which thus appears dark. It is useful for highlighting parenchymal lesions that lie