Pediatric Section
American Association of
Neurological Surgeons

20th Winter Meeting Program

Boston, Massachusetts
December 3 - 6, 1991

Pediatric Section
American Association of
Neurological Surgeons

20th Annual Meeting

The Four Seasons Hotel
Boston, Massachusetts
December 3 - 6, 1991

The Joint Committee on Education of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons designates this continuing medical education activity for 19 credit hours toward the Continuing Education Award in Neurosurgery and the Physician's Recognition Award of the American Medical Association. The Joint Committee on Education of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons is accredited by the Accreditation Council for Continuing Medical Education to sponsor continuing medical education for physicians.

Program Committee: R. Michael Scott, Harold L. Rekate, Paul H. Chapman, Alan R. Cohen

Program Summary

Paolo Raimondi Lecturers

1978—E. Bruce Hendrick
1979—Paul C. Bucy
1980—Floyd Gilles
1981—Panel Discussion
1982—Panel Discussion
1983—Derek Harwood-Nash
1984—Anthony E. Gallo, Jr.
1985—Frank Nulsen
1986—William F. Meacham
1987—Dale Johnson
1988—Joseph J. Volpe
1989—Martin Eichelberger
1990—George R. Leopold
1991—Judah Folkman

Kenneth Shulman Award Recipients:

1983 — Kim Manwaring: Neonatal Post-hemorrhagic Ventriculomegaly: Management with Pulsed Lumbar Cisternostomy

1984 — Arno Fried: A Laboratory Model of Shunt Dependent Hydrocephalus

1985 — Anne-Christine Duhaime: The Shaken Baby Syndrome

1986 — Robert E. Breeze: CSF Formation in Acute Ventriculitis

1987 — Marc R. DelBigio: Shunt-induced Reversal of Periventricular Pathology in Experimental Hydrocephalus

1988 — Scott Falci: Rear Seatlap Belts. Are They Really "Safe" for Children?

1989 — James M. Herman: Tethered Cord as a Cause of Scoliosis in Children with a Myelomeningocele

1990 — Christopher D. Heffner: Basilar Pons Attracts Its Cortical Innervation by Chemotropic Induction of Collateral Branch Formation

Hydrocephalus Association Prize Recipients:

1989 — Eric Altschuler: Management of Persistent Ventriculomegaly Due to Altered Brain Compliance

1990 — S.D. Michowiz: High Energy Phosphate Metabolism in Neonatal Hydrocephalus

Pediatric Section Chairmen:

1972-73—Robert L. McLaurin
1973-74—M. Peter Sayers
1974-75—Frank Anderson
1975-76—Kenneth Shulman
1976-77—E. Bruce Hendrick
1977-78—Frank Nulsen
1978-79—Luis Schut
1979-81—Fred J. Epstein
1981-83—Joan L. Venes
1983-85—Harold J. Hoffman
1985-87—William R. Cheek
1987-89—David G. McLone
1989-91—Donald H. Reigel
1991-93—R. Michael Scott

Annual Winter Meeting Sites

1972 Cincinnati
1973 Columbus
1974 Los Angeles
1975 Philadelphia
1976 Toronto
1977 Cleveland
1978 Philadelphia
1979 New York
1980 New York
1981 Dallas
1982 San Francisco
1983 Toronto
1984 Salt Lake City
1985 Houston
1986 Pittsburgh
1987 Chicago
1988 Scottsdale
1989 Washington, D.C.
1990 San Diego & Pebble Beach
1991 Boston
1992 Vancouver, B.C.

Acknowledgements

The Section on Pediatric Neurological Surgery of the American Association of Neurological Surgeons gratefully recognizes the support of the following exhibitors for the 1991 Pediatric Annual Meeting.

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Chairman:	R. Michael Scott (terms expires 1993)
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Executive Council:	Donald H. Reigel (immediate past president) Thomas R. Luerssen (1992) Robert A. Sanford (1992) William Chadduck (1993) Tae Sung Park (1993)
Membership Committee:	Bruce Storrs (Chairman) (1992) Bruce Breslow (1992) Paul Steinbok (1992)
Rules and Regulations:	Harold L. Rekate (Chairman) (1992) Arnold Menezes (1992) Thomas Luerssen (1992)

Program of the Pediatric Section 20th Winter Meeting

TUESDAY, DECEMBER 3, 1991

3:00 pm - 8:30 pm
Registration, Wendell Phillips Room

6:30 pm - 8:30 pm
Welcoming Reception, Ballroom

WEDNESDAY, DECEMBER 4, 1991

7:00 am - 5:00 pm
Registration, Ballroom Foyer

7:00 am - 8:00 am
Continental Breakfast, Ballroom Foyer

8:00 am - 8:15 am
Welcome and Introductory Remarks — R. Michael Scott

SCIENTIFIC SESSION I — PARTNERS IN THE CARE OF PEDIATRIC NEUROSURGICAL PATIENTS: SURGERY, NEUROLOGY, AND UROLOGY

8:15 am - 8:45 am
Hardy W. Hendren, Chairman, Department of Pediatric Surgery, The Children's Hospital, Boston, MA: The Evaluation and Repair of Cloacal Syndromes

8:45 am - 9:15 am
Joseph J. Volpe, Chairman, Department of Pediatric Neurology, The Children's Hospital, Boston, MA: Management of the Premature Infant with Intraventricular Hemorrhage and Hydrocephalus

9:15 am - 9:45 am

Stuart B. Bauer, Director, Urodynamics Laboratory, Department of Pediatric Urology, The Children's Hospital, Boston, MA: Understanding Urodynamic Studies in the Child with Spinal Dysraphism

9:45 am - 10:15 am

COFFEE BREAK AND EXHIBITS - Blaxton Room and Ballroom Foyer

SCIENTIFIC SESSION II - BRAIN TUMORS I
Moderators: Karin Muraszko, Ann Arbor, MI; Robert A. Sanford, Memphis, TN

10:15 am - 10:30 am

1. "Neurosurgical Treatment in CCSG-9882 of Brain Stem Gliomas". A. Leland Albright, MD, Roger Packer, MD, Pittsburgh, PA

10:30 am - 10:45 am

2. "Surgical Management of Brainstem Tumors of Childhood: The PCMC Experience, 1977-1991". Joseph Petronio, MD, Marion L. Walker, MD, Salt Lake City, UT

10:45 am - 11:00 am

3. "Brainstem Gliomas Growth Patterns". Fred J. Epstein, Jean-Pierre Farmer, Montreal, Quebec

11:00 am - 11:15 am

4. "The Long-Term Outcome After Treatment of Dorsally Exophytic Brainstem Gliomas". Ian F. Pollack, MD, Harold J. Hoffman, MD, Robin P. Humphreys, MD, Toronto, Ontario

11:15 am - 11:30 am

*5. "Cerebrospinal Fluid Dissemination of Supratentorial Malignant Gliomas in Children". Paul A. Grabb, MD, A. Leland Albright, MD, Dachling Pang, MD, Pittsburgh, PA

11:30 am - 11:45 am

6. "Use of High Activity I125 Interstitial Therapy for Pediatric Central Nervous System Malignancies". Michael S. Muhlbauer, MD, Robert A. Sanford, MD, James Fontanesi, MD, Larry E. Kun, MD, Elizabeth A. Kirk, RN, MSN, Memphis, TN

11:45 am - 12:00 pm

* 7. "Prognostic Factors for Shunting in Pediatric Patients with Medulloblastoma". Mark R. Lee, MD, PhD, Fred Epstein, MD, Jeffrey Wisoff, MD, I. Rick Abbott, MD, New York, NY

12:00 pm - 12:15 pm

8. "Tyrosine Kinases in Medulloblastomas and Normal Human Cerebellum". Liliana C. Goumnerova, MD, FRCSC, Boston, MA

12:15 pm - 12:30 pm

9. "Development of Malignant Change in Low-Grade Astrocytomas in Childhood". James T. Rutka, Peter B. Dirks, Robin P. Humphreys, James M. Drake, Harold J. Hoffman, Toronto, Ontario

12:30 pm - 1:30 pm

LUNCH — Phillips and Stuart Rooms, 2nd Floor; Bullfinch, Benjamin, Parris and Shaw Rooms, 5th Floor

SCIENTIFIC SESSION III — BRAIN TUMORS II
Moderators: Corey Raffel, Los Angeles, CA; Ann Flannery, Columbus, GA

1:30 pm - 1:45 pm

*10. "Pineocytomas in Children: A Clinicopathologic Analysis of Outcome". Nicholas Poulos, MD, Arno H. Fried, MD, Mindy Estes, MD, Joseph Hahn, MD, Cleveland, OH

1:45 pm - 2:00 pm

*11. "The Endocrine Morbidity of Hypothalamic Gliomas". S.L. Taylor, MD, PhD, S.L. Kaplan, MD, PhD, F.A. Conte, MD, J.A. Szymansky, RN, MSN, P.H. Cogen, MD, PhD, and M.S.B. Edwards, MD, San Francisco, CA

2:00 pm - 2:15 pm

12. "Craniopharyngioma—Total Surgical Removal". Thomas S. Berger, MD, Kerry R. Crone, MD, Cincinnati, OH

2:15 pm - 2:30 pm

*13. "Benign Cerebellar Astrocytomas of Childhood". John J. Schneider, Jr., MD, Corey Raffel, MD, PhD, J. Gordon McComb, MD, Los Angeles, CA

2:30 pm - 2:45 pm

*14. "Occult Periaqueductal Tumors in 'Benign' Aqueductal Stenosis". B. Gregory Thompson, Jr., MD, Ian Pollack, MD, Dachling Pang, MD, FRCS(C), Pittsburgh, PA

2:45 pm - 3:00 pm

15. "Stereotactic Radiosurgery for Pediatric Patients with Acoustic Tumors and Neurofibromatosis". Mark E. Linskey, MD, L. Dade Lunsford, MD, John C. Flickinger, MD, Pittsburgh, PA

3:00 pm - 3:30 pm

COFFEE BREAK — Blaxton Room and Ballroom Foyer

SCIENTIFIC SESSION IV — SEIZURE SURGERY — VASCULAR SURGERY Moderators: Bruce Kaufman, St. Louis, MO; Joseph Madsen, Boston, MA

3:30 pm - 3:45 pm

*16. "Moya Moya Phenomenon in Neurofibromatosis Patients Radiated for Optic Pathway Gliomas". John R.W. Kestle, MD, MSc, FRCSC, Antonio R. Mock, MD, Harold J. Hoffman, MD, FRCSC, FACS, Toronto, Ontario

3:45 pm - 4:00 pm

17. "Pre- and Postoperative Evaluation of Moyamoya Syndrome with Three Dimensional Time-of-Flight Angiography". Anthony Martino, MD, Michael Edwards, MD, Jay Tsuruda, MD, and Christopher Dowd, MD, Detroit, MI

4:00 pm - 4:15 pm

*18. "Cerebral Hemispherectomy in Children with Intractable Seizures". Jon Weingart, MD, Ben Carson, MD, Donlin Long, MD, PhD, Sumio Uematsu, MD, Eileen Vining, MD, John Freeman, MD, Baltimore, MD

4:15 pm - 4:30 pm

*19. "Reorganization of the Cortical-tectal Pathway Following Neonatal Cerebral Hemispherectomy in Cats". P.D. Adelson, MD, D.A. Hovda, PhD, J.R. Villablanca, MD, K. Tatsukawa, BS, Los Angeles, CA

4:30 pm - 4:45 pm

20. "Hemispherectomy: Its Role in the Management of Hemimegalencephaly". Jamal Taha, MD, Thomas S. Berger, MD, Kerry R. Crone, MD, Cincinnati, OH

4:45 pm - 5:00 pm

21. "One-Stage Complete Corpus Callosum Section in Children with Intractable Epilepsy". Peter McL. Black, MD, PhD, Gregory Holmes, MD, Cesare Lombroso, MD, Boston, MA

5:00 pm - 5:30 pm

BUSINESS MEETING — Members of the Pediatric Section

THURSDAY, DECEMBER 5, 1991

7:00 am - 1:00 pm

Registration, Ballroom Foyer

7:00 am - 8:00 am

Continental Breakfast, Ballroom Foyer

SCIENTIFIC SESSION V — TOPICS IN PEDIATRIC NEUROSURGERY Moderators: Joseph Piatt, Portland, OR; Brooke Swearingen, Boston, MA

7:30 am - 7:45 am

Leland Albright, Pittsburgh, PA: Update on CCSG Clinical Studies and Protocols for Pediatric Brain Tumors

7:45 am - 8:00 am

Robert A. Sanford, Memphis, TN: Update on POG Clinical Studies and Protocols for Pediatric Brain Tumors

8:00 am - 8:15 am

22. "Increased Intracranial Pressure: An Unexpected Finding in Craniosynostosis with Minimal Cosmetic Deformity". Robert C. Dauser, MD, Steven R. Cohen, MD, Frank Vicari, MD, Ann Arbor, MI

8:15 am - 8:30 am

23. "Pediatric Herniated Lumbar Disc Disease". Rosemaria Gennuso, MD, Robin P. Humphreys, MD, Harold J. Hoffman, MD, E. Bruce Hendrick, MD, and James M. Drake, MD, New York, NY

8:30 am - 8:45 am

24. "Midline Epicranial Mass Lesions in Children". Andrew D. Parent, MD, Jackson, MS

8:45 am - 9:00 am

25. "Surgical Management of Symptomatic Benign Pineal Cysts". Jeffrey H. Wisoff, MD, Fred Epstein, MD, New York, NY

9:00 am - 9:15 am

26. "Interventional Neuroradiology in the Management of Arteriovenous Malformations in Children". Marion L. Walker, MD, Salt Lake City, UT

9:15 am - 9:30 am

*27. "The Role of Cell Lineage in Forming Striatal Compartments". Andrea Halliday, MD, Connie Cepko, PhD, Boston, MA

9:30 am - 10:00 am

PAOLO RAIMONDI LECTURE

Judah Folkman, MD, Andrus Professor of Pediatric Surgery, The Children's Hospital, Boston, MA: Clinical Applications of Angiogenesis Research Introduced by:Peter McL. Black, Boston, MA

SCIENTIFIC SESSION VI — HYDROCEPHALUS I

Moderators: Arno Fried, Cleveland, OH; Mark R. DelBigio, Toronto, Ontario

10:30 am - 10:45 am

*29. "Long-Term Complications of Lumboperitoneal Shunting in the Paediatric Population". P.D. Chumas, A. Kulkarni, J.M. Drake, D. Armstrong, Toronto, Ontario

10:45 am - 11:00 am

30. "Acquired Chiari Malformations Following Lumboperitoneal Shunting: Incidence, Diagnosis and Management". Troy Payner, MD, Thomas S. Berger, MD, Kerry R. Crone, MD, Cincinnati, OH

11:00 am - 11:15 am

*31. "Phospholipid Metabolism in a Neonatal Model of Hydrocephalus". Marcia D. da Silva, MD, James M. Drake, MD, Toronto, Ontario

11:15 am - 11:30 am

*32. "Death Related to Hydrocephalic Shunted Patients". Young Chung, Stephen J. Haines, Minneapolis, MN

11:30 am - 11:45 am

33. "Computer Modelling of CSF Shunt Siphoning". James M. Drake, MD, Toronto, Ontario

11:45 am - 12:00 pm

*34. "Gravitational Shunt: A Novel Approach to Cerebrospinal Fluid Shunting". John H. Sampson, MD, Erico R. Cardoso, MSc, MD, Durham, NC

12:00 pm - 12:15 pm

*35. "Outcome Study of Neonatal Posthemorrhagic Hydrocephalus Treated with Early Ventriculoperitoneal Shunting: Surgical and Neurodevelopmental Findings". Kenneth W. Reichert, MD, Glenn A. Meyer, MD, Ruth Heimler, MD, Milwaukee, WI

12:15 pm - 12:30 pm

*36. "Aggressive Surgical Management of Progressive Hydrocephalus in Pre-Term Infants with Intracranial Hemorrhage Does Not Alter Outcomes". Michael L. Levy, MD, J. Gordon McComb, MD, Lena Masri, MS, Los Angeles, CA

12:30 pm - 12:45 pm

*37. "Venous Sinus Occlusion and Ventriculomegaly in Craniectomized Rabbits". Nesher G. Asner, MD, William C. Olivero, MD, Peoria, IL

12:45 pm - 1:00 pm

38. "Decrease in Ventricular Size Produced by a Venous Tourniquet Around the Neck". Harold L. Rekate, MD, W. Bruce Cherny, MD, Phoenix, AZ

6:30 pm - 7:30 pm

Reception, Ballroom Foyer

7:30 pm - 11:30 pm

Annual Banquet, Ballroom

FRIDAY, DECEMBER 6, 1991

7:00 am - 1:00 pm

Registration, Ballroom Foyer

7:00 am - 8:00 am

Continental Breakfast, Ballroom Foyer

SCIENTIFIC SESSION VII — HYDROCEPHALUS II
Moderators: Paul Kanev, Philadelphia, Pa; Timothy Mapstone, Cleveland, OH

8:00 am - 8:15 am

39. "Factorial Analysis of Shunt Infection in Neonatal Spina Bifida Patients". F.A. Boop, MD, W.M. Chadduck, MD, Anthony Russell, MD, Little Rock, AR

8:15 am - 8:30 am

40. "Do Antibiotics Prevent Shunt Infections? A Meta Analysis". Stephen J. Haines, MD, Minneapolis, MN

8:30 am - 8:45 am

41. "The Relationship of Ethylene Oxide to Sterile Shunt Malfunction". Thomas Pittman, MD, Alan Knutsen, MD, Mobeen Rathore, MD, St. Louis, MO

8:45 am - 9:00 am

42. "VP Shunt Rejection Secondary to Implanted Foreign Material". James T. Goodrich, MD, PhD, Robert Keating, MD, Bronx, NY

9:00 am - 9:15 am

*43. "The Neurosurgeon's Role in the Quality Control of Shunt Products". D. Bruce Ramsey, MD, William M. Chadduck, MD, Anthony E. Russell, MD, Frederick A. Boop, MD, Paul Steinbok, MB, Little Rock, AR/Vancouver, BC

9:15 am - 9:30 am

*44. "Broviac Ventriculostomy for Long-Term External Ventricular Drainage". M.J. Chaparro, M.B. Pritz and K.S. Yonemura, Orange, CA

9:30 am - 9:45 am

45. "The Adventitia of the Major Cranial Blood Vessels Does Not Provide a Pathway for Lymphatic Drainage of CSF". J.G. McComb, S.H. Song, S. Hyman, D. Chan, F.E. Gilles, Los Angeles, CA

9:45 am - 10:00 am

46. "Morphometric Analyses of the Effectiveness of Decompression in Experimental Infantile Hydrocephalus". James P. McAllister II, PhD, Leslie M. Sharpe, BS, Pamela M. Hale, BS, Raymond A. Morano, Deven V. Shroff, BS, and Richard M. Kriebel, PhD, Philadelphia, PA

10:00 am - 10:30 am

COFFEE BREAK AND EXHIBITS — Blaxton Room and Ballroom Foyer

SCIENTIFIC SESSION VIII —MYELOMENINGOCELE — SPINAL DYSRAPHISM Moderators: William Bell, Winston-Salem, NC; Jeffrey Winfield, Syracuse, NY

10:30 am - 10:45 am

*47. "Open Neural Tube Defect Model Induced by Exogenous Lectin in Chick Embryos". T. Inagaki, K. Wang, R. Higbee, D.G. McLone and P.A. Knepper, Chicago, IL

10:45 am - 11:00 am

*48. "Hydromelia Decompression with VP Shunt Revision in Patients with Chiari II Malformations". Jose Espinosa, MD, Jean-Pierre Farmer, MD, and Jose L. Montes, MD, Montreal, Quebec

11:00 am - 11:15 am

49. "The Tethered Spinal Cord: Aspects of Retethering, Shunt Function, and Neurologic Outcome". Lyn Carey Wright, MD, Marion L. Walker, MD, and Lynn D. Falkner, PA-C, Salt Lake City, UT

11:15 am - 11:30 am

50. "Rethering After Myelomeningocele Repair: Review of Thirty Consecutive Cases". Steven J. Schneider, MD, Alan D. Rosenthal, MD, New Hyde Park, NY

11:30 am - 11:45 am

*51. "The Effect of Surgical Repair on Urodynamic Studies in Infants with Lipomeningocele". Sumeer Sathi, MD, Joseph Madsen, MD, R. Michael Scott, MD, Anthony Atala, MD, Stuart Bauer, MD, Boston, MA

11:45 am - 12:00 pm

*52. "Anterior Sacral Meningocele—Issues in Management". M. Boland, R. Dauser, J. Venes, M. Dipietro, J. Brunberg, K. Muraszko, Ann Arbor, MI

12:00 pm - 12:15 pm

53. "The Tight Filum Terminale Syndrome". Gregory B. Nazar, MD, FRCS(C), Gregory Roberts, BS, David Petruska, MD, R. Dean Linden, PhD, Gregory Niznik, MSc, Louisville, KY

12:15 pm - 12:30 pm

54. "Tethered Cord Syndrome with a Conus of Normal Position". W. Jerry Oakes, MD, Daryl E. Warder, MD, Durham, NC

12:30 pm - 1:30 pm

LUNCH — Phillips and Stuart Rooms, 2nd Floor; Bullfinch, Benjamin, Parris and Shaw Rooms, 5th Floor

SCIENTIFIC SESSION IX — TRAUMA
Moderators: Thomas Luerrsen, Indianapolis, IN; Anne-Christine Duhaime, Philadelphia, PA

1:30 pm - 1:45 pm

55. "Accidental Head Trauma Does Not Cause Retinal Hemorrhage". Dennis L. Johnson, MD, David Friendly, MD, Joyce Wong, BS, Washington, DC

1:45 pm - 2:00 pm

56. "Late MRI After Closed Head Injury in Children:Relationship to Clinical Features and Outcome". Derek A. Bruce, MD, MB, ChB, Harvey S. Levin, PhD, and Dianne Mendelsohn, MD, Dallas, TX

2:00 pm - 2:15 pm

57. "Perinatal and Neonatal Head Injuries". Yoon S. Hahn, MD, David G. McLone, MD, PhD, Maywood, IL

2:15 pm - 2:30 pm

*58. "Hippocampal Damage in Fatal Head Injury in Children". Mark J. Kotapka, MD, David I. Graham, MB, PhD, FRCPath**, J. Hume Adams, MD, PhD, FRCPath**, and Thomas A. Gennarelli, MD, Philadelphia, PA

2:30 pm - 2:45 pm

59. "Perinatal Spinal Cord Injury: Clinical, Radiographic and Pathologic Features". Eugene Rossitch, Jr., MD, W. Jerry Oakes, MD, Durham, NC

2:45 pm - 3:00 pm

*60. "Pediatric Spinal Cord Concussion: Redefining the Entity and Therapeutic Ramifications". Seth M. Zeidman, MD, Thomas B. Ducker, MD, Paul Sponsellar, MD, and Benjamin Carson, MD, Baltimore, MD

3:00 pm - 3:15 pm

*61. "Pediatric Spinal Injury:60 Deaths". Mark Hamilton, MD, CM, S. Terence Myles, MD, Calgary, Alberta

3:15 pm - 3:30 pm

*62. "Spinal Cord Injury Without Radiographic Abnormality in Children with Otherwise Asymptomatic Type I Chiari Malformation". Charles P. Bondurant, MD, John J. Oro, MD, Columbia, MO

3:30 pm - 3:45 pm

COFFEE BREAK AND EXHIBITS — Blaxton Room and Ballroom Foyer

SCIENTIFIC SESSION X — SPASTICITY

Moderators: Alan Cohen, Boston, MA; Steven Schiff, Washington, DC

3:45 pm - 4:00 pm

63. "Selective Functional Posterior Rhizotomy for Treatment of Spastic Cerebral Palsy: A Study of 50 Consecutive Cases". P. Steinbok, D.D. Cochrane, A. Reiner, R.D. Beauchamp, Vancouver, BC

4:00 pm - 4:15 pm

64. "Use of the Pudendal Neurogram to Protect Bladder Function in Children Undergoing Rhizotomy". Rick Abbott, MD, Vedran Deletis, MD, V. Vodusek, MD, Fred J. Epstein, MD, New York, NY

4:15 pm - 4:30 pm

65. "A Comparison of EMG Recordings in Spastic Children and Normal Monkeys During Selective Posterior Rhizotomy Surgery". Jeffrey H. Owen, PhD, T.S. Park, MD, B.A. Kaufman, MD, G. Balzar, PhD, D. York, PhD, D. Kreiger, PhD, A. Padberg, MS, R.M. O'Meilia, MS, St. Louis, MO

4:30 pm - 4:45 pm

*66. "Improvement in Upper Extremity Function and Trunk Control After Selective Posterior Rhizotomy". Sarah J. Gaskill, MD, Allison Beck, OT, Arthur E. Marlin, MD, San Antonio, TX

4:45 pm - 5:00 pm

67. "Osteoplastic Laminotomy: Preferred Technique for Spinal Canal Exposure in Children". Eric Mirsky, Rick Abbott, MD, Fred J. Epstein, MD, New York, NY

*indicates that the paper is eligible for a resident award and is primarily the work of the resident who is presenting the paper, as designated on the abstract submission form.

Scientific Abstracts

1. NEUROSURGICAL TREATMENT IN CCSG-9882 OF BRAIN STEM GLIOMAS

A. Leland Albright, MD, Roger Packer, MD (Pittsburgh, PA)

CCSG-9882, a study to treat children with brain stem gliomas with hyperfractionated irradiation, opened for patient accrual on September 21, 1988. The first 53 children in the study were treated with 100 cGy BID to 7200 cGy and the next 56 children were treated similarly to 7800 cGy. Tumors were diagnosed by clinical and radiographic features. Decisions about operations were left to the discretion of the treating neurosurgeon; tissue diagnosis did not alter therapy. The study closed on June 30, 1991. Neurosurgery report forms were reviewed to evaluate the neurosurgical treatment of children entered on the study.

Operations were performed on 51/109 patients. Of the 51 children who were operated on, 40 had a tumor operation. There were 22 stereotactic biopsies and 19 craniotomies. The craniotomies were for biopsy only (<10% tumor removed) in 11 cases, for partial resection (11-50%) in 4 and for subtotal resection (51-90%) in 3. Neurologic complications were reported in 3 patients; in another two, neurologic condition was said to be worse after the operation although no specific complication was noted. Of the five who deteriorated, two had stereotactic operations and three had open biopsies. CSF shunts were inserted in 27 children, as the sole operation in 11 and in conjunction with a tumor operation in 16. The majority of operations were performed in academic medical centers.

It is our opinion that tumor operations are being performed with insufficient rationale for children with brain stem gliomas.

2. SURGICAL MANAGEMENT OF BRAINSTEM TUMORS OF CHILDHOOD: THE PCMC EXPERIENCE, 1977-1991

Joseph Petronio, MD, Marion L. Walker, MD (Salt Lake City, UT)

Between October, 1977 and February, 1991, fifty-one children were operated on at the Primary Children's Medical Center in Salt Lake City, for tumors involving the brainstem, either primarily or secondarily. The case histories and operative records were analyzed retrospectively according to location of tumor, pattern of growth, histology, surgical approach and survival.

The availability of magnetic resonance (MR) imaging has afforded better preoperative assessment of tumor extent and planning of the surgical approach. Fourteen patients were classified retrospectively as having diffuse intrinsic tumors involving a large extent of the brainstem. Before the MR era, these tumors were usually biopsied through a suboccipital-transvermian, retromastoid or subtemporal-transtentorial approach. Of late, MR has accurately predicted their extent and dismal prognosis; most have been stereotactically biopsied prior to irradiation or investigational chemotherapy. Of these 14 patients, 9 had histologic evidence of anaplasia present at the time of biopsy. An additional nine patients were classified as having focal intrinsic tumors, which were resected through a suboccipital or subtemporal-transtentorial approach. This group included the previously reported focal cervico-medullary tumors, and long-term survival was significantly better, sometimes even without adjuvant radiation therapy. Histologically, these were well-differentiated tumors, including 5/9 low-grade astrocytomas. A third common pattern of tumor growth was seen in 11 patients with lesions displaying a prominent exophytic component either into the fourth ventricle or peribulbar cisterns. Open resection was again utilized and survival depended on the histology and biologic behavior of the tumor.

Lastly, 17 patients were found to have primarily vermian, fourth ventricular or cerebellar peduncular tumors that invaded the brainstem secondarily. The majority of these patients were operated on through a suboccipital-transvermian approach. Because of a preponderance of "poor-risk" medulloblastomas and anaplastic ependymomas, long-term survival in this group was poor, often with leptomeningeal dissemination at the time of recurrence.

3. BRAINSTEM GLIOMAS GROWTH PATTERNS

Fred J. Epstein, Jean-Pierre Farmer (Montreal, Quebec)

Brainstem gliomas have traditionally been associated with a grim prognosis but during the last decade, empirical data has suggested that certain tumors may be associated with a better outlook. In this paper, based on the correlation of MRI appearance and histology of 88 patients treated at NYU between 1984 and 1990, several consistent observations that help understand why cervico-medullary, dorsal exophytic and focal tumors carry a favorable prognosis are made. There were 44 cervico-medullary, 12 dorsal exophytic, 12 focal and 20 diffuse tumors and all lesions were either removed radically or analyzed at autopsy.

According to these observations a hypothesis suggesting that growth of benign gliomas of the brainstem is guided by secondary anatomical structures, such as pia, fiber tracts and ependyma is proposed. These secondary structures lead to consistent stereo-typical growth patterns which are clearly identified by the MRI scan. It is therefore possible, in the preoperative phase, by combining the clinical history and the evolution of the disease with the MRI appearance, to establish the likelihood of the lesion being benign or malignant. Because empirical data suggests that certain low-grade tumors differ in outlook from the traditional grim prognosis, a knowledge of the type of tumor present will facilitate the selection of candidates for surgery. In addition, during surgery, a knowledge of the secondary anatomical structures and of the growth pattern will facilitate tumor resection.

4. THE LONG-TERM OUTCOME AFTER TREATMENT OF DORSALLY EXOPHYTIC BRAINSTEM GLIOMAS

Ian F. Pollack, MD, Harold J. Hoffman, MD, Robin P. Humphreys, MD (Toronto, Ontario)

Seventeen children with dorsally exophytic brainstem gliomas were treated at our institution between 1975 and 1990. The diagnosis was based on CT or MR imaging and confirmed by operative observations. The current study examined the long-term outcome after treatment in these children. Fourteen children had hydrocephalus at presentation. Five received ventriculo-peritoneal (VP) shunts before undergoing posterior fossa exploration, and eight received internal transaqueductal catheters from the third ventricle to the cisterna magna at the time of surgery. Five of the latter patients ultimately required a VP shunt because of persistent hydrocephalus. At operation, the tumors filled the fourth ventricle, fungating out of a broad-based area of the dorsal brainstem. Exophytic tumor was resected; no attempt was made to remove tumor from the brainstem. Histological examination showed low-grade astrocytoma in 16 patients; one other child had several foci of anaplasia in an otherwise low-grade glioma. This patient was one of only two in the series to receive postoperative radiation therapy (RT); both have no evidence of disease (NED) on follow-up imaging studies 61 and 135 months postoperatively. Serial radiological studies in the other 15 patients have shown NED in three, reduction of tumor volume in two others, stable disease in four, and tumor regrowth in four (mean follow-up = 99 months). Tumor regrowth was detected radiographically 12, 28, 40, and 84 months postoperatively and was associated with the onset of recurrent symptoms. All four patients underwent repeat tumor excision. Two also received RT; both have had reduction in tumor volume 28 and 55 months after their second operations. The other two patients had tumor regrowth 48 and 84 months after their second operations and underwent a third tumor resection. One received postoperative RT and has NED 58 months after his third operation. The other child has stable disease 25 months postoperatively. Histological examination of the tumor specimens from the second and third operations showed no change from the appearance of the tumor on the initial resection. We conclude that the majority of dorsally exophytic brainstem gliomas can be successfully managed with subtotal excision and, if necessary, CSF diversion. The small percentage of tumors that show recurrent growth remain histologically benign. In these patients, repeat tumor resection and radiotherapy are effective in providing long-term disease control.

5. CEREBROSPINAL FLUID DISSEMINATION OF SUPRATENTORIAL MALIGNANT GLIOMAS IN CHILDREN

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Dachling Pang, MD (Pittsburgh, PA)

Of 100 children with supratentorial gliomas (excluding gliomas of the anterior visual pathways) treated at the Children's Hospital of Pittsburgh from 1980 to 1990, malignant gliomas were present in 34. Thirty-three of these had adequate follow-up, and 11 were diagnosed with cerebrospinal fluid (CSF) dissemination of the malignant glioma. Of these, eight were boys and three were girls ranging in age from 17 months to 16 years at the time of diagnosis of the primary glioma. The histologic types were:glioblastoma multiforme — 4; malignant oligodendroglioma — 3; anaplastic astrocytoma — 2; malignant mixed glioma —1; malignant ependymoma — 1. The time interval between diagnosis and CSF dissemination ranged from 1 week to 59 months (median 8 months). Survival after dissemination ranged from 3 weeks to 11 months (median 4 months). Two patients are alive five and three months after diagnosis of dissemination, respectively. These 11 patients are compared to the other 22 patients without CSF dissemination. Risk factors for dissemination suggested by our data include male sex, operative ventricular entry, multiple resections, and malignant oligodendroglioma. Because of the high incidence (33%) of CSF dissemination, postoperative evaluation with gadolinium enhanced MRI of the craniospinal axis should be performed on all children with supratentorial malignant gliomas.

Moreover, since the mortality is extremely high once dissemination has occurred, aggressive therapy directed to the craniospinal axis should be considered in children with one or more of the above risk factors, even before symptoms or definite radiographic evidence of CSF dissemination emerge.

6. USE OF HIGH ACTIVITY I^{125} INTERSTITIAL THERAPY FOR PEDIATRIC CENTRAL NERVOUS SYSTEM MALIGNANCIES

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The prospect of cure for many pediatric central nervous system (CNS) malignancies has not been promising. Since 1/88, we have used stereotaxic I^{125} interstitial therapy on patients with recurrent CNS malignancy (n=3) or as part of primary treatment (n=10). Ages ranged from 3 to 13 yrs. Catheters were placed using computed tomography (CT) guidance and the BRW frame. In an attempt to standardize our treatment, implants were planned to deliver 1000 cGy/day at 0.5 to 1 cm margin beyond the area of tumor enhancement on CT scans obtained prior to implant. Total dose delivered was 60 Gy.

Patients treated for recurrence had ependymoma (n=2) or glioblastoma multiforme (GBM) (n=1). All 3 patients obtained excellent tumor regression at 2 months post implant; however, 1 progressive disease was documented in each case at 23, 12 and 3 months, respectively. A single episode of hyponatremia with resultant seizure activity which responded to medical management was the only noted complication.

The 10 patients treated with stereotaxic implants as part of initial treatment had histologies of GBM (n=7), anaplastic astrocytoma (n=1) and ependymoma (n=2). In each case hyperfractionated external beam irradiation was initiated 2-4 weeks post implant as planned. There has been one instance of post irradiation necrosis requiring surgery. No other severe complications have been documented.

At present, 7/10 remain alive without evidence of progressive disease 2 to 21 months post implantation. Local control has been maintained in 8/10 patients. The 3 local failures occurred at 3 and 4 months post completion of external beam irradiation. One patient remains alive with disease while receiving Phase I chemotherapy. One initially showed an unusual recurrence pattern along the catheter tracts, later, evidencing CNS dissemination.

6. USE OF HIGH ACTIVITY I^{125} INTERSTITIAL THERAPY FOR PEDIATRIC CENTRAL NERVOUS SYSTEM MALIGNANCIES (continued)

Based on this small experience, we continue to recommend the combination of I^{125} stereotaxic implantation followed by hyperfractionated external beam irradiation for select children with supratentorial malignant lesions.

7. PROGNOSTIC FACTORS FOR SHUNTING IN PEDIATRIC PATIENTS WITH MEDULLOBLASTOMA

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Posterior fossa primitive neuroectodermal tumors (medulloblastoma) commonly obstruct cerebralspinal fluid pathways with resultant hydrocephalus. While not all medulloblastoma patients will continue to suffer from hydrocephalus after the tumor is resected, there is a subpopulation which will require a permanent shunt. We have studied a group of pediatric patients with medulloblastoma not shunted preoperatively, and have identified several characteristics which are associated with requirement for permanent postoperative shunt. The medical records for all pediatric patients (<21 yrs) with histologically verified posterior fossa PNET operated on at NYU Medical Center between the years 1979-1990 were retrospectively reviewed. Fifty-five patients were identified. Eleven patients were excluded from the final analysis for preoperative shunt (7), operative death (2), recurrent tumor (1), or pontine PNET (1). Thus, 44 patients were included in the final analysis. The patients were divided into two groups, postoperative shunt vs no shunt, and were compared by age, sex, presence and duration of preoperative ICP symptoms, degree of hydrocephalus on preoperative CT or MRI (ratios of both ventricular body and frontal horn diameters to paranchymal diameter), tumor stage (Chang's staging system), extent of resection (by surgeon's report), perioperative extraventricular drainage, dural closure, CSF cytology, and metastatic disease. Fifteen patients required a permanent shunt within 4 weeks of tumor resection (34%). Compared to the "no shunt" group, these patients were younger ($4.2 \pm .6$ yrs (mean $\pm$ SEM) vs 9.8 ± 1.2 yrs, $p = .0012$), had a greater degree of preoperative hydrocephalus (ventricular body ratio $.56 \pm .09$ vs $.35 \pm .03$, $p = .013$, frontal horn ratio $.73 \pm .12$ vs $.46 \pm .05$, $p = .029$), and had a higher tumor stage ($2.7 \pm .12$ vs $1.9 \pm .19$, $p = .018$). The 2 groups did not differ significantly in the other variables analyzed.

8. TYROSINE KINASES IN MEDULLOBLASTOMAS AND NORMAL HUMAN CEREBELLUM

Liliana C. Goumnerova, MD, FRCSC (Boston, MA)

Numerous recent reports have focused on the expression of a variety of growth factors and receptors in brain tumors. So far, a specific growth factor or oncogene has not been identified. Receptor-associate tyrosine kinases have been shown to play an important role in regulating cellular growth and have been implicated in transformation and neoplasia. Tyrosine phosphorylation is important in the regulation of specific signalling pathways in the cell.

Medulloblastomas are tumors of primitive neuroectodermal origin which have the ability to differentiate along several lineages. Because of their frequency and unique pathological characteristics, we elected to study medulloblastomas for the expression of specific receptor-associated tyrosine kinases. Samples of tissue were obtained at time of surgery and immediately frozen in liquid nitrogen. Total RNA was isolated from the tissue. Following isolation of total RNA, we applied the polymerase chain reaction to amplify the RNA and for first-strand cDNA synthesis. Oligonucleotide probes (primers) corresponding to the conserved amino acid sequences of all tyrosine kinase family members were employed in the PCR reaction to amplify sequences between them. The DNA was subsequently cloned and sequenced. Additionally, a human cerebellum cDNA library was obtained. Oligonucleotide probes were constructed and were utilized to screen the library for protein tyrosine kinase. Data on the isolation of specific receptor-associated tyrosine kinases in human cerebellum and in medulloblastoma will be presented. The isolation of specific proteins to medulloblastoma will be of great value as they can serve as markers for this tumor and also enable us to create antibodies against it which can be used in its treatment.

9. DEVELOPMENT OF MALIGNANT CHANGE IN LOW-GRADE ASTROCYTOMAS IN CHILDHOOD

James T. Rutka, Peter B. Dirks, Robin P. Humphreys, James M. Drake, Harold J. Hoffman (Toronto, Ontario)

Malignant transformation of low-grade astrocytomas in children is uncommon. We reviewed a series of children who developed malignant astrocytomas following treatment for low-grade astrocytomas. Six children, four males and 2 females, between the ages of two and nine (mean 5 y, 1 mo) were studied. Five children had chiasmatic/hypothalamic tumors, and one child had a thalamic tumor. Four children underwent craniotomy for tissue diagnosis by either biopsy or subtotal resection of tumor. The histopathological diagnosis in all these cases was low-grade astrocytoma. Two patients had characteristic radiographic findings of optic chiasmatic/hypothalamic tumors and were not biopsied prior to treatment. All children underwent external beam radiation therapy with an average dose of 5050 rad to a minimum 6-8 cm3 volume field which was fractionated over 6 weeks. All children progressed symptomatically and radiographically and required reinvestigation. Five children underwent reoperation and were found to harbour malignant astrocytomas. One child was not operated upon because a tentorial lesion was found associated with spinal metastasis. Two children developed malignant tumors in the temporal lobe, one in the cerebellum, one in the subfrontal region, and one in the intraventricular space. All malignant tumors were found contiguous to the primary low-grade astrocytoma site within the field of irradiation. The time to development of malignant change varied between two years and ten years (mean 6 y 5 mo). Three children received additional therapy, and two had chemotherapy. Survival after recurrence ranged between 2 and 22 months. The 5 patients with chiasmatic/hypothalamic tumors in this study are among 55 patients we have followed and treated since 1976 with tumors in this region. Thirty patients received radiation therapy for their tumors, and 25 were merely observed following surgery. Interestingly, malignant astrocytomas developed only in the group which received radiation therapy (5/30 patients or 16%). From this study, we cannot determine if previously low-grade astrocytomas undergo malignant transformation as part of their natural history or if radiation therapy leads to progression into an anaplastic form. However, the data suggest that the role of radiation therapy especially for young children with chiasmatic/hypothalamic low-grade astrocytomas needs to be critically reevaluated.

10. PINEOCYTOMAS IN CHILDREN: A CLINICOPATHOLOGIC ANALYSIS OF OUTCOME

Nicholas Poulos, MD, Arno H. Fried, MD, Mindy Estes, MD, Joseph Hahn, MD (Cleveland, OH)

The pineocytoma is an uncommon tumor in which the optimal management and outcome is controversial. Further confusion exists with regard to differentiating these pineal neoplasms from pineal cysts which do not require surgery. The present study looked at the outcome for pineocytomas as it relates to the type of cellular differentiation, as well as degree of resection.

Three children, age 5-17 years, presented with signs of elevated intracranial pressure. All three had hydrocephalus and mass effect at the quadrigeminal plate, differentiating tumor from benign pineal cysts. A transcallosal approach was used in two and a supracerebellar in one. A complete resection was accomplished in all three. Two received adjuvant craniospinal radiation. Using immunohistochemical techniques, astrocytic differentiation was seen in two cases and neuronal in the other. All are disease-free 1-4 years postoperatively.

In conclusion: 1) pineocytomas can be differentiated from benign pineal cysts by the presence of hydrocephalus and mass effect of the tectal region, 2) cellular differentiation is one predictor of tumor behavior with neural and mixed having a benign course and undifferentiated a more aggressive course, 3) the surgical goals should be total excision and not stereotactic biopsy and shunting, 4) postoperative craniospinal radiation should be used when there has not been a total excision, when there is undifferentiated or astrocytic cellular differentiation or when spinal staging shows drop lesions.

11. THE ENDOCRINE MORBIDITY OF HYPOTHALAMIC GLIOMAS

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Hypothalamic low-grade gliomas are generally associated with long-term survival and significant endocrine morbidity. We retrospectively reviewed the progressive endocrine status of 16 children treated by the Divisions of Pediatric Neurosurgery and Pediatric Endocrinology at the University of California, San Francisco, since 1980.

Presenting symptoms included diencephalic syndrome (5), visual symptoms (8), developmental delay (2), and premature thelarche (1). Only 1 child had symptoms of endocrine dysfunction, but 3 out of 10 patients had demonstrable hormonal abnormalities at diagnosis, including elevated Testosterone (1), Somatomedin C (2), and Prolactin (2). Two children underwent biopsies, while fourteen underwent subtotal resection of 30-75% of tumor bulk. Even following aggressive surgical resection, the only new postsurgical deficit was Diabetes Insipidus (3). Five children received radiation therapy, two of whom developed growth hormone deficiency and panhypopituitarism as early as 1 year following treatment. Fifteen of sixteen children received chemotherapy, two as primary treatment. Three patients evaluated after receiving both surgery and chemotherapy developed new deficits, including primary hypothyroidism, premature thelarche, and pan-hypopituitarism; however, in the two latter cases, MRI documented tumor progression. Two patients who received all three treatment modalities developed new deficits, including premature thelarche and pan-hypopituitarism.

This retrospective review with up to 11 year follow-up indicates that the added endocrine morbidity associated with various treatment options appears to be the least with surgery and chemotherapy. However, to adequately define treatment-related endocrine morbidity, baseline pretreatment endocrine testing of all newly diagnosed hypothalamic gliomas must be instituted, as hormonal abnormalities may be present without being clinically apparent. In addition, current treatment approaches must be continuously reevaluated as these children reach the age of reproductive capability.

12. CRANIOPHARYNGIOMA—TOTAL SURGICAL REMOVAL

Thomas S. Berger, MD, Kerry R. Crone, MD (Cincinnati, OH)

The treatment of craniopharyngioma remains controversial. In recent years the pendulum has swung from radical surgical treatment toward a more conservative stance of limited surgery followed by radiotherapy.

We are presenting a small series of 16 consecutive patients whose initial or only treatment was radical surgery (15 subfrontal; 1 transsphenoidal; 1 both) by a single primary surgeon. The average age at the time of presentation was 10 years with an average follow-up of 6.5 years. All patients had a gross total removal of their tumor confirmed by postop imaging. All patients are alive, but four have had recurrences (8 months to 14 years postoperative) manages with reoperation, cyst aspiration and injection of P-32, conventional radiotherapy or a combination of the above. These four patients either have stable or no obvious tumor at this time by CT or MRI scan. All but one patient has panhypopituitarism or is on some type of hormonal replacement. Several patients have difficulty with obesity. In those patients who could be evaluated preoperatively, two had permanent increase in visual problems postoperatively consisting of a partial field cut. We based our functional outcome on a scale used by Wen, et al (J. Rad. Onc. Biophys. Jan. 1989, Vol 16, No. 1, pp. 2l-22) with Grade I being normal and independent on hormonal replacement and Grade IV being totally dependent. We have six patients Grade I, five patients Grade II, five patients Grade III and no patient being totally dependent. One patient is Grade III because of mental illness, probably not related to his tumor or treatment, three because of preoperative visual problems and the final patient with a significant learning disability presented in coma with dilated fixed pupils secondary to raised intracranial pressure which may well be the source of his problems.

Even though this is a small series of patients, we feel that the ability to totally remove 16 tumors without a related death and acceptable postoperative disability supports this as the primary approach to this difficult problem.

13. BENIGN CEREBELLAR ASTROCYTOMAS OF CHILDHOOD

John J. Schneider, Jr., MD, Corey Raffel, MD, PhD, J. Gordon McComb, MD (Los Angeles, CA)

Benign cerebellar astrocytomas of childhood are potentially surgically curable lesions. Histologically, these neoplasms can be divided into pilocytic and diffuse astrocytomas. Whether there is difference in recurrence rate between these two tumor types after surgical resection is not clear. In addition, the role of immediate postoperative imaging in predicting a recurrence has not been established. To answer these questions, we have reviewed the charts of 23 patients with benign cerebellar astrocytomas treated at CHLA over the ten year period 1977-1987. Of the 23 tumors, 15 were pilocytic and 8 were diffuse. All underwent an attempted gross total surgical removal of tumor, and all patients had a postoperative CT scan with and without intravenous contrast enhancement performed within 72 hours of their operation. Based on the postoperative CT scan, 12 patients had residual tumor. Seven of the subtotally resected tumors were pilocytic (7/15) and 5 were diffuse (5/8). Interestingly, the surgeon believed that a gross total resection had been obtained in nine of these cases. Four recurrences have occurred in these 23 patients, with a mean follow-up of 4.9 years. All recurrences were in patients with subtotal resections. Of the eleven patients with total removal of tumor, seven developed a small rim of enhancement on subsequent scans an average of five months after surgery. No recurrences of tumor have occurred in these eleven patients. These results suggest that the surgeon's impression of the degree of resection is not accurate, that patients with gross total resections on immediate postoperative CT scans do well regardless of histology, and that appearance of a small rim of contrast enhancement on subsequent CT scans does not herald the presence of recurrent tumor.

14. OCCULT PERIAQUEDUCTAL TUMORS IN "BENIGN" AQUEDUCTAL STENOSIS

B. Gregory Thompson, Jr., MD, Ian Pollack, MD, Dachling Pang, MD, FRCS(C) (Pittsburgh, PA)

"Late-onset" or "Benign" Aqueductal Stenosis (AS) are terms which refer to non-neoplastic, non-congenital, noncommunicating hydrocephalus. Recent experience with superior imaging techniques and longer follow-up suggests that many patients assigned this diagnosis may harbor occult neoplasms. At the Children's Hospital of Pittsburgh (CHP) 7 patients have been identified in whom initial evaluation of hydrocephalus with CT failed to demonstrate what were later found to be periaqueductal tumors. Four of these patients from the pre-MRI era were misdiagnosed and carried the diagnosis of "Benign" AS for 7-10 years. One patient was referred to CHP within one month of diagnosis of AS, and was subsequently found to have a periaqueductal tumor on MRI. Two other patients had a negative CT and positive MRI during their evaluation at CHP. For the group, the average age of diagnosis of AS was 8 years (range 6 months to 13 years). The average interval between diagnosis of AS and the periaqueductal tumor was 55 months (range 1 week to 9 years). Magnetic Resonance Imaging was necessary in each case to establish the diagnosis. With MRI periaqueductal mass effect was noted prospectively in 5 of 7 patients, and absence of flow void sign in only 3 of 7. T2 weighted images were 100% sensitive and superior to T1 images. Due to tumor growth and symptomatic progression, 3 of 7 patients were biopsied for histologic confirmation of neoplasia, and were subsequently irradiated. Average follow-up after tumor diagnosis is 3.2 years. We conclude that CT alone is inadequate evaluation and MRI should be a requisite investigation for any patient with either a standing or suspected diagnosis of aqueductal stenosis and not previously examined with MRI. In addition, serial MRI studies may be required to follow patients with apparent AS.

15. STEREOTACTIC RADIOSURGERY FOR PEDIATRIC PATIENTS WITH ACOUSTIC TUMORS AND NEUROFIBROMATOSIS

Mark E. Linskey, MD, L. Dade Lunsford, MD, John C. Flickinger, MD (Pittsburgh, PA)

We have evaluated the role of stereotactic radiosurgery in 7 neurofibromatosis (NF) patients (8 acoustic tumors) during a 4 year interval. Multiple isocenter radiosurgery was computer-determined to provide a single fraction dose of 15-20 Gy to the irregular tumor margin. All patients were discharged within 48 hours of treatment and functional performance was maintained over the average follow-up interval of 25 months in all cases. Six patients had untreated contralateral "internal control" tumors evaluated by neuroimaging over the same period. Four "internal control" tumors increased in size and 2 remained unchanged; among contralateral treated tumors 1 tumor decreased, 1 increased, and 4 remained unchanged in size. Overall 1 treated tumor decreased in size, 5 remained unchanged and 2 increased in size. All 4 patients with useful hearing (Gardner-Robertson Class I or II) preoperatively lost useful hearing from 3-12 months after radiosurgery. Only 1 of 4 patients with normal preoperative facial nerve function developed a postoperative facial neuropathy (House Grade II) while 3 of 4 with a pre-existing facial neuropathy experienced worsening of facial function. Mild sensory trigeminal symptoms developed in 2 patients.

Using these dose parameters stereotactic radiosurgery achieved tumor control in 88%, with maintenance of functional performance in 100% of pediatric patients with NF. Although hearing preservation rates were unsatisfactory, hearing loss occurred gradually, allowing the patient time to adjust. Early treatment, prior to the development of tumor-induced facial neuropathy, appears to lessen the likelihood of facial neuropathy after radiosurgery. A reduced tumor margin dose (12-14 Gy) may enhance hearing preservation rates in future patients.

16. MOYA MOYA PHENOMENON IN NEUROFIBROMATOSIS PATIENTS RADIATED FOR OPTIC PATHWAY GLIOMAS

John R.W. Kestle, MD, MSc, FRCSC, Antonio R. Mock, MD, Harold J. Hoffman, MD, FRCSC, FACS (Toronto, Ontario)

A number of options are available for the treatment of patients with optic pathway gliomas. In particular, the role of radiotherapy is controversial. In a series of patients with optic pathway gliomas treated at The Hospital for Sick Children in Toronto, five patients were encountered who developed moya moya phenomenon after treatment with radiotherapy. A retrospective review of the medical records was performed in order to assess the relationship between optic pathway gliomas, neurofibromatosis -1 (NF-1), radiation therapy and moya moya phenomenon.

There were 47 cases of optic pathway glioma between 1971 and 1990. Moya moya did not occur in any of the 19 patients treated without radiation. Among the 28 patients who received radiation, two of 23 without NF-1 and three of five with NF-1 developed moya moya. There was a statistically significant relationship between radiotherapy and moya moya when the analysis was stratified according to the presence of NF-1 (Mantel-Haenszel chi square = 15.23, $p < 0.01$).

The high incidence of moya moya (three of five cases, 60%) in the patients with both NF-1 and radiotherapy suggests a synergistic relationship which should be considered when formulating a treatment plan for NF-1 patients with optic pathway gliomas.

17. PRE- AND POSTOPERATIVE EVALUATION OF MOYAMOYA SYNDROME WITH THREE DIMENSIONAL TIME-OF-FLIGHT ANGIOGRAPHY

Anthony Martino, MD, Michael Edwards, MD, Jay Tsuruda, MD, and Christopher Dowd, MD (Detroit, MI)

Moyamoya disease is characterized by stenosis of the distal internal carotid artery with subsequent development of collateral vessels perforating the base of the brain. The diagnosis is based upon the x-ray angiographic (XRA) features. Due to increased sensitivity to infarct and vessel patency MRI has been found helpful in the noninvasive evaluation of this disorder. In addition, we have recently utilized three dimensional time-of-flight angiography (3D TOFA) in the pre- and postoperative evaluation.

Six patients with proven moyamoya disease by XRA were examined with short TR and long TR SE MRI and 3D TOFA. Two patients were studied preoperatively as well as postop encephaloduro-arteriosynangiosus (EDAS) revascularization.

The SE MRI studies demonstrated diminished flow voids primarily involving the terminal branches of the internal carotid artery and the proximal middle/anterior cerebral arteries. Cortical, watershed, deep white matter and basal ganglia infarcts were noted in all our cases. Hemorrhage was seen in our only adult patient. Determining the patency and site of EDAS anastomosis was not possible by SE MRI.

3D TOFA demonstrated very good correlation with XRA in revealing the extent of the large vessel occlusion. No improvement was seen in the visualization of moyamoya vessels at the base of the brain. Visualization of the leptomeningeal collaterals was improved compared to SE MRI. Postoperative evaluation of EDAS patency one year after revascularization by 3D TOFA confirmed the patency of the superficial temporal artery and demonstrated collateral filling of the distal MCA branches.

In conclusion, 3D TOFA improved the overall specificity of MRI in the diagnosis of moyamoya disease by detailed depiction of the pattern of large vessel occlusion. 3D TOFA's ability to visualize the patency of EDAS revascularization and collateral filling of cortical vessels renders it a promising role in the postoperative evaluation of moyamoya disease.

18. CEREBRAL HEMISPHERECTOMY IN CHILDREN WITH INTRACTABLE SEIZURES

Jon Weingart, MD, Ben Carson, MD, Donlin Long, MD, PhD, Sumio Uematsu, MD, Eileen Vining, MD, John Freeman, MD (Baltimore, MD)

Hemispherectomy is an effective treatment for children with intractable seizures. Delayed complications (increased intracranial pressure, intellectual deterioration, progression of neurological deficits, and death) due to cerebral hemosiderosis have occurred in 25% to 33% of patients undergoing anatomically complete hemispherectomy. These complications have resulted in subtotal and functional hemispherectomy replacing complete hemispherectomy.

We report 32 patients, treated between 1975 and 1991, with intractable seizures who underwent a complete hemispherectomy. These patients can be divided into 2 groups; first, Rasmussen's encephalitis (12 patients) and second, developmental abnormalities (20 patients). The follow-up in these patients ranges from 8 months to 16 years (mean=4.6 years); 13 patients have been followed for 4.5 to 16 years. Eleven of the 12 (92%) patients with Rasmussen's encephalitis are seizure free and 12 of the 18 (66%) patients with developmental abnormalities are seizure free. Complications include 2 deaths as well as aseptic meningitis (46%), bacterial meningitis (16%), and hydrocephalus with shunt placement (26%). No delayed complications have occurred in the patients followed more than 4 years. The procedure in these patients involves removing the entire cerebral cortex, leaving the corona radiata, basal ganglia, and thalamus, and avoiding entering the ventricle. Hemostatic agents (gelfoam and surgicel) are placed over the decorticated white matter at the end of the procedure.

These results confirm the benefit of hemispherectomy in selected patients. In addition, we propose that complete hemispherectomy can be safely performed without the late complications of cerebral hemosiderosis.

19. REORGANIZATION OF THE CORTICAL-TECTAL PATHWAY FOLLOWING NEONATAL CEREBRAL HEMISPHERECTOMY IN CATS

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Cerebral hemispherectomy sustained early in life results in sparing of function in the contralateral visual field. It has been proposed that the mechanism involves the reorganization of the cortical-tectal pathway. To define this anatomical reorganization, the left superior colliculus of 3 intact adult (INA) cats, 3 neonatal-hemispher-ectomized (NH), (5-15 days of age), and 3 adult-hemispherectomized (AH) cats was injected (1 mm deep) with WGA-HRP (.3-.5 m1). Brains were processed for combined TMB/DAB histochemistry and the primary visual cortex (VC; areas 17 & 18) was examined (light microscopy, 1500X). For each group, labelled neurons, (restricted to layers IV and V), were counted, and their soma measured. For INA cats, the left VC had 1,268.7 cells (mean per cat, MPC), with a mean soma size (MSS) of 366.7 μm^2 (SD=$\pm$185.5) with the greatest percentage of neurons within the 300-700 μm^2 range. No cells were detected in the right VC. For NH, the remaining contralateral VC exhibited a MPC=474.6, and a MSS=436.1 μm^2 (SD=$\pm$186.0), and peak distribution of 400-800 μm^2. For AH, the remaining contralateral VC exhibited a MPC=93.6, had a MSS=486.6 μm^2, (SD=$\pm$202.5) with a peak distribution of 500-800 μm^2. In AH, the new cortical-tectal projection is primarily due to collateral sprouting. The findings in NH's could be the result of a lesion-induced sustaining of fibers which normally die off during development. Since a crossed pathway could not be demonstrated in an intact neonate, this suggests that cerebral hemispherectomy early in life also results in a novel crossed pathway. We propose that the collateralized pathway in NH animals may be responsible for the sparing of the visual fields. Finally, the cell bodies of the lesioned groups in this reorganized pathway were larger than in intact animals, suggesting that they may increase their size in response to greater axonal arborization.

20. HEMISPHERECTOMY: ITS ROLE IN THE MANAGEMENT OF HEMIMEGALENCEPHALY

Jamal Taha, MD, Thomas S. Berger, MD, Kerry R. Crone, MD (Cincinnati, OH)

Hemimegalencephaly is a rare disorder of neuronal migration characterized clinically by intractable seizures and severe developmental delay. Five children are presented. Three underwent hemispherectomy before two years of age, in two stages for intractable seizures. Two did not. EEG demonstrated polyspikes from the hemimegalencephalic hemisphere and progressive generalized slowing of the opposite side. Three developed polyspikes in the contralateral hemisphere. Preoperative WADA testing proved useful in evaluating pharmacologically the effect of hemispherectomy on contralateral polyspikes. Seizures improved following partial hemispherectomy and subsided immediately following complete hemispherectomy. Postoperative EEG revealed absence of polyspikes in the operated hemisphere and reduction of slowing in the contralateral side.

Psychomotor development was superior to that of children who did not undergo hemispherectomy. Of those, one died at four years in status epilepticus and the other, now five years old, has frequent seizures with severe developmental delay. From our series, it appears that hemispherectomy is a useful procedure in controlling seizures and improving psychomotor development in children with hemimegalencephaly. Surgery in early infancy can prevent or minimize seizure foci and encephalopathic changes that may develop in the opposite hemisphere. Staging the procedure and use of a fiberoptic hemostatic laser can make surgery relatively safe in infants who otherwise have significant blood loss associated with increased blood flow to the hemimegalencephalic hemisphere.

21. ONE-STAGE COMPLETE CORPUS CALLOSUM SECTION IN CHILDREN WITH INTRACTABLE EPILEPSY

Peter McL. Black, MD, PhD, Gregory Holmes, MD, Cesare Lombroso, MD (Boston, MA)

Section of the corpus callosum may be an extremely helpful technique in children with intractable epilepsy, especially with akinetic episodes as part of their presentation. We reviewed 21 successive corpus callosal sections done by the senior author at the Children's Hospital, Boston. All patients were evaluated by a multidisciplinary epilepsy group which includes neurophysiologists, neuropsychologists, radiologists, and neurosurgeons.

There were 5 patients who had anterior callosotomy. These patients tended to be older, with higher cognitive function, than those selected for complete callosotomy. MRI showed satisfactory section in every case. Three of them had improvement in seizure frequency although none have achieved complete control of seizures. None have had long-term morbidity from their procedure.

Eleven patients had a complete callosotomy:their ages ranged from 6 months to 20 years. Medication previously used to control seizures included Dilantin, Mysoline, Tegretol, Mebaral, Diamox, Clonopin, Phenobarbital, Ritalin, and Valproate, all without effect; most children were significantly developmentally delayed as well.

Six patients of the 11 had a callosotomy in two stages. Four of these had improvement in seizure rate and type; in one of these focal seizures replaced drop attacks. There was no long-term morbidity.

Five patients had one-stage complete callosal division. This one-stage complete callosotomy was done through a precoronal craniotomy on the right with a technique that will be described. Three children were improved, one was seizure free. There was no difference in the morbidity of this as opposed to two-stage callosotomy.

One-stage callosal resection is a useful and feasible procedure in children, especially those with substantial developmental delay.

22. INCREASED INTRACRANIAL PRESSURE: AN UNEXPECTED FINDING IN CRANIOSYNOSTOSIS WITH MINIMAL COSMETIC DEFORMITY

Robert C. Dauser, MD, Steven R. Cohen, MD, Frank Vicari, MD
(Ann Arbor, MI)

Signs and symptoms of increased intracranial pressure (ICP) have long been described in cases of craniosynostosis. However, past reports have dealt mainly with patients exhibiting obvious cosmetic deformities in need of surgical correction. This study reviews five children (ages 4-7) with various forms of craniosynostosis producing only mild degrees of deformity, who in general would not be considered candidates for reconstructive surgery strictly from a cosmetic standpoint. All children were found to have objective signs and symptoms of increased ICP, presumably on the basis of reduced cranial vault size. Two patients who had undergone frontoorbital advancement several years prior presented with solid fusion of the skull at the old repair site producing shallow forehead deformities, digital markings on radiography, small head circumferences, headaches, and papilledema. Another two children were found to have papilledema on routine ophthalmologic examination. Subsequent radiologic workup revealed swollen optic nerves, compressed subarachnoid cisterns, and digital markings. ICP monitoring revealed markedly elevated pressures in both of these children, who were noted only in retrospect to have slightly narrowed foreheads suggestive of very mild trigonencephaly. A fifth child with mild metopic synostosis of questionable cosmetic significance developed headaches and a sixth cranial nerve palsy during a period of conservative observation. All five children underwent frontoorbital advancement with cranial vault expansion resulting in relief of all signs and symptoms of increased ICP. Elevated ICP must therefore be suspected in cases of craniosynostosis even if only minor deformity is present. Clinical signs and symptoms, radiologic studies, and direct monitoring techniques can be used to document this phenomenon, thereby justifying a craniofacial reconstructive procedure. Following craniofacial surgery, patients should be monitored routinely for the development of increased ICP with regular neurologic and ophthalmologic evaluation. Finally, craniosynostosis of minimal cosmetic significance must be suspected in the workup of patients with symptoms and signs of increased ICP such as papilledema. Chronically elevated ICP can have devastating effects on the brain and visual system, making recognition and treatment of this condition of paramount importance.

23. PEDIATRIC HERNIATED LUMBAR DISC DISEASE

Rosemaria Gennuso, MD, Robin P. Humphreys, MD,
Harold J. Hoffman, MD, E. Bruce Hendrick, MD, and
James M. Drake, MD (New York, NY)

Lumbar disc disease as the cause for low back pain in the pediatric population is an uncommon finding. The results of a retrospective review of 90 patients (age 10-18 years) treated over a 23 year period are reported. Presentation in the adolescent is typically one of low back pain, infrequently antedated by a history of trauma (38/90). Mechanical findings were present in all cases. Focal neurological deficits, in contrast, were seen in less than 1/3 of the population: sensory changes 8%; motor weakness 25%; reflex change 14%; and bowel/bladder disturbance 0%.

The L4-5 interspace was the most often affected spinal level (51 cases). Various congenital anomalies were additionally demonstrated on radiological studies: scoliosis (5), stenosis (7), transitional vertebra (4) and spina bifida occulta (2). A posteriorly dislocated epiphysis was noted in nine patients and required alteration of the conventional surgical approach.

All patients had a trial of conservative treatment prior to referral. 12/13 patients treated nonoperatively improved. 77 required operative treatment with 97% improvement (mean follow-up of 8.2 years). Two patients suffered confirmed recurrent disc disease, one two weeks after initial surgery (same level) and one as an adult at an adjacent spinal level. Unlike the adult, the disc material is often moist and elastic in nature. The unique nature of the juvenile disc requires familiarity with this syndrome and its distinct features for optimum outcome.

24. MIDLINE EPICRANIAL MASS LESIONS IN CHILDREN

Andrew D. Parent, MD (Jackson, MS)

The asymptomatic scalp mass that presents as a cosmetic abnormality in children has, until recently, excited little significant study of its diagnosis and management. Although many authors have stressed the preponderance of dermoid cysts in the differential diagnosis, few recent studies have correlated modern neuroimaging studies with the surgical pathology.

We present 19 cases of midline scalp lesions in children studied in the past 5 years. The lesions include 10 in the anterior fontanelle area, 3 in the obelion, I in the nasion, and 5 in the inion area. Thirteen of the I9 children (68%) were diagnosed at less than 12 months of age (range: 1 month - 4 years). Although several of these lesions had been noted to progress in size, none were associated with clinical symptoms or neurological deficits. There were 5 dermoids, 4 epidermoids, 4 hemangiomas, 1 infantile fibrosarcoma, 1 eosinophilic granuloma, 2 heterotrophic glial tissues with meningocele, and 2 sinus pericranii. Twelve of these patients were studied with MRI scan, 8 with CT scan, and 2 with ultrasound. Only one case with infantile fibrosarcoma had a recurrence of the lesion which required an extensive scalp resection with secondary grafting to obtain a cure.

Both the MRI scan and the CT scan provided evidence of the absence of intracranial extension of the lesion as well as its relationship to the sagittal sinus. The MRI scan demonstrated evidence of old hemorrhage in a few cases of dermoid cyst as well as signal voids in the hemangiomas and sinus pericranii. The radiologic imaging studies, however, were only suggestive and not diagnostic of the tissue diagnosis and failed to differentiate benign from neoplastic lesions.

25. SURGICAL MANAGEMENT OF SYMPTOMATIC BENIGN PINEAL CYSTS

Jeffrey H. Wisoff, MD, Fred Epstein, MD (New York, NY)

The authors present a series of 6 patients with large symptomatic benign pineal cysts that were surgically resected. 27 patients previously reported in the literature are reviewed to establish patterns of presentation and appropriate treatment. 80% of all of the patients diagnosed antemortem were in the high resolution CT/MRI era. Patients with symptomatic pineal cysts most often present with one of three syndromes: 1) paroxysmal headache with gaze paresis, 2) chronic headache, gaze paresis, papilledema and hydrocephalus, and 3) pineal apoplexy with acute hydrocephalus.

In the authors' series, 4 patients presented with paroxysmal headache and 2 patients with chronic headache, gaze paresis and hydrocephalus. All children had the diagnosis established by MRI. Four patients had prior CT scans interpreted as normal. There was complete resolution of symptoms following radical resection (4 total removals, 2 95% removals) in all patients. There was no morbidity or mortality.

Surgical intervention with radical cyst removal is the treatment of choice for all symptomatic pineal cysts. Complete cyst removal is desirable however radical subtotal resection is appropriate if the cyst cannot be easily separated from the quadrigeminal plate. Ventricular shunting should be reserved for patients with persistent hydrocephalus after cyst resection.

26. INTERVENTIONAL NEURORADIOLOGY IN THE MANAGEMENT OF ARTERIOVENOUS MALFORMATIONS IN CHILDREN

Marion L. Walker, MD (Salt Lake City, UT)

Interventional neuroradiological techniques are being used with increasing frequency in the management of arteriovenous malformations (AVM). This treatment modality combined with microsurgical techniques is especially useful in pediatric patients. We present our experience with 12 patients over a 15 month period from April 1990 to July 1991. Of the 12 patients presenting with AVM's during this period, one had radiosurgical treatment, one had embolization only, one has refused treatment, three had surgical excision only and six patients had a combined approach with selective embolization and microsurgical excision. Location of the AVM's were: Hemispheric — 9; Posterior Fossa — 2; Thalamic — 1. Six patients presented with hemorrhage, two had seizures, three had headaches and one patient was discovered to have an AVM during a routine fetal ultrasound examination. The average age at presentation was 11.3 years. Two patients have persistent visual defects and eight patients remain neurologically intact. One patient has a persistent severe hemiparesis after presenting in deep coma with fixed pupils and decerebration.

Reasons to consider interventional neuroradiology in the management of pediatric AVM's include:

1. The feeding arteries are less tortuous in children.
2. Embolization stages the procedure.
3. Embolization allows time for neurological assessment of the surgical risks.
4. Embolization gives a window of opportunity to select the best elective time for surgery.
5. There is less blood loss.

27. THE ROLE OF CELL LINEAGE IN FORMING STRIATAL COMPARTMENTS

Andrea Halliday, MD, Connie Cepko, PhD (Boston, MA)

The organization of the mammalian striatum into two neurochemically distinct compartments, the patches and matrix, may help to explain how the striatum accomplishes diverse functions. To understand the role of cell lineage in forming the striatal compartments, two recombinant retroviruses, containing two distinct marker genes, were used to infect rat striatal progenitor cells in vivo. Progeny cells (clones) were then followed histochemically as the infected progenitor passed the marker gene onto all of its progeny. Analysis of clones from two to six days after infection (accomplished by intraventricular injection of the viruses into embryonic rats through the uterine wall of the mother) demonstrated that clones exhibit two types of migration patterns, radial and tangential, a finding which suggests that patches and matrix have separate progenitors.

This hypothesis is being tested in the rat by analyzing the location of clonally related cells in relationship to the patch/matrix compartments found in the adult. To determine which of the marked cells came from the same progenitor in the adult rat, where clonal relationships are more difficult to determine because of wide migration, an innoculum containing a "library" of 100 viruses, each with its own unique genetic tag is being used. Marked cells are then removed from the striatum of adult rats after mapping their location in a 3d computer. The DNA from the cells is amplified using the polymerase chain reaction to determine which of the hundred different genetic tags it contains. One can then ask if cells from the same progenitor are restricted to one compartment and whether or not the different migration patterns seen in the embryonic rat striatum plays a role in distributing cells to the different compartments.

29. LONG-TERM COMPLICATIONS OF LUMBOPERITONEAL SHUNTING IN THE PAEDIATRIC POPULATION

P.D. Chumas, A. Kulkarni, J.M. Drake, D. Armstrong (Toronto, Ontario)

Lumboperitoneal shunts are considered by many as the treatment of choice for communicating hydrocephalus. However, there are few long-term follow-ups—especially of the paediatric population. A retrospective study of 95 children (62 males, 33 females) who underwent LP shunting (1974-1984) was therefore carried out.

Age at first surgery ranged from 18 days to 16.5 years (mean 2.2) and the follow-up from 15 days to 16.4 years (mean 6.6 years). The underlying aetiology was:35 idiopathic communicating hydrocephalus; 22 intracranial haemorrhage; l4 post-traumatic; 5 post-meningitis; 4 neoplasm; 2 spina bifida and 12 other.

There were 2 non-shunt related deaths. Shunt malfunction was experienced by 62/95 (65%) of the patients and in total, there were 127 surgical reinterventions: 7l obstructions; 17 over-drainage; 12 insufficient drainage; 11 shunt infections (in 9 patients); 11 shunt migration; 8 disconnections/fractures and 9 other malfunctions.

Other complications consisted of : scoliosis (12/95); back pain/sciatica (11/95); foot deformity/weakness (5/95); neurogenic bladder (3/95) and acquired Chiari "malformation" (2/95). In fact, CT review of 15 patients in which the foramen magnum was suitably visualised revealed 10 (61%) apparently asymptomatic acquired Chiari "malformations". The previously reported "absent cistern sign" on CT was confirmed as a reliable indicator of LP shunt function.

The rate of complications is far higher than in most recent series but probably reflects a longer follow-up period and a purely paediatric population. The rate of incidental acquired Chiari "malformation" is disturbing as we recently experienced a fatality as a consequence of this development.

30. ACQUIRED CHIARI MALFORMATIONS FOLLOWING LUMBOPERITONEAL SHUNTING: INCIDENCE, DIAGNOSIS AND MANAGEMENT

Troy Payner, MD, Thomas S. Berger, MD, Kerry R. Crone, MD (Cincinnati, OH)

The occurrence of acquired cerebellar tonsil descent radiographically indistinguishable from Chiari I malformations has been previously reported. The relationship between lumbar shunting procedures and symptomatic chiari malformations has been established.

We have studied nine patients with lumboperitoneal shunts in whom previous radiographic studies have confirmed a normal hindbrain configuration. Six of the nine patients had acquired tonsillar descent into the foramen magnum by MRI scanning. Three of six patients were symptomatic with the remaining three discovered by routine scanning. Treatment of the three symptomatic patients included removal of the lumboperitoneal shunt and conversion to a ventriculoperitoneal shunt in two patients, and posterior fossa decompression in the third patient. In the two patients who underwent conversion to a ventriculo-peritoneal shunt, repeat MRI has demonstrated ascent of the cerebellar tonsils. All patients are asymptomatic at present.

We conclude that ventriculoperitoneal shunting should be undertaken in patient with communicating hydrocephalus to avoid this potential problem. In patients who undergo lumboperitoneal shunting, periodic surveillance of the cervicomedullary junction is advised. Finally, if symptomatic, a trial conversion to ventriculoperitoneal shunting may be successful treatment and avoids posterior fossa decompression.

31. PHOSPHOLIPID METABOLISM IN A NEONATAL MODEL OF HYDROCEPHALUS

Marcia D. da Silva, MD, James M. Drake, MD (Toronto, Ontario)

The effect of hydrocephalus on the maturation processes of the developing brain is yet not fully understood. Phosphomonoesters and phosphodiesters compounds have been demonstrated to be precursors and breakdown products of membrane phospholipids. The phospholipid metabolism of an experimental model of neonatal hydrocephalus was studied using in vivo 31 phosphorus nuclear magnetic resonance spectroscopy (31P MRS).

Hydrocephalus was produced in 1-week-old kittens by cisternal injection of 0.05 ml of a solution of kaolin 25%; litter mates were used as control subjects. T-test was employed to determine whether there were significant changes that could be ascribed to the hydrocephalus.

At 1 and 3 weeks following the kaolin injection, a significant change of the ratio between phosphomonoesters/phosphodiesters was demonstrated in the hydrocephalic animals compared to controls.

We conclude that, in this neonatal model, hydrocephalus significantly affects normal phospholipid metabolism induced by brain maturation.

32. DEATH RELATED TO HYDROCEPHALIC SHUNTED PATIENTS

Young Chung, Stephen J. Haines (Minneapolis, MN)

Modern shunts have significantly decreased the mortality and morbidity from hydrocephalus. Death related to shunted hydrocephalus, however, has not been eliminated. In order to identify those factors that are associated with the death of patients shunted for hydrocephalus, we did a retrospective analysis of those patients admitted to our institution with a ventriculo-peritoneal (VPS) or ventriculoatrial (VAS) shunt in the past 15 years.

During the period, January 1, 1975 to December 31, 1989, 927 shunted patients had 2063 admissions to this institution (2.2 admissions/patient). Of these 927 patients, 31 died while hospitalized. Ten of these deaths were related to their shunt: 6 from malfunction, 2 from infection, and 2 from a combination of causes. Six of the patients had an autopsy. In the 2 patients that died from a shunt infection, the shunt had been placed during that admission. In the 6 patients that died from malfunction the average time from placement of the shunt was 205 days. All of these patients had symptoms $>$6 hours, half of these patients had been evaluated by a neurosurgeon or neurologist within 2 weeks of their admission. We have examined a number of factors including the etiology of the hydrocephalus, number of shunt revisions, admitting diagnosis and service, problems in diagnosis and treatment.

With careful attention to the symptoms present at admission and an aggressive attitude toward early shunt evaluation and revision, shunt related deaths should be preventable.

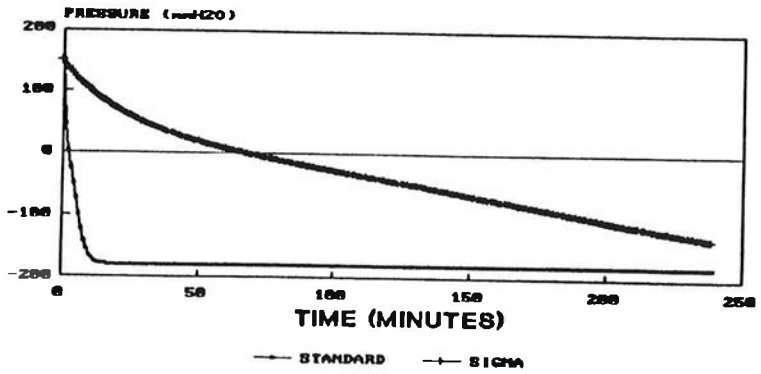
33. COMPUTER MODELLING OF CSF SHUNT SIPHONING

James M. Drake, MD (Toronto, Ontario)

A number of models of hydrocephalus of varying levels of complexity have been developed to simulate the hydrocephalic state. None has specifically addressed the problem of large negative intracranial pressures in shunted hydrocephalic patients as a result of CSF shunt siphoning. We report the development of computer model to simulate siphoning. This allows the modeling of the effects of various shunt valve designs, and the investigation of the effects of new valve design formulations. Many models of hydrocephalus have been based on Marmorou's nonlinear simulation of CSF pressure and volume using the pressure volume index or PVI where $PVI = \Delta V/\log(P_p/P_0)$. However, one cannot simulate negative ICP using this model. A new nonlinear one compartment model was developed to simulate siphoning. This model produces identical pressure volume relationships for positive pressures as the PVI index, but allows for negative pressures.

The Simulation and Control Program or SCoP, developed at the National Biomedical Simulation Resource, Duke University Medical Center, Durham, North Carolina, was used to implement the model on an IBM PC. Both the exact solution and simulation of the PVI model were performed to verify the accuracy of the simulation. Using the new formulation for siphoning, the effects of various hydrostatic gradients and valve designs were investigated. Below the results comparing the effects of a low pressure slit valve to the Orbis Sigma valve on the ICP when a simulated hydrocephalic infant is moved into the vertical position and experiences a 25 cm H_20 hydrostatic gradient.

COMPUTER SIMULATION OF SIPHONING STANDARD SHUNT VS SIGMA -25CM H_2O



34. GRAVITATIONAL SHUNT: A NOVEL APPROACH TO CEREBROSPINAL FLUID SHUNTING

John H. Sampson, MD, Erico R. Cardoso, MSc, MD
(Durham, NC)

Current models of cerebrospinal fluid (CSF) shunts rely on complex mechanical devices to control CSF drainage. The authors describe a simplified alternative approach to CSF shunting. The gravitational shunt (GS) relies on the differential hydrostatic pressures generated by the lengths of the proximal and distal shunt catheters to open or close a simple gravitational anti-siphon valve (GASV). Thus, the intracranial pressure (ICP) will be determined by the vertical position of the GASV along the cranio-abdominal axis, and not the mechanical properties of complex valve designs. The GS has the advantages of simultaneous control of ICP and prevention of siphoning while using a simple shunt design.

GASV prototypes use an opening along the side of conventional shunt tubing which is covered by a mobile diaphragm. Similarly sized inlet and outlet surface areas allow equal hydrostatic effectiveness of the CSF in the proximal and distal catheters. The position of the diaphragm is controlled by the pressure gradient between the GASV lumen and the subcutaneous tissue. With inward deflection, the diaphragm rests upon a transverse partition lying across the middle of the opening which closes the GASV. When the GS is in a horizontal position, the GASV remains open and has no directional features.

Six GASV prototypes were bench tested with pulsatile infusions of saline and high protein CSF. A linear relationship was established between ICP and the difference between the proximal and distal catheter vertical heights ($p<0.001$) ($r=0.9l$) ($n=1269$). Changes in infusion rate, infusion type, or total shunt length had no significant effect. The results showed satisfactory long-term performance of the GASV and GS for pressure regulation and anti-siphoning.

The GS compares favorably with conventional shunt systems because of its simplicity and physiologic self-adjustment of ICP during childhood. As a child grows, the hydrostatic effect of CSF within the distal catheter increases and allows the GS to create a simultaneous physiologic increase in ICP.

35. OUTCOME STUDY OF NEONATAL POSTHEMORRHAGIC HYDROCEPHALUS TREATED WITH EARLY VENTRICULOPERITONEAL SHUNTING: SURGICAL AND NEURODEVELOPMENTAL FINDINGS

Kenneth W. Reichert, MD, Glenn A. Meyer, MD, Ruth Heimler, MD (Milwaukee, WI)

Sixteen infants were treated for neonatal posthemorrhagic hydrocephalus with early ventriculoperitoneal shunting from 1973-1983. One patient was lost to follow-up at age 2. One child died from complications of his ventriculo-peritoneal shunt. Two children died during their neonatal admission from complications unrelated to the ventriculoperitoneal shunt. One child died at 23 months from pulmonary infection and sepsis unrelated to the CNS. The mean age at shunt placement was 28.25 days with an average of 5.6 revisions done per shunt placed. Complications were infection (2.8%), respiratory depression requiring prolonged ventilation (3.7%), and hemorrhage (0.9%) Neurodevelopmental outcome was evaluated at a mean age of 13.5 years. Four of the eleven survivors had normal intelligence, four had borderline mental retardation, two had mild retardation, and one had severe mental retardation. Six children have esotropia. Six children have other associated anomalies. Three children have visual impairment with one child being blind. Two children have no evidence of cerebral palsy, two children have mild cerebral palsy, four children have moderate cerebral palsy and three children have severe cerebral palsy. The worst outcomes were in children of birth weight less than 1,000 grams, low social economic status, and degree of prematurity.

36. AGGRESSIVE SURGICAL MANAGEMENT OF PROGRESSIVE HYDROCEPHALUS IN PRE-TERM INFANTS WITH INTRACRANIAL HEMORRHAGE DOES NOT ALTER OUTCOMES

Michael L. Levy, MD, J. Gordon McComb, MD, Lena Masri, MS (Los Angeles, CA)

A retrospective review of 76 pre-term infants with Grade III or IV intracranial hemorrhage and surgically treated progressive hydrocephalus was undertaken to determine the outcome as to mortality, intellectual impairment, and motor deficit. The variables examined were degree of prematurity, birth weight, sex, Apgar scores, extent of intracranial hemorrhage, seizures, age at the time of initial placement of a ventricular catheter reservoir to control hydrocephalus, the need to convert the reservoir to a ventriculo-peritoneal shunt, the timing of the conversion of the reservoir to a shunt, and the number of shunt revisions.

Outcome was assessed for statistical significance using hierarchical linear regression multivarient analysis. Mortality was best predicted, in order of importance, by extent of the intracranial hemorrhage, number of shunt revisions, birthweight, and Apgar score at five minutes ($P<0.001$, $R^2=.68$). The Apgar scores were significant for inclusion but did not alter the predictive value of the model. Extent of intracranial hemorrhage, birthweight, and seizure activity in order of significance were the strongest predictors of motor function at follow-up ($P<0.001$, $R^2=.78$). Extent of intracranial hemorrhage alone was the strongest predictor of cognitive development ($P<0.0001$, $R^2=.79$).

In conclusion, the overwhelming factor in determining the outcome in this patient group was the extent of the intracranial hemorrhage. Hydrocephalus and its treatment was not of significance.

37. VENOUS SINUS OCCLUSION AND VENTRICULOMEGALY IN CRANIECTOMIZED RABBITS

Nesher G. Asner, MD, William C. Olivero, MD (Peoria, IL)

Most attempts at production of hydrocephalus in experimental animals by obstructing the venous sinuses have failed. In adult humans, venous sinus occlusion usually results in the clinical syndrome of pseudotumor cerebri with small or normal sized ventricles. However, in children less than 18 months with venous sinus hypertension, ventriculomegaly has been reported. We examined the change in ventricular size in craniectomized animals (simulating children with open sutures) with occlusion of the superior sagittal sinus. New Zealand rabbits weighing 1500 to 1800 grams were anesthetized with an intramuscular injection of 2 ml of 7:3 Ketamine (100mg/ml): Rompun (20mg/ml) solution. The scalp was shaved, prepped with Betadine, and infiltrated with 1% lidocaine and a midline scalp incision was made. The periosteum was reflected laterally and a craniectomy performed with microscopic magnification. The dura was exposed overlying both cerebral hemispheres and the superior sagittal sinus from its origin to the torcula. In five control animals, the scalp was then closed. In ten experimental animals, small incisions were made in the dura just lateral to the superior sagittal sinus with a #11 scalpel and then with microscopic magnification the sinus was coagulated with the bipolar cautery and transected; the scalp was then closed. All animals were allowed to recover 5 to 7 days, then ultrasound was used to assess ventricular size. We observed a small but statistically significant increase in ventricular size in the experimental group compared to the control group. This model provides evidence that venous sinus occlusion in animals with expandable crania can produce ventriculomegaly.

38. DECREASE IN VENTRICULAR SIZE PRODUCED BY A VENOUS TOURNIQUET AROUND THE NECK

Harold L. Rekate, MD, W. Bruce Cherny, MD (Phoenix, AZ)

Three patients who normally had slit-like ventricles presented with symptoms and signs of shunt malfunction (headache, changes in mental status, Parinaud's syndrome, or ventriculomegaly on CT). Shunt series were normal and all had low intracranial pressures (ICP) at shunt tap. All patients underwent shunt revision. During surgery the shunt systems were functioning normally, so the valves were replaced.

Postoperatively, the ventricles remained enlarged and the patients remained symptomatic. Pressures obtained by repeat shunt tap (two cases) and contralateral ventriculostomy (one case) showed extremely low ICP. Two shunt systems contained siphon-control devices. One patient had a ventriculoatrial shunt that siphons less than a ventriculoperitoneal shunt.

All patients had their neck loosely wrapped with an ace bandage to impede venous drainage. The patients' symptoms resolved completely, and follow-up CT scans showed that the ventricles had returned to subnormal size. Ventriculomegaly recurred in one patient when the neck was unwrapped. The ace bandage was reapplied and the siphon-retarding device was removed with complete resolution of the symptoms.

The ability of the brain to resist distention has been termed Kb, or brain resilience. The present study illustrates the importance of Kb in the regulation of ventricular volume. These patients may have had low brain resilience due to softened viscoelastic properties. The use of a venous tourniquet on the neck stiffened the brain and normalized intracranial dynamics, ventricular volume, and the response of the brain to siphoning.

39. FACTORIAL ANALYSIS OF SHUNT INFECTION IN NEONATAL SPINA BIFIDA PATIENTS

F.A. Boop, MD, W.M. Chadduck, MD, Anthony Russell, MD
(Little Rock, AR)

Because of the belief that a leaking myelomeningocele predisposes to cerebrospinal fluid contamination, traditional neurosurgical doctrine has been to repair the myelomeningocele at birth and to delay shunt placement. We have shown it unnecessary to delay shunting. This study reviews variables contributing to shunt infection (demographics, presurgical management, intraoperative factors, and postoperative complications) in 40 neonates with dysraphism. Of these, 63% were term, 46% were born by cesarean section and mean defect size was 23.5 cm^2.

Defects included three occipital encephaloceles and 37 myelomeningoceles (1 thoracic, 16 thoracolumbar, 2 lumbar, and 18 lumbosacral). Mean interval from birth to repair was 16.9 hours. Seventeen were leaking at birth. Preoperative white blood cell counts (WBC) were 1.7-34.1 (mean 18.5). All but one patient received antibiotic prophylaxis. Surgical time averaged 1.88 hours with no significant increase in procedural time by simultaneous shunting. Twenty-six patients had simultaneous myelomeningocele repair and ventriculo-peritoneal shunting.

There were no mortalities. Five patients (3 shunted simultaneously) developed shunt infections. Two gram negative infections were recognized early and 3 gram positive infections 6, 7, and 12 weeks later. Preoperative WBC's averaged 19,700 in uninfected infants versus 9,500 in infected ($p<0.05$). All patients with shunt infections had preoperative WBC's$<$12,000; four of five were pre-term ($p<0.03$). Simultaneous ventriculo-peritoneal shunting and myelomeningocele repair by itself does not increase the risk of shunt infection. Prematurity and preoperative WBC's$<$12,000 are associated with increased risk of perinatal shunt infection.

40. DO ANTIBIOTICS PREVENT SHUNT INFECTIONS? A META ANALYSIS

Stephen J. Haines, MD (Minneapolis, MN)

Ten controlled studies of antibiotic prophylaxis for shunt operation have been performed. All suffer from some flaws, usually inadequate sample size. Only two have claimed to show a significant protective effect of antibiotic prophylaxis. Nonetheless, many of the smaller studies appear to show a statistically insignificant trend favoring antibiotic use and the use of prophylactic antibiotics for shunt operations is widespread among neurosurgeons.

When the results of the 9 technically satisfactory studies are combined using meta analysis there is a statistically significant reduction in infection rate in those patients receiving antibiotic prophylaxis. The effect of predictors such as the year of publication of the study, the antibiotic used, the age of the patients, the duration of antibiotic administration were not significant. Analysis of the effect of the control infection rate, however, shows that all of the significance in the combined studies is restricted to those with a baseline infection rate exceeding 15%. In those patients, infection risk was significantly reduced to 36% of baseline while in the series with control infection rates $<$15%, the combined reduction to 88% of the control rate was not significant.

It is concluded that prophylactic antibiotics are less effective in preventing shunt infection than infection following clean neurosurgical operations and that they are most effective when the baseline infection rate exceeds 15%. Their use by surgeons with a lower baseline infection rate is not likely to significantly reduce the incidence of infection.

41. THE RELATIONSHIP OF ETHYLENE OXIDE TO STERILE SHUNT MALFUNCTION

Thomas Pittman, MD, Alan Knutsen, MD, Mobeen Rathore, MD (St. Louis, MO)

Failure of an intact ventriculoperitoneal shunt, in the absence of overt infection, is often due to its occlusion by cellular debris and/or an abdominal pseudocyst. Traditionally these problems have been thought to have been caused by either an infection by a fastidious organism or some poorly defined allergic response to the shunt materials. Little attention has been directed to the treatment that the shunts receive prior to implantation: specifically, their exposure to ethylene oxide as a means of sterilization.

We have found ethylene oxide breakdown products in the spinal fluid of several children with shunts, months, and occasionally years, after the systems were implanted. Many of these patients had coincident CSF eosinophilia. In addition, two children with abdominal pseudocysts had serum IgE antibody to an albumin ethylene oxide conjugated protein. No antibodies were present in lab controls, in patients with working shunts, or in patients with malfunctioning shunts which were overtly infected. Another child with a pseudocyst had no demonstrable antibody to the altered albumin; her spinal fluid grew staph epidermitis after several days in culture. Consequently, we suggest that in some patients proteins altered by ethylene oxide and/or its by-products incite an IgE mediated response which leads to shunt malfunction.

42. VP SHUNT REJECTION SECONDARY TO IMPLANTED FOREIGN MATERIAL

James T. Goodrich, MD, PhD, Robert Keating, MD (Bronx, NY)

Two children, ages 4 years and 9 years, developed severe sterile rejections to the silicone material used in ventriculo-peritoneal shunts. Both of these children initially presented with fever, erythema, and high white blood cell counts suggesting an infectious reaction. The CSF fluid remained sterile in both cases. In both children the rejection was so severe, shunt material extruded through the skin. The younger child became sensitized to several different approved biologically implantable materials, even absorbable suture material (e.g., vicryl) could not be used. In the first child, a custom VP shunt system was designed, coated with a surface of polyurethane; to date this system has not been rejected. In the second child, a polyurethane material was first used; this was rejected. A polyvinyl-chloride coated system was designed and this was also rejected. A system was then designed using teflon as the coating material. While silicone is normally one of the best implantable materials, occasionally systemic rejection can occur. In this paper we will present two examples and a discussion of the management of such rejections.

43. THE NEUROSURGEON'S ROLE IN THE QUALITY CONTROL OF SHUNT PRODUCTS

D. Bruce Ramsey, MD, William M. Chadduck, MD, Anthony E. Russell, MD, Frederick A. Boop, MD, Paul Steinbok, MB (Little Rock, AR/Vancouver, BC)

Federal regulation of implanted devices and research efforts by manufactures have led to reasonably safe shunting products for neurosurgery. The relative nonreactivity of silastic revolutionized ventriculo-peritoneal shunts; many modifications in design and materials are now available. Neurosurgeons have an obligation to assess performance of these shunts by recording unusual patterns of failure. A significant problem with one shunt system has been frequent and premature fracturing of tubing. Of 114 patients having new ventriculo-peritoneal shunts implanted between March 1986 and February 1989, 15 had broken shunts from 20-62 months (average 34.8) after placement, an incidence of 13.2%. There were no infections in the 15 patients subsequent to initial placement and none were infected at the time of revision. All systems broke at points between the valve and the clavicle despite the absence of connectors at break points. In all cases coiling of the peritoneal tubing within the abdomen indicated fixation reactions, again, unassociated with infections or pseudocysts. Peri-tubal tissue histopathology in three cases showed fibrotic reactions with lymphocytic cellular responses. Two additional patients showed bowstringing of shunts also indicating abnormal tissue reaction to the tubing. Experimental data from a canine model show the same responses. The shunts were made of platinum-cured silastic, impregnated with barium. We propose that the bi-metallic junction potential creates a battery effect when in contact with an electrolyte solution (CSF), causing the excessive tissue reaction. Our results and those included from another institution indicate shunts containing platinum and barium together should not be used, and that clinical and laboratory assessments should continue.

44. BROVIAC VENTRICULOSTOMY FOR LONG-TERM EXTERNAL VENTRICULAR DRAINAGE

M.J. Chaparro, M.B. Pritz and K.S. Yonemura (Orange, CA)

Long-term external ventricular drainage in children presents major problems: maintenance of a patent system and preservation of sterility. To address these difficulties, we have combined the advantages of subcutaneous tunneling with the use of a Broviac catheter whose dacron cuff presents a formidable barrier to secondary external infection.

Detailed information is available for 17 patients who underwent 19 procedures. The mean age at device placement was 11.4 months. Indications for Broviac ventriculostomy placement were: postsurgical CSF leak (1 case) and shunt infection (16 patients). External drainage was maintained for an average of 19 days with a range of 6 to 47 days. Thirteen of the 16 children with shunt infections eventually underwent placement of a shunt. However, two of these children developed a second, unrelated shunt infection that was successfully treated with a second Broviac ventriculostomy. Three children died. Two of these deaths were unrelated to shunt infection. Complications included: ventricular catheter revision (4 children) and secondary CSF infection (1 case). The infection rate was one in 361 patient-days or 2.77 per 1000 patient-catheter-days. This figure compares favorably with ventriculostomy infection rates of 9% at 10 days and infection attack rates of Broviac catheters of 1.2 to 7.5 per 1000 patient-catheter-days.

The advantages of the Broviac ventriculostomy are two-fold. First, it is highly resistant to infection. Second, it is difficult to dislodge. These attributes make the Broviac ventriculostomy a superior alternative to currently used techniques for long-term external ventricular drainage.

45. THE ADVENTITIA OF THE MAJOR CRANIAL BLOOD VESSELS DOES NOT PROVIDE A PATHWAY FOR LYMPHATIC DRAINAGE OF CSF

J.G. McComb, S.H. Song, S. Hyman, D. Chan, F.E. Gilles (Los Angeles, CA)

Drainage of cerebrospinal fluid (CSF) into the lymphatics from the optic nerves and olfactory fila has been identified. Another potential site for CSF egress is via the adventitia of the major blood vessels at the cranial base.

Artificial CSF containing radio-iodinated serum albumin (RISA) and indigo carmine as markers for bulk flow were infused into the ventricles of either monkeys or rabbits for four hours. The middle cerebral and basilar arteries were examined intracranially and the carotid and vertebral arteries and internal jugular vein extracranially for the presence of the tracers. Another group of rabbits was infused in a similar fashion with artificial CSF containing ferritin or colloidal gold. The transition area where these blood vessels cross the dura mater was studied with electron microscopy.

Both physiologic and morphologic investigations found no evidence of bulk CSF drainage into the lymphatics via the adventitia of these major cranial blood vessels.

46. MORPHOMETRIC ANALYSES OF THE EFFECTIVENESS OF DECOMPRESSION IN EXPERIMENTAL INFANTILE HYDROCEPHALUS

James P. McAllister II, PhD, Leslie M. Sharpe, BS, Pamela M. Hale, BS, Raymond A. Morano, Deven V. Shroff, BS, and Richard M. Kriebel, PhD (Philadelphia, PA)

As a sequel to our previous descriptive analyses, the present study has quantified the effects of ventriculomegaly and subsequent surgical decompression on the immature cerebral cortex. After kaolin induction of ventriculomegaly in 10 day old kittens, two groups of hydrocephalic animals received "early" (n=4) or "late" (n=7) VP shunts at 7-8 or 12-15 days post-kaolin, respectively. A series of 10 hydrocephalic animals were sacrificed to correspond to both preshunt and terminally ill periods, and normal age-matched animals served as controls. Tissue from primary visual (area 17) and parietal association (area 22) cortices was processed for light and electron microscopy, and evaluated using computer-assisted morphometry. Cortical thickness, which was decreased 70-80% in severe hydrocephalics without decompression, returned to near or above control values after early and late shunt placement. Likewise, the size of neuronal somata returned to normal compared to 27-38% decreases in severe hydrocephalus. Compression was evident during hydrocephalus by an increase in the density of neurons. After late shunting, this density remained below control values, especially in superficial cortical layers, and may be indicative of residual neuron loss. Preliminary ultrastructural analyses revealed that interstitial edema, axonal and dendritic swelling, and synaptic loss occurred prior to both early and late shunt placement, but that decompression was effective in returning the number of synapses to normal. Compared to our previous studies in which appreciable residual deficits occurred in cortical neurotransmitters, these positive results indicate that considerable improvements in morphology can be obtained by decompression. Thus, the mechanisms responsible for any persistent neurological impairment in hydrocephalus may be operating at more sophisticated cellular or molecular levels.

47. OPEN NEURAL TUBE DEFECT MODEL INDUCED BY EXOGENOUS LECTIN IN CHICK EMBRYOS

T. Inagaki, K. Wang, R. Higbee, D.G. McLone and P.A. Knepper (Chicago, IL)

The process of neurulation in vertebrates can be interrupted by a variety of experimental methods. To test whether an exogenous lectin (Concanavalia ensiformis, Con A) may bind to mannose/glucose containing glycoconjugates of neuroepithelium during the process of neurulation and induce neural tube defects (NTD), chick eggs were incubated for 48 hours (Hamilton and Hamburger stage 11 to 14), a small window (7/10 mm size) was made in the egg shell, and the embryos were staged according to the number of somites. Embryos were treated with Con A (500 ng in a volume of 10 ul, dissolved in Dulbecco's phosphate-buffered saline), or with saline, and the air space was filled with saline and the windows were sealed with vinyl tape. The embryos were re-incubated, examined on incubation day 4 or 5 by darkfield illumination, catalogued according to the type of NTD, and processed for light microscopy. The results were: Sixty-four of 105 Con A treated embryos (61%) were alive, 8 of 64 had NTDs (12.5%), and the type of NTD was:One exencephaly, 2 NTDs around the cranio-cervical junction, and 5 NTDs around the thoracolumbar region. These results indicate that an exogenous lectin interferes with the process of neurulation, and that mannose/glucose containing glycoconjugates may be one of the cellular components for the process of normal neurulation.

48. HYDROMELIA DECOMPRESSION WITH VP SHUNT REVISION IN PATIENTS WITH CHIARI II MALFORMATIONS

Jose Espinosa, MD, Jean-Pierre Farmer, MD, and Jose L. Montes, MD (Montreal, Quebec)

Five children with the myelomeningocele-hydrocephalus-Chiari II complex in whom a diagnosis of hydromyelia was made by MRI are presented. There were 2 girls and 3 boys aged 18 months to 10 years. Two patients were asymptomatic whereas three patients showed symptoms felt to be related to hydromyelia or hydrobulbia. No patients showed symptoms or signs suggestive of VP shunt malfunction. Four of the five patients had evidence of enlarged fourth ventricle on their spine MRI. The fifth patient did not. All patients underwent CT scan evaluation preoperatively which demonstrated, in four of the five patients, an enlarged ventricular system compared to previous examinations. The fifth patient had an unchanged ventricular size. The four patients with CT demonstration of shunt malfunction underwent revisions. The three symptomatic patients rapidly improved and follow-up MRI demonstrated resolution of the hydromyelic cavity. The asymptomatic patient with shunt malfunction had MRI proven improvement in her hydromyelia. The fifth patient in whom the CT scan was unchanged underwent syringo-pleural shunting. However, at the time of shunt lengthening several days following the initial syringo-pleural shunt, the VP shunt was noted to be leaking from a disconnection of the ventricular catheter and valve.

In conclusion, patients with the myelomeningocelehydrocephalus-Chiari II complex who have shunt malfunctions may not show classical symptoms or signs of VP shunt malfunction if the pressure is dissipated down a hydromyelic cavity. In these patients, verification of the VP shunt function should be done prior to decompression of the hydromyelia. This should be done with CT scan or even, as is shown with the patient showing a stable CT scan, a nuclear shuntogram.

49. THE TETHERED SPINAL CORD:ASPECTS OF RETETHERING, SHUNT FUNCTION, AND NEUROLOGIC OUTCOME

Lyn Carey Wright, MD, Marion L. Walker, MD, and Lynn D. Falkner, PA-C (Salt Lake City, UT)

Progressive neurologic deterioration has often been accepted as a natural history of the myelomeningocele defect. More recently it has been noted that with proper closure of the myelomeningocele defect and the available untethering techniques many of these neurologic deficits can be prevented or alleviated. We have looked at all children who have been untethered at our institution between 1986 and 1991 inclusively. Seventy-six children were looked at retrospectively. Thirty-eight of these were children with myelomeningocele defects. Nine had lipomyelomeningocele, 18 had thickened filums, 9 had diastematomyelia and 2 were untethered for orthopedic prophylaxis. The major presenting symptoms in the myelomeningocele group were bladder dysfunction, a decrease in lower extremity function, and pain. Two young adults demonstrated upper extremity symptoms which were alleviated with an untethering procedure. The overall outcome was very good in all groups. In the myelomeningocele group 14 were improved, 21 were unchanged, and only 3 were worsened. These worsening symptoms were bladder related. The most common age for symptom presentation in the myelomeningocele group was between the ages of three and seven years. Shunt function in the myelomeningocele group for six months following an untethering procedure was also documented. There was a 15% incidence of shunt malfunction following surgery for cord untethering. In conclusion, much of the deterioration seen in the children with myelomeningocele defects can be prevented, alleviated, or arrested when untethered procedures are performed in a timely fashion. Children with other disease entities associated with tethering should be treated prophylactically, if possible.

50. RETETHERING AFTER MYELOMENINGOCELE REPAIR:REVIEW OF THIRTY CONSECUTIVE CASES

Steven J. Schneider, MD, Alan D. Rosenthal, MD (New Hyde Park, NY)

Retethering of the spinal cord after prior myelomeningocele repair can lead to late neurologic deterioration. Thirty consecutive cases of symptomatic retether requiring surgery were reviewed. The incidence in the authors' series of 110 myelomeningocele repairs was 20% (21 cases). The average age of presentation was 10 years, ranging from 7 to 16 years. The average duration of symptoms was 6 months, ranging from 6 weeks to 5 years. Deterioration in gait was the most common presenting symptom in 23 patients (76%). Pain in 20 patients (67%), progressive scoliotic deformity in 3 patients (10%), and sphincteric loss in 2 patients (7%) were also seen on neurologic examination. Motor loss was documented in 28 of 30 patients (93%) and sensory loss in 14 of 30 (46%). MRI was performed in 26 cases and revealed dorsal displacement of the cord and attachment of the site of prior repair. Associated syrinx in 6 patients, lipoma in 5 patients, and diastometamyelia in 2 patients were also reported. All patients underwent tethered cord release and treatment of any associated abnormality. The results based upon an average follow-up of four years demonstrated pain relief and stabilization of scoliosis in all cases with these symptoms. Neurologic function and gait improved in 40% and stabilized in 60%. Several patients experienced transient neurologic decline during the perioperative period, however, there was complete resolution within one month's time. Neurologic and gait improvement correlated directly with a shorter duration of symptoms and preoperative neurologic function. Our research would support aggressive intervention at the early onset of symptoms which may prevent irreversible loss of neurologic function. Spinal MRI should be employed routinely as a guideline to establishing a firm diagnosis of tethered spinal cord with its associated abnormalities. All radiographic findings must be carefully weighed as operative intervention is planned.

51. THE EFFECT OF SURGICAL REPAIR ON URODYNAMIC STUDIES IN INFANTS WITH LIPOMENINGOCELE

Sumeer Sathi, MD, Joseph Madsen, MD, R. Michael Scott, MD, Anthony Atala, MD, Stuart Bauer, MD (Boston, MA)

We studied 18 patients, 12 months or younger (average age 3 months), who underwent surgical resection of lipomeningocele from 1978 to 1990. Preoperative and postoperative urodynamic studies (UDS) and neurologic exams were done in every patient. Neurologic exams were performed by a neurologist at the time of the UDS without knowledge of the neurosurgeon's exam or radiographic studies.

Eight patients had an abnormal neurologic exam. Abnormal preoperative UDS, consisting of detrusor sphincter dyssynergy (DSD) and detrusor hyperreflexia, were seen in 6 of the 18 patients. Two of the 6 patients with abnormal UDS had a normal neurologic exam. Postoperatively, 5 of 6 with an abnormal UDS normalized or improved. Three of 8 with an abnormal neurologic exam improved and the rest remained stable. Two of 12 with normal preoperative UDS developed abnormalities postoperatively. Review of the operative notes showed that no single operative finding or maneuver predicted a good or bad result. In only one case, although the surgeon felt that it was impossible to untether the cord completely, the patient's UDS improved after surgery during which the spinal lipoma was extensively debulked by laser.

Early surgery for lipomeningocele may cause improvement or normalize abnormal preoperative UDS in these patients.

52. ANTERIOR SACRAL MENINGOCELE—ISSUES IN MANAGEMENT

M. Boland, R. Dauser, J. Venes, M. Dipietro, J. Brunberg, K. Muraszko (Ann Arbor, MI)

Anterior sacral meningoceles (ASM) is a rare malformation, most likely occurring as a variant of the caudal regression syndrome. It has an autosomal-dominant variable penetrance and thereby can produce familial groups who express various sacral anomalies. We present two such families in which 5 of the children were affected. Four of these children had anterior sacral meningoceles, all had tethered cords and 4 had terminal myelocystoceles. All children initially underwent posterior surgical approaches with untethering of their spinal cords and repair of the anterior sacral meningocele. One child had a tumor mass associated with the ASM and required an anterior approach for resection of this lesion which was adherent to the rectum and proved to be a benign teratoma.

Neurologic improvement occurred in 4 patients and one patient remained with a stable neurologic deficit. All of these children presented with symptoms consistent with tethered cord. MRI scans and intraoperative ultrasonography proved important in the evaluation of these children.

The use of pre- and postoperative imaging studies; efficacy of intraoperative ultrasonography; and the use of posterior and anterior surgical approaches will be discussed.

53. THE TIGHT FILUM TERMINALE SYNDROME

Gregory B. Nazar, MD, FRCS(C), Gregory Roberts, BS, David Petruska, MD, R. Dean Linden, PhD, Gregory Niznik, MSc (Louisville, KY)

The tethered cord syndrome (TCS) is a well defined clinical entity characterized by a varying array of neurological, urological and/or orthopaedic signs and symptoms. In the present study, a highly select profile of nine patients with spina bifida occulta presented with severe, incapacitating, mechanical lower back and/or non-radicular leg pain. The pain, sharp and lancinating in nature, was accentuated by activities involving flexion-extension of the lumbosacral spine. In addition, six patients had urological dysfunction presenting as either diurnal incontinence and/or urinary frequency and urgency.

Urodynamic testing revealed a neurogenic bladder in those with urological dysfunction, while imaging studies (CT/myelography, MRI, bone scan), blood chemistry (including ESR) and electrophysiological monitoring (pudendal and tibial SSEP, H-reflex) failed to demonstrate any evidence of abnormality. In all ten patients the conus medullaris lay at spinal level L-1 with a filum terminale appearing normal in structure and thickness (<2mm). A diagnosis of TCS was suggested based on their clinical profile and the exclusion of other causes of low back pain in children. The mechanism involved was proposed secondary to a tight filum terminale producing intermittent mechanical traction on the conus medullaris. In all patients surgical division of a normal appearing filum terminale through a L-5 laminotomy was performed. Postoperatively all nine patients experienced complete pain relief, while those with urological dysfunction became asymptomatic. The clinical course of this unique patient population is reviewed.

54. TETHERED CORD SYNDROME WITH A CONUS OF NORMAL POSITION

W. Jerry Oakes, MD, Daryl E. Warder, MD (Durham, NC)

We have reviewed our series of 75 patients diagnosed with tethered cord syndrome. Fourteen in this series had a conus of normal position (at or above the L1-2 disc space). Of this group, thirteen underwent surgery for tethered cord syndrome. Of the 61 patients with an abnormally low positioned conus, 56 underwent surgery for tethered cord syndrome. These two groups of patients, with a normally and abnormally positioned conus were compared. The analysis included assessment of cutaneous stigmata of occult spinal dysraphism, vertebral anomalies, filum terminale diameter, presence of fat within the filum, neurologic abnormalities at the time of presentation, neurologic status at follow-up, and extremity abnormalities.

Of the thirteen patients with a normally positioned conus who underwent surgery, ten presented with neurologic abnormalities. Of the three patients with a normally positioned conus, a normal neurologic examination and having undergone surgery, each additionally presented with one of the following:vertebral anomalies and extremity length discrepancy, cutaneous stigmata and spinal dysraphism, or cutaneous stigmata and fat within the filum. In the group of thirteen patients with a normally positioned conus and having undergone surgery, 92% were neurologically improved or unchanged at follow-up. In the group of 56 with an abnormally low positioned conus and having undergone surgery, 82% were neurologically improved or unchanged at follow-up.

In patients with normal position of the conus but with other associated anomalies, (skin changes, vertebral anomalies, etc.) consideration of release of the filum terminale should be given.

55. ACCIDENTAL HEAD TRAUMA DOES NOT CAUSE RETINAL HEMORRHAGE

Dennis L. Johnson, MD, David Friendly, MD, Joyce Wong, BS (Washington, DC)

The head-injured child who has retinal hemorrhage and intracranial hemorrhage has been abused. The mechanism of head injury in abused children is seldom witnessed or known and often concealed behind closed doors. All too often there are no outward physical signs of trauma, and medical caregivers may fail to recognize abuse and return the child to a potentially lethal environment. Moreover, the mechanism of injury may be falsified by the perpetrator to avoid prosecution. Prosecution is in turn hampered by inadequate studies of causation. Nonetheless the force required to cause both intracranial hemorrhage and retinal hemorrhage leaves little question as to malicious intent. The purpose of this study was to establish whether retinal hemorrhage can occur after significant accidental trauma.

From October, 1990, to June, 1991, 45,588 children were seen in the emergency room at Children's National Medical Center (CNMC). There were 350 children admitted because of head injury. **Significant head trauma was defined as skull fracture and/or parenchymal injury.** Of the 143 patients who satisfied entry criteria, 6 children with gunshot wounds to the head and 17 abused children were excluded from the study. The median age was 4.5 years with a range from 3.5 months to 19 years 9 months. Fifty-two children were less than 2 years of age. Of the eligible 120 children, 97 were evaluated by an ophthalmologist for retinal hemorrhage. No retinal hemorrhages were found.

Retinal hemorrhage does not occur after accidental head trauma.

56. LATE MRI AFTER CLOSED HEAD INJURY IN CHILDREN: RELATIONSHIP TO CLINICAL FEATURES AND OUTCOME

Derek A. Bruce, MD, MB, ChB, Harvey S. Levin, PhD, and Dianne Mendelsohn, MD (Dallas, TX)

To characterize the neuroanatomic distribution of persisting cerebral abnormalities after closed head injury (CHI), we performed magnetic resonance imaging (MRI) on 55 children and adolescents selected from consecutive admissions for moderate/severe injury to the pediatric trauma service. Mean age was 7.9 years at injury and 9.5 years at the time of MRI. T1-weighted midsagittal and paired spin density, T-2 and T-1 weighted coronal images were obtained after an average postinjury interval of 2.7 years (minimum interval=3 months). Cerebral lesions (including areas of gliosis and encephalomalacia) were present in 39 children (71% of series), including 12 (22%) with lesions confined to the frontal lobes, 10 patients (18%) with predominantly frontal lesions, and 6 cases (11%) with extrafrontal lesions which encroached on the frontal lobes. Taken together, 51% of the sample had frontal lobe lesions. Eleven children (20% of series) had localized extrafrontal lesions and 16 cases (29%) had diffuse injury. Frontal lesions were situated primarily in three sites, including the orbital/rectal gyri, the inferior/middle/superior gyri, and the white matter. Analysis of clinical features revealed that speech/language defects were more common in children with frontal lesions than the diffuse group. The Glasgow Outcome Scale (modified for children) disclosed that patients with frontal lesions were more frequently disabled than children whose MRI was consistent with diffuse injury. Our findings implicate the vulnerability of the frontal lobes to persistent lesions after moderate/severe CHI and underscore the potential importance of elucidating the neurobehavioral correlates.

57. PERINATAL AND NEONATAL HEAD INJURIES

Yoon S. Hahn, MD, David G. McLone, MD, PhD (Maywood, IL)

There has been a drastic decrease in the occurrence of head injuries in the peri- and neonatal period because of the improved obstetrical management. However, a significant number of neonates are inflicted by serious injuries. Perinatal and neonatal trauma to the brain is so broadly defined that the term is rather confusing. Part of this reason is that any adverse effects on the fetus during labor or delivery, such as hypoxic-ischemic brain injury, are included.

The purpose of this presentation is to scrutinize head injuries in neonates (under one month of age), primarily by mechanical factors.

During the nine year study period from 1982 to 1990, there were 1215 children (0-16 years) with head injuries admitted at Children's Memorial Hospital and Loyola University Medical Center in Chicago. There were 55 neonates (4.5%) who received head injuries during labor or delivery or within 30 days after birth. Two newborns were injured in-utero because of maternal MVA and required cranial surgery.

Initial analysis showed the following observation:

1. The most common mechanism of injury, by far, was fall (63.6%); 11 (20.0%) were related to labor and/or delivery; 7 by mid-forceps, 2 by birth canal injury, 1 by fetal manipulation and 1 by vacuum extraction.
2. Twenty-five (45.5%) neonates were either lethargic or irritable; 9 (16.4%) developed seizures, 2 focal and 7 generalized.
3. Cephalhematoma was the most common extracranial concern:16 (70%) showed significant anemia; 6 neonates required cranial surgery because of associated epidural hematoma.
4. There were 41 neonates (74.5%) with skull fractures, 7 epidural (12.7%), 3 subdural hematoma (5.5%).
5. Three neonates received severe head injury, 2 died (3.6%); 47 children received minor head injury, and 5 received moderate head injury, all achieved a good outcome.

The detailed data, as well as the follow-up, will be substantiated. Head injury in the perinatal and neonatal period is a serious problem. A multicenter study is recommended.

58. HIPPOCAMPAL DAMAGE IN FATAL HEAD INJURY IN CHILDREN

Mark J. Kotapka, MD, David I. Graham, MB, PhD, FRCPath**, J. Hume Adams, MD, PhD, FRCPath**, and Thomas A. Gennarelli, MD (Philadelphia, PA)

The hippocampus is known to be frequently involved in head injury. In adults, such hippocampal lesions frequently include regions of selective neuronal necrosis. The present report examines the frequency and distribution of hippocampal damage in 37 cases of fatal head injury in children.

Damage to the hippocampus was noted in 27 of 37 cases (73%). Lesions were typically focal areas of selective neuronal necrosis located in the CA-1 subfield. Other subfields of the hippocampus were also involved to lesser degrees. The frequency and distribution of hippocampal damage in fatal head injury in children is similar to that reported in fatal head injuries of all ages.

Pathologic evidence of high intracranial pressure and/or hypoxic damage in other anatomic locations was present in the majority of cases. Clinical seizures occurred in 23% of the cases studied. However, these factors could not account for all cases of hippocampal damage in the present report.

Thus, the hippocampus is frequently damaged in fatal head injury in children. The mechanisms involved in such damage may involve hypoxia, raised intracranial pressure and altered cerebral perfusion. However, other yet to be elucidated mechanisms, may be involved.

KEY WORDS: Hippocampus-head injury-selective vulnerability

59. PERINATAL SPINAL CORD INJURY: CLINICAL, RADIOGRAPHIC AND PATHOLOGIC FEATURES

Eugene Rossitch, Jr., MD, W. Jerry Oakes, MD (Durham, NC)

Perinatal spinal cord injury is a relatively uncommon, but a frequently misdiagnosed disorder. Often, the injury is not suspected and an erroneous diagnosis is made. We present five cases of perinatal spinal cord injury. In four, the referring physicians (including pediatric neurologists) misdiagnosed the condition. In view of these diagnostic difficulties, we review the clinical, radiographic and pathologic aspects of these injuries.

All five pregnancies were term, two were complicated by preeclampsia and decreased fetal movements, respectively. Three were cephalic presentations (2 requiring forceps); two were breech. The level of injury was upper cervical (3), lower cervical (1) and low thoracic (1). The mechanisms of injury were:distraction (2), rotation (2), and in-utero hyperextension (1). The most common physical findings were:respiratory insufficiency, hypotonia and quadriplegia (upper cervical lesions); diaphragmatic breathing, lower extremity hypotonia and hyperreflexia (lower cervical lesion); and flaccid paraplegia (lower thoracic lesion). It was particularly difficult to distinguish complex evoked motor responses which were not cortically mediated and represented spinal reflex from true cortically mediated spontaneous muscle activity. The period of spinal shock with flaccid extremities was brief if present at all.

Plain x-rays were abnormal in one patient (atlanto-occipital dislocation). This is the only patient who arrived with the correct diagnosis. The remaining patients had ligamentous injury with proper static alignment of the spine. These four patients were misdiagnosed as having Werdnig-Hoffman (2), occult myelodysplasia (1), and birth asphyxia (1). Myelograms were done in three cases and were nondiagnostic.

In the upper cervical lesion group, two deaths occurred at age 4.5 months and 2 years. Autopsies confirmed the diagnosis. The remaining child is ventilator dependent at age 2. The child with the thoracic lesion is age 10 and walking with crutches. The child with the low cervical lesion was sent home at 2 months of age.

59. PERINATAL SPINAL CORD INJURY: CLINICAL, RADIOGRAPHIC AND PATHOLOGIC FEATURES (continued)

Serious spinal injuries occasionally occur in the perinatal period. With improving medical care, many infants with less severe injuries are surviving the neonatal period. Therefore, the prompt recognition of neonatal spinal cord damage is essential and allows for optimal treatment of the injured child.

60. PEDIATRIC SPINAL CORD CONCUSSION: REDEFINING THE ENTITY AND THERAPEUTIC RAMIFICATIONS

Seth M. Zeidman, MD, Thomas B. Ducker, MD, Paul Sponsellar, MD, and Benjamin Carson, MD (Baltimore, MD)

Concussion is defined as a transient depression of function secondary to traumatic injury without evidence of damage. Spinal cord concussion represents a rare but real entity with implications for clinical management. We define the syndrome of spinal cord concussion by the following criteria:occurrence of a neurological deficit consistent with the involved spinal cord level with complete neurological recovery within 24 hours and without evidence of spinal cord contusion on CT or MRI scan. In reviewing over 500 cases of pediatric trauma over the period 1980-1991 we have identified three patients who fulfill these criteria and warrant the diagnosis of spinal cord concussion.

Previous studies have failed to adequately assess the state of the spinal cord. Evidence excluding cord injury has been indirect, relying on resolution of clinical symptomatology to delineate contusion from concussion. MRI and CT scanning allow direct evaluation of the cord and excludes cord contusion.

All three patients presented with a transient quadriparesis secondary to traumatic injury to the cervical spine. In each case the patient was evaluated with a CT (1 patient) or an MRI (2 patients) scan which revealed no evidence of traumatic injury to the spinal cord. No increased signal or other signs of contusion were noted in this group of patients. All patients had complete resolution of their symptoms within 24 hours.

The development of effective therapies including high dose methylprednisolone and ganglioside revolutionizes management of spinal cord injury. By carefully defining the criteria for spinal cord concussion we allow more precise prognostication and direction of appropriate therapy.

61. PEDIATRIC SPINAL INJURY: 60 DEATHS

Mark Hamilton, MD, CM, S. Terence Myles, MD (Calgary, Alberta)

Spinal injury (SI) occurs infrequently in the pediatric population and information concerning the role of SI in traumatic death of children is lacking. We present a review examining pediatric (17 years or younger) spinal injury and traumatic death, over a 13 year period. The records of the Provincial Medical Examiner and the local neurosurgical institutions were reviewed.

We identified 60 pediatric deaths. An additional 156 children were admitted to hospital with SI during this time period. There were 366 adult deaths and 2971 adult hospital admissions. The mortality of children with SI appears to be much higher than the adult mortality:27.8% of children with SI died compared with 11% of adults (ratio 2.5:1). The average age was 11.5 years. MVA accounted for 29 (48.3%), pedestrian MVA for 20 (33.3%) and MBA for 6 (10%) of the deaths. Alcohol was involved in 22 (36.7%) of the accidents and only 1 of the 29 MVA victims was using proper car seat restraint.

Complete autopsy was performed in 30 children (50%). In the group of children without autopsy, the cervical region was involved in 29 (96.7%) and all 30 (100%) died at the accident scene. In the group of children with autopsy performed, the cervical region was involved in 23 (76.7%) and 24 (80%) died at the accident scene. SI was determined to be the primary cause of death in only 8 of the 30 (26.7%) autopsied children. The causes of death in the remaining 22 children included massive hemorrhage (45.5%), severe head injury (31.8%) and severe multiple trauma (22.7%). Only 3 of these 30 deaths could have potentially been prevented by changes in management61.PEDIATRIC SPINAL INJURY:60 DEATHS (continued)strategy. Further, given that 54 of the 60 children (90%) were dead at the accident scene, it would appear that efforts to reduce mortality in this group of children would best be directed towards injury prevention.

62. SPINAL CORD INJURY WITHOUT RADIOGRAPHIC ABNORMALITY IN CHILDREN WITH OTHERWISE ASYMPTOMATIC TYPE I CHIARI MALFORMATION

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Spinal cord injury is a common cause of morbidity and mortality across all ages in North America. Though the pediatric population tends to yield less than one-tenth of all spinal cord injuries, the injuries tend to be of greater consequence, result from less violent, often seemingly trivial events, and present without radiographic abnormality. Congenital cerebellar ectopia without associated anomaly is occasionally discovered only after traumatic events, though for any manifestation to appear before the second decade is quite uncommon. A young boy who had recently fallen from his porch was transferred to the Neurosurgery service with a high cervical central cord syndrome; careful study demonstrated no radiographic abnormality, and, though previously quite well, magnetic resonance imaging revealed Type I Chiari malformation. Though expectedly uncommon, reports of three other similar cases support a less than independent relationship between these two processes. All four children were premorbidly asymptomatic and in their third year of life. All were playing when they fell from low elevations, and, indeed, two were playing on a couch. All were evaluated by primary authorities twelve to forty-eight hours before their definitive admission, and all had normal plain film examinations. Three of the four suffered injuries in flexion, the fourth in extension. Three realized a five minute to three hour delay before the onset of symptoms, and three realized gradual progression of deficit. Magnetic resonance imaging was the most commonly applied and productive diagnostic medium demonstrating cerebellar ectopia in three of three cases. Moreover, anatomic and pathologic details demonstrated by the studies corresponded to distinct high cervical neurologic deficit patterns. Two children were treated operatively and all realized at least a functional outcome. Similarities among these cases support a common mechanism of injury. As well, these cases support careful counselling of such children discovered to have otherwise asymptomatic Type I Chiari malformation.

63. SELECTIVE FUNCTIONAL POSTERIOR RHIZOTOMY FOR TREATMENT OF SPASTIC CEREBRAL PALSY: A STUDY OF 50 CONSECUTIVE CASES

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50 consecutive children are described with spastic cerebral palsy treated with selective bilateral functional posterior rhizotomies of the L2 to S1 or S2 roots from February 1987 to June 1990. All patients were followed for at least six months. The age at surgery ranged from 2.2 years to 18.1 years. 28 children were diplegic, 21 quadriplegic and 1 triplegic.

In all patients, spasticity improved dramatically in the lower limbs immediately after surgery. In 39 patients improvements were noted at levels of the central nervous system above the lumbar segments. All 17 children who could walk preoperatively could walk following rhizotomies, and in 15 gait was improved. 18 children who could not walk prior to surgery were able to walk with a walker postoperatively. Complications included transient urinary dysfunction in four children, and an intraoperative spinal subdural hematoma in one patient.

The operative procedure evolved with time: the technique of replacement laminotomy was refined; the electrophysiologic basis for selection of nerve rootlets changed; there has been a trend toward preservation of large part of the nerve roots involved with quadricep function, and toward sectioning a smaller percentage of each nerve root.

The data suggest that selective functional posterior rhizotomies may be useful in the management of selected children with spastic cerebral palsy. However, the most appropriate electrical criteria, and the value of functional selection based on intraoperative responses to nerve rootlet stimulation, have not been adequately established.

64. USE OF THE PUDENDAL NEUROGRAM TO PROTECT BLADDER FUNCTION IN CHILDREN UNDERGOING RHIZOTOMY

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Many centers performing sensory rhizotomies to treat leg spasticity have chosen to include the S2 roots in their testing. In 1989 we decided to do this because of clinically significant residual spasticity in the gastrocnemius muscles seen in 31% of our patients at their six month postoperative examination. By including the S2 roots in the operative testing, we have decreased the incidence of significant postoperative spasticity in the gastrocnemius muscles to 5%. Unfortunately, in doing this we saw a rise in transient postoperative urologic dysfunction from 8% to 25%. Because of this rise, we developed the pudendal neurogram, a technique which maps afferent pudendal nerve activity within the sacral roots. The dorsal penle or clitoral nerve is stimulated transcutaneously while individual sacral roots are monitored for afferent action potentials. Those roots which have significant afferent potentials are preserved during the subsequent lesioning. Using this technique, we have seen a decrease in postoperative urologic dysfunction back to 8%. This technique will be described. Its use with selective dorsal rhizotomy greatly lessens the risk of postoperative urologic dysfunction while allowing more aggressive lesioning.

65. A COMPARISON OF EMG RECORDINGS IN SPASTIC CHILDREN AND NORMAL MONKEYS DURING SELECTIVE POSTERIOR RHIZOTOMY SURGERY

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MATERIALS AND METHODS: Lower limb EMGs were recorded following stimulation of 1666 rootlets in 25 children and 1184 rootlets in 37 monkeys. Routine elicitation, recording and interpretation criteria were used (Phillips, 1989).

RESULTS: In both species, EMG threshold increased in a caudal to rostral direction, with thresholds being lower for total root stimulation versus rootlet stimulation. In the humans there was no significant relationship between severity of EMG and degree of spasticity. Thirty-four percent of the humans and 0.6% of the monkeys demonstrated EMG activity in the limb contralateral to the side of stimulation. However, a significantly greater percentage of monkeys demonstrated a sustained response to tetanic stimulation than humans. EMG monkey data versus results obtained when the legs were held during rootlet stimulation were more specific and sensitive to muscle contraction, with the type of EMG response being independent of intensity level.

66. IMPROVEMENT IN UPPER EXTREMITY FUNCTION AND TRUNK CONTROL AFTER SELECTIVE POSTERIOR RHIZOTOMY

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Selective posterior rhizotomy for the treatment of spasticity associated with cerebral palsy has become a widely used procedure. Anecdotal reports of improved upper extremity function and trunk control have been noted in the literature. However, a systematic analysis of this, to our knowledge, has not been performed. Presented, are 14 patients who underwent selective posterior rhizotomy at Santa Rosa Children's Hospital. Patients were videotaped prior to surgery and one year postoperatively. These videos were reviewed "blind" by an occupational therapist and the patients were graded systematically for preoperative and postoperative performance in three categories:assumption of side-sitting, maintenance of side-sitting and block building. Statistically significant improvements were noted in all three categories with p values of .0003, .0001, and .0044 respectively. This study supports the anecdotal reports of improvement in upper extremity function and trunk control with selective posterior rhizotomy.

67. OSTEOPLASTIC LAMINOTOMY: PREFERRED TECHNIQUE FOR SPINAL CANAL EXPOSURE IN CHILDREN

Eric Mirsky, Rick Abbott, MD, Fred J. Epstein, MD (New York, NY)

Multiple level osteoplastic laminotomy has received interest as an alternative to laminectomy for complete exposure of the spinal canal. This procedure has been performed in over 200 patients. The majority are children who have undergone selective dorsal rhizotomy, and others include both pediatric and adult patients with spinal cord tumors. Laminotomy has been accomplished in all cases without added intraoperative time, and without increased operative morbidity or mortality compared with multilevel laminectomy. There is evidence of partial to complete reossification bridging the laminar cuts at each lamina level in all 32 patients with spine x-rays available one year postoperatively. The procedure has been especially well received in the pediatric population, where it is known that deformity and instability of the spine are common complications of laminectomy. In theory, reapproximation of the posterior elements of the spinal column in a laminotomy allows for reattachment of the soft tissue structures in this region, and enables the surgeon to preserve the normal architecture of the developing spine. Of 32 patients, only six (<20%) showed evidence of scoliosis at one year follow-up, with a mean value of 15 degrees and a range of 6-36 degrees. Furthermore, of 10 patients with both one year and three year postoperative x-rays available, none showed progressive deformity. It is proposed that multiple level osteoplastic laminotomy provides a viable alternative to laminectomy for complete exposure of the spinal canal in the pediatric population.

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