

# Contents

Preface to the First Edition, xi

Preface to the Sixth Edition, xii

Acknowledgments, xiii

Contributors, xiv

## PART I Clinical Evaluation

- 1 General Aspects of the Patient's Neurologic History, 1**

*Kenneth F. Swaiman and John Phillips*

- 2 Neurologic Examination of the Older Child, 7**

*Kenneth F. Swaiman and John Phillips*

- 3 Neurologic Examination after the Newborn Period Until 2 Years of Age, 14**

*Kenneth F. Swaiman and John Phillips*

- 4 Neurologic Examination of the Term and Preterm Infant, 20**

*Kenneth F. Swaiman and John Phillips*

- 5 Muscular Tone and Gait Disturbances, 27**

*Kenneth F. Swaiman and John Phillips*

- 6 Vision Loss, 33**

*Douglas R. Fredrick*

- 7 Hearing Impairment, 43**

*Lionel Van Maldergem, Guy Van Camp, and Paul Deltenre*

- 8 Vertigo, 52**

*Joseph M. Furman and Amy Goldstein*

- 9 Taste and Smell, 58**

*Julie A. Mennella, Nuala Bobowski, and Djin Gie Liem*

- 10 Neuropsychological Assessment, 65**

*Margaret Semrud-Clikeman and Kenneth F. Swaiman*

## PART II Neurodiagnostic Testing

- 11 Spinal Fluid Examination, 73**

*David J. Michelson*

- 12 Pediatric Neuroimaging, 78**

*Nathaniel D. Wycliffe, Barbara A. Holshouser, Brenda Bartnik-Olson, and Stephen Ashwal*

- 13 Pediatric Neurophysiologic Evaluation, 87**

*Mark S. Scher*

## PART III Emerging Neuroscience Concepts

- 14 Microstructural and Functional Connectivity in the Developing Brain, 97**

*Laura R. Ment, Dustin Scheinost, and Todd Constable*

- 15 Stem Cell Transplantation for Childhood Neurologic Disorders, 107**

*Jean-Pyo Lee, Marcia Pereira, Rodolfo Gonzalez, Milton H. Hamblin, and Evan Y. Snyder*

- 16 Cellular and Animal Models of Neurologic Disease, 114**

*Sampathkumar Rangasamy, Mohan J. Narayanan, Isabelle Schrauwen, Alysson R. Muotri, and Vinodh Narayanan*

## PART IV Perinatal Acquired and Congenital Neurologic Disorders

- 17 Neonatal Neurointensive Care, 123**

*Hannah C. Glass and Sonia L. Bonifacio*

- 18 Neonatal Seizures, 129**

*Renée A. Shellhaas, Hannah C. Glass, and Taeun Chang*

- 19 Hypoxic-Ischemic Brain Injury in the Term Newborn, 138**

*Vann Chau, Donna M. Ferriero, and Steven P. Miller*

- 20 Cerebrovascular Disorders in the Newborn, 147**

*Adam Kirton, Lori Jordan, and Linda S. de Vries*

- 21 Neonatal Nervous System Trauma, 156**

*Mary J. Harbert and Andrea C. Pardo*

- 22 Injury to the Developing Preterm Brain: Intraventricular Hemorrhage and White Matter Injury, 161**

*Janet S. Soul and Laura R. Ment*

**Video 22.1 Endoscopic View of Clot at the Foramen of Monro**

**Video 22.2 Endoscopic Third Ventriculostomy in an Infant with Posthemorrhagic Hydrocephalus**

- 23 Perinatal Metabolic Encephalopathies, 171**

*Rebecca N. Ichord and David R. Bearden*

## PART V Congenital Structural Defects

- 24 Overview of Human Brain Malformations, 179**  
*William B. Dobyns, Renzo Guerrini, and A. James Barkovich*
- 25 Disorders of Neural Tube Development, 183**  
*Nalin Gupta and M. Elizabeth Ross*
- 26 Disorders of Forebrain Development, 192**  
*Elliott H. Sherr and Jin S. Hahn*
- 27 Disorders of Cerebellar and Brainstem Development, 199**  
*Dan Doherty and Andrea Poretti*
- 28 Disorders of Brain Size, 208**  
*Ghayda M. Mirzaa and William B. Dobyns*
- 29 Malformations of Cortical Development, 218**  
*William B. Dobyns, Richard J. Leventer, and Renzo Guerrini*
- 30 Hydrocephalus and Arachnoid Cysts, 226**  
*Amal Abou-Hamden and James M. Drake*
- 31 Congenital Anomalies of the Skull, 233**  
*Pedro Sanchez and John M. Graham, Jr.*
- 32 Developmental Encephalopathies, 242**  
*Alex R. Paciorkowski, Laurie E. Seltzer, and Jeffrey L. Neal*
- 33 Prenatal Diagnosis of Structural Brain Anomalies, 249**  
*Tally Lerman-Sagie, Liat Ben-Sira, Catherine Garel, and Gustavo Malinge*

## PART VI Genetic, Metabolic and Neurocutaneous Disorders

- 34 Neurogenetics in the Genome Era, 257**  
*Kelly McMahon, Alex R. Paciorkowski, Lauren C. Walters-Sen, Jeff M. Milunsky, Alexander Bassuk, Benjamin Darbro, Julianne Diaz, William B. Dobyns, and Andrea Gropman*
- 35 Chromosomes and Chromosomal Abnormalities, 268**  
*Maria Descartes, Bruce R. Korf, and Fady M. Mikhail*
- 36 Approach to the Patient with a Metabolic Disorder, 277**  
*Linda De Meirlier and Lance H. Rodan*
- 37 Aminoacidemias and Organic Acidemias, 286**  
*Renata C. Gallagher, Gregory M. Enns, Tina M. Cowan, Bryce Mendelsohn, and Seymour Packman*
- 38 Inborn Errors of Urea Synthesis, 298**  
*Sandesh C.S. Nagamani and Uta Licher-Konecki*
- 39 Diseases Associated with Primary Abnormalities in Carbohydrate Metabolism, 305**  
*Marc C. Patterson*
- 40 Disorders of Glycosylation, 317**  
*Hudson H. Freeze, Bobby G. Ng, and Marc C. Patterson*

- 41 Lysosomal Storage Diseases, 323**  
*Gregory M. Pastores and Raymond Y. Wang*
- 42 Mitochondrial Diseases, 334**  
*Darryl C. De Vivo and Salvatore DiMauro*
- 43 Peroxisomal Disorders, 347**  
*Gerald V. Raymond, Kristin W. Barañano, and S. Ali Fatemi*
- 44 Neurotransmitter-Related Disorders, 355**  
*Kathryn J. Swoboda and Melissa A. Walker*
- 45 Phakomatoses and Allied Conditions, 362**  
*Elizabeth A. Thiele and Bruce R. Korf*
- 46 Disorders of Vitamin Metabolism, 373**  
*Barbara Plecko and Robert Steinfeld*
- 47 Nutrition and the Developing Brain, 383**  
*Maria Victoria Escolano-Margarit and Cristina Campoy*
- 48 The Neuronal Ceroid Lipofuscinosis Disorders, 390**  
*Joseph Glykys and Katherine B. Sims*
- 49 Channelopathies, 405**  
*Kelly Knupp and Amy R. Brooks-Kayal*

## PART VII Neurodevelopmental Disorders

- 50 Neurodevelopmental Disabilities: Conceptual Framework, 413**  
*Iris Etzion, Sinan O. Turnacioglu, Karen A. Spencer, and Andrea L. Gropman*
- 51 Global Developmental Delay and Intellectual Disability, 418**  
*Elliott H. Sherr and Michael I. Shevell*
- 52 Cognitive and Motor Regression, 424**  
*Stanford K. Shu, David J. Michelson, and Stephen Ashwal*
- 53 Developmental Language Disorders, 431**  
*Doris A. Trauner and Ruth D. Nass*
- 54 Nonverbal Learning Disabilities and Associate Disorders, 437**  
*Margaret Semrud-Clikeman and Doris A. Trauner*
- 55 Dyslexia, 442**  
*Sally E. Shaywitz and Bennett A. Shaywitz*
- 56 Attention Deficit–Hyperactivity Disorder, 447**  
*David E. Mandelbaum*
- 57 Autistic Spectrum Disorders, 459**  
*Deborah G. Hirtz, Ann Wagner, Pauline A. Filipek, and Elliott H. Sherr*
- 58 Management of Common Comorbidities Associated with Neurodevelopmental Disorders, 472**  
*Darcy L. Fehlings, Melanie Penner, Elizabeth J. Donner, and Michael I. Shevell*
- 59 Treatment of Neurodevelopmental Disorders, 478**  
*Clara D.M. van Karnebeek, Elizabeth Berry-Kravis, and Andrea Gropman*

- 60 Neuropsychopharmacology, 489**  
*Breck Borcherding, Rebecca L. Rendleman, and John T. Walkup*

## PART VIII Epilepsy

- 61 Overview of Seizures and Epilepsy in Children, 497**  
*Phillip L. Pearl*
- 62 Principles of Management and Outcome, 501**  
*Peter R. Camfield and Carol S. Camfield*
- 63 Neurophysiology of Seizures and Epilepsy, 506**  
*Carl E. Stafstrom and Jong M. Rho*
- 64 Epilepsy Genetics, 513**  
*Maria Roberta Cilio and Tristan T. Sands*
- 65 Febrile Seizures, 519**  
*Syndi Seinfeld and Shlomo Shinnar*
- 66 Generalized Seizures, 524**  
*Gregory L. Holmes*
- 67 Focal and Multifocal Seizures, 531**  
*Douglas R. Nordli, Jr.*
- 68 Epileptic Spasms and Myoclonic Seizures, 538**  
*Nihika Shah Singhal, Chellamani Harini, and Joseph Sullivan*
- 69 Status Epilepticus, 543**  
*Iván Sánchez Fernández, Nicholas Scott Abend, and Tobias Loddemann*
- 70 Electroclinical Syndromes: Neonatal Onset, 552**  
*Abeer J. Hani and Mohamad A. Mikati*
- 71 Electroclinical Syndromes: Infantile Onset, 557**  
*Elaine C. Wirrell and Katherine C. Nickels*
- 72 Electroclinical Syndromes: Childhood Onset, 569**  
*Jeffrey R. Tenney and Tracy Glauser*
- 73 Electroclinical Syndromes: Adolescent Onset, 576**  
*Andrea M. Harriott and William O. Tatum IV*
-  **Video 73.1 Focal Seizure with Dyscognitive Features**
- 74 Focal Structural Epilepsy, 583**  
*Ghayda M. Mirzaa, Christopher J. Yuskaitsis, and Annapurna Poduri*
- 75 Other Acquired Epilepsies: Trauma, Stroke, Tumors, 590**  
*Russell C. Bailey, Nicole J. Ullrich, and Howard P. Goodkin*
- 76 Inherited Metabolic Epilepsies, 594**  
*Phillip L. Pearl*
- 77 Antiseizure Drug Therapy in Children, 600**  
*Jeannine M. Conway, Ilo E. Leppik, and Angela K. Birnbaum*

- 78 Epilepsy Surgery in the Pediatric Population, 612**  
*Mary L. Zupanc, Lily Tran, and Andrew Mower*

- 79 Neuromodulation in Epilepsy, 619**  
*Sameer C. Dhamne, Harper L. Kaye, and Alexander Rotenberg*

- 80 Ketogenic Diets, 624**  
*James W. Wheless and Eric H. Kossoff*

- 81 Pediatric Psychogenic Nonepileptic Seizures and Psychiatric Disorders, 631**  
*Sigita Plioplys and W. Curt LaFrance, Jr.*

- 82 Behavioral, Cognitive, and Social Aspects of Childhood Epilepsy, 636**  
*Wendy G. Mitchell, Michèle Van Hirtum-Das, Jay Desai, and Quyen N. Luc*

- 83 Mortality in Children with Epilepsy, 642**  
*Jeffrey Buchalter, Carol S. Camfield, and Peter R. Camfield*

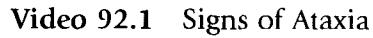
## PART IX Nonepileptiform Paroxysmal Disorders and Disorders of Sleep

- 84 Headache in Children and Adolescents, 647**  
*Marielle A. Kabbouche, Joanne Kacperski, Hope L. O'Brien, Scott W. Powers, and Andrew D. Hershey*
- 85 Breath-Holding Spells and Reflex Anoxic Seizures, 656**  
*Sarah M. Roddy*
- 86 Syncope and Postural Orthostatic Tachycardia Syndrome, 660**  
*Manikum Moodley*
- 87 Nocturnal Paroxysmal Disorders, 667**  
*Sanjeev V. Kothare and Sejal V. Jain*
- 88 Disorders of Excessive Sleepiness, 672**  
*Sejal V. Jain and Sanjeev V. Kothare*
- 89 Restless Legs Syndrome and Periodic Limb Movement Disorder in Children and Adolescents, 678**  
*Allison Przekop*
- 90 Apparent Life-Threatening Event and Sudden Infant Death Syndrome, 683**  
*Michael A. Mohan and Kiran P. Maski*

## PART X Disorders of Balance and Movement

- 91 The Cerebellum and the Hereditary Ataxias, 689**  
*Paymaan Jafar-Nejad, Stephen M. Maricich, and Huda Y. Zoghbi*

- 92 Acute Cerebellar Ataxia, 701**  
*Harry T. Whelan, Gregory S. Aaen, Kumar Sannagowdara, and Megan B. DeMara-Hoth*

-  **Video 92.1 Signs of Ataxia**

- 93** Movement Disorders: An Overview, 706  
*Jonathan W. Mink and Terence D. Sanger*
- 94** Paroxysmal Dyskinesias, 718  
*Laura Silveira Moriyama, Thomas T. Warner, and Jonathan W. Mink*
- 95** Movement Disorders of Infancy, 724  
*Joanna S. Blackburn and Jonathan W. Mink*
- 96** Drug-Induced Movement Disorders in Children, 728  
*Donald L. Gilbert*
- 97** Cerebral Palsy, 734  
*Maryam Oskoui, Michael I. Shevell, and Kenneth F. Swaiman*
- 98** Tics and Tourette Syndrome, 741  
*Laura Tochen and Harvey S. Singer*

## PART XI White Matter Disorders

- 99** Genetic and Metabolic Disorders of the White Matter, 747  
*Adeline Vanderver and Nicole I. Wolf*
- 100** Acquired Disorders Affecting the White Matter, 759  
*Naila Makhani, J. Nicholas Brenton, and Brenda Banwell*

## PART XII Brain Injury and Disorders of Consciousness

- 101** Disorders of Consciousness in Children, 767  
*Stephen Ashwal*
- 102** Traumatic Brain Injury in Children, 781  
*Jason T. Lerner and Christopher C. Giza*
- 103** Abusive Head Trauma, 794  
*Elizabeth E. Gilles and Cindy W. Christian*
- 104** Hypoxic-Ischemic Encephalopathy in Infants and Older Children, 804  
*Craig M. Smith, Mark S. Wainwright, and Stephen Ashwal*
- 105** Disorders of Intracranial Pressure, 813  
*Mark S. Wainwright*
- 106** Spinal Cord Injury, 820  
*Chellamani Harini and N. Paul Rosman*
- 107** Determination of Brain Death in Infants and Children, 831  
*Mudit Mathur and Stephen Ashwal*

## PART XIII Cerebrovascular Disease in Children

- 108** Development and Function of the Cerebrovascular System, 841  
*William J. Pearce*
- 109** Arterial Ischemic Stroke in Infants and Children, 848  
*Mark Mackay, Adam Kirton, and Gabrielle deVeber*

- 110** Sinovenous Thrombosis in Infants and Children, 858  
*Lori Billingham and Mahendranath Moharir*
- 111** Vascular Malformations, Intracerebral Hemorrhage, and Subarachnoid Hemorrhage in Infants and Children, 865  
*Lauren A. Beslow, Lori Jordan, and Edward Smith*
- 112** Cerebral Arteriopathies in Children, 871  
*Catherine Amie-Lefond and Dennis W. Shaw*
- 113** Coagulation Disorders and Cerebrovascular Disease in Children, 877  
*Timothy J. Bernard, Sharon Poisson, Brian R. Branchford, and Ulrike Nowak-Göttl*

## PART XIV Infections of the Nervous System

- 114** Bacterial Infections of the Nervous System, 883  
*Geoffrey A. Weinberg and Robert Thompson-Stone*
- 115** Viral Infections of the Nervous System, 895  
*Daniel J. Bonithus and James F. Bale, Jr.*
- 116** Fungal, Rickettsial, and Parasitic Diseases of the Nervous System, 907  
*Alexander L. Greninger and Carol A. Glaser*
- 117** Neurologic Complications of Immunization, 918  
*Claudia A. Chiriboga*

## PART XV Immune Mediated Disorders of the Nervous System

- 118** Paraneoplastic Neurologic Syndromes, 925  
*Adrienne Boire and Yasmin Khakoo*
- 119** Immune-Mediated Epilepsy, Movement Disorders, and Hashimoto's Encephalopathy in Children, 932  
*Russell C. Dale*
- 120** Opsoclonus Myoclonus Syndrome, 938  
*Michael R. Pranzatelli and Elizabeth D. Tate*  
 Video 120.1 OMS Evaluation Scale
- 121** Neurologic Manifestations of Rheumatic Disorders of Childhood, 945  
*Nina Felice Schor, Emily von Scheven, and Stephen Ashwal*

## PART XVI Pediatric Neurooncology

- 122** Pediatric Neuro-oncology: An Overview, 957  
*Roger J. Packer*
- 123** Medulloblastoma, 963  
*Roger J. Packer and Stefan M. Pfister*
- 124** Other Embryonal and Pineal Malignancies of the Central Nervous System, 969  
*Emily Gertsch, Yoon-Jae Cho, and Scott L. Pomeroy*

- 125 Ependymoma, 973**  
*Richard Grundy and Nicholas K. Foreman*
- 126 Pediatric Brain Tumors – High-Grade Glioma, 979**  
*Sabine Mueller and Matthias A. Karajannis*
- 127 Pediatric Low-Grade Glioma, 985**  
*Nicole J. Ullrich and Bruce H. Cohen*
- 128 Diffuse Intrinsic Pontine Glioma, 991**  
*Nicholas A. Vitanza, Paul G. Fisher, and Michelle Monje Deisseroth*
- 129 Atypical Teratoid/Rhabdoid Tumors, 995**  
*Alyssa T. Reddy, Susan N. Chi, and Jaclyn A. Biegel*
- 130 Central Nervous System Germinoma and Other Germ Cell Tumors, 1000**  
*Jeffrey C. Allen and Ute K. Bartels*
- 131 Craniopharyngioma, Meningiomas, and Schwannomas, 1005**  
*Michelle Lauren Feinberg, Jeffrey H. Wisoff, and Robert Keating*
- 132 Pediatric Intradural Spinal Cord Tumors, 1012**  
*Ben Shofty, Ori Barzilai, Zvi Lidar, Eugene Hwang, and Shlomi Constantini*
- 133 System Cancer and the Central Nervous System Involvement, 1017**  
*Sharyu Hanmantgad and Yasmin Khakoo*
- 134 Posttreatment Neurologic Sequelae of Pediatric Central Nervous System Tumors, 1021**  
*Elizabeth M. Wells and Colin R. Kennedy*
- 142 Acquired Peripheral Neuropathies, 1081**  
*Stephen A. Smith*
- 143 Inflammatory Neuropathies, 1086**  
*Malcolm Rabie, Stephen Ashwal, and Yoram Nevo*
- 144 Congenital Myasthenic Syndromes, 1092**  
*Duygu Selcen and Andrew G. Engel*
- 145 Acquired Disorders of the Neuromuscular Junction, 1098**  
*Nicholas J. Silvestri, Richard J. Barohn, and Gil I. Wolfe*
- 146 Duchenne and Becker Muscular Dystrophies, 1106**  
*Kevin Flanigan*
- 147 Congenital, Limb Girdle and Other Muscular Dystrophies, 1112**  
*Richard S. Finkel, Payam Mohassel, and Carsten G. Bönnemann*
- 148 Congenital Myopathies, 1123**  
*Jahannaz Dastgir, Hernan D. Gonorazky, Jonathan B. Strober, Nicolas Chrestian, and James J. Dowling*
- 149 Metabolic Myopathies, 1131**  
*Ingrid Tein*
- 150 Inflammatory Myopathies, 1141**  
*Anthony A. Amato and John T. Kissel*
- 151 Channelopathies: Myotonic Disorders and Periodic Paralysis, 1148**  
*Richard T. Moxley III and Chad Heatwole*
- 152 Management of Children with Neuromuscular Disorders, 1157**  
*Dennis J. Matthews, Joyce Oleszek, Julie A. Parsons, and Oren Kupfer*

## PART XVII Neuromuscular Disorders

- 135 Muscle and Nerve Development in Health and Disease, 1029**  
*Jeremy K. Deisch*
- 136 Laboratory Assessment of the Child with Suspected Neuromuscular Disorders, 1038**  
*Peter B. Kang and Eugenio Mercuri*
- 137 Clinical Assessment of Pediatric Neuromuscular Disorders, 1044**  
*Richard S. Finkel*
- 138 The Floppy Infant, 1051**  
*Graeme A.M. Nimmo and Ronald D. Cohn*
- 139 Genetic Disorders Affecting the Motor Neuron: Spinal Muscular Atrophy, 1057**  
*Basil T. Darras, Umrao R. Monani, and Darryl C. De Vivo*
- 140 Other Motor Neuron Diseases of Childhood, 1065**  
*Michele L. Yang and Anne M. Connolly*
- 141 Genetic Peripheral Neuropathies, 1073**  
*Kathryn M. Brennan and Michael E. Shy*

## PART XVIII Systemic and Autonomic Nervous System Diseases

- 153 Endocrine Disorders of the Hypothalamus and Pituitary in Childhood and Adolescence, 1165**  
*Roger K. Long and Stephen M. Rosenthal*
- 154 Disorders of the Autonomic Nervous System: Autonomic Dysfunction in Pediatric Practice, 1173**  
*Jose-Alberto Palma, Lucy Norcliffe-Kaufmann, Cristina Fuente-Mora, Leila Percival, Christy L. Spalink, and Horacio Kaufmann*
- 155 Disorders of Micturition and Defecation, 1184**  
*Israel Franco and Cecile Ejerskov*
- 156 Poisoning and Drug-Induced Neurologic Diseases, 1193**  
*Kristyn Tekulve, Laura M. Tormoehlen, and Laurence Walsh*
- 157 Neurologic Disorders in Children with Heart Disease, 1205**  
*Daniel J. Licht, John Brandsema, Michael von Rhein, and Beatrice Latal*

- 158 Neurologic Disorders Associated with Renal Diseases, 1215**  
*Cheryl P. Sanchez, Rita D. Sheth, Robert S. Rust, Jessica L. Carpenter, and Stephen Ashwal*

- 159 Neurologic Disorders Associated with Gastrointestinal Diseases, 1228**  
*Yitzchak Frank and Stephen Ashwal*

## PART XIX Care of the Child with Neurologic Disorders

- 160 Counseling Children with Neurologic Disorders and Their Families, 1239**  
*David J. Michelson and Robin D. Clark*

- 161 Approaches to Personalized Medicine in Pediatric Neurology, 1244**  
*Bruce R. Korf*

- 162 Pediatric Neurorehabilitation Medicine, 1248**  
*Michael J. Noetzel and Nico U. F. Dosenbach*

- 163 Pain Management and Palliative Care, 1256**  
*John Colin Partridge and Elizabeth E. Rogers*

- 164 Ethical Issues in Child Neurology, 1263**  
*David L. Coulter*

- 165 Transitional Care for Children with Neurologic Disorders, 1270**  
*Carol S. Camfield, Peter R. Camfield, and Lawrence W. Brown*

- 166 Practice Guidelines in Pediatric Neurology, 1276**  
*David J. Michelson, Gary Gronseth, and Stephen Ashwal*
- 167 Special Education Law as it Relates to Children with Neurologic Disorders, 1283**  
*Kathleen A. Hurwitz*
- 168 Measurement of Health Outcomes in Pediatric Neurologic Disorders, 1289**  
*Annette Majnemer and F. Virginia Wright*
- 169 The Influence of Computer Resources on Child Neurology, 1295**  
*Michael M. Segal and Steven M. Leber*
- 170 Education and Training of Child Neurologists and Workforce Issues, 1299**  
*David K. Uroian*

APPENDIX A, 1304

APPENDIX B

Index, 1309