

**Joint Section on Pediatrics
of
The American Association of
Neurological Surgeons
and the
Congress of
Neurological Surgeons
and
Washington University
School of Medicine**

23rd Annual Meeting

**St. Louis, Missouri
December 6-9, 1994**

**The American Association of
Neurological Surgeons
and the
Congress of
Neurological Surgeons
and
Washington University
School of Medicine**

**Joint Section on Pediatrics
23rd Annual Meeting**

**Adam's Mark Hotel
St. Louis, Missouri
December 6–9, 1994**

This program is sponsored by The American Association of Neurological Surgeons, the Congress of Neurological Surgeons, the Office of Continuing Medical Education and the Department of Neurological Surgery, Washington University School of Medicine.

Washington University is accredited by the Accreditation Council for Continuing Medical Education to sponsor Continuing Medical Education for physicians.

Washington University designates this continuing medical education activity for a maximum of 20 credit hours (with attendance of breakfast seminars) in Category 1 of the Physician's Recognition Award of the American Medical Association.

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Paolo Raimondi Lecturers

1978	E. Bruce Hendrick	1987	Dale Johnson
1979	Paul C. Bucy	1988	Joseph J. Volpe
1980	Floyd Gilles	1989	Martin Eichelberger
1981	Panel Discussion	1990	George R. Leopold
1982	Panel Discussion	1991	Judah Folkman
1983	Derek Harwood-Nash	1992	Olof Flodmark
1984	Anthony E. Gallo, Jr.	1993	Maurice Albin
1985	Frank Nulsen	1994	Blaise F.D. Bourgeois
1986	William F. Meacham		

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 Seat-Lap 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
1991	P. David Adelson: Reorganization of the Cortical-Tectal Pathway Following Neonatal Cerebral Hemispherectomy in Cats
1992	David Frim: Effects of Biologically Delivered Neurotrophins in Animal Models of Neural Degeneration
1993	Monica C. Wehby: Metabolic Demonstration of Retained CNS Function in the Rabbit Model of Infantile Hydrocephalus

Hydrocephalus Foundation Award Recipients

- 1989 Eric Altschuler: Management of Persistent Ventriculomegaly Due to Altered Brain Compliance
- 1990 S.D. Michowiz: High Energy Phosphate Metabolism in Neonatal Hydrocephalus
- 1991 Neshor G. Asner: Venous Sinus Occlusion and Ventriculomegaly in Craniectomized Rabbits
- 1992 Marcia DaSilva: Reversal of High Energy Phosphate Metabolism Changes in Experimental Hydrocephalus After CSF Shunting
- 1993 Charles Bondurant: The Epidemiology of Cerebrospinal Fluid Shunting

Pediatric Section Chairmen

- | | | | |
|---------|--------------------|---------------|-------------------|
| 1972-73 | Robert L. McLaurin | 1979-81 | Fred J. Epstein |
| 1973-74 | M. Peter Sayers | 1981-83 | Joan L. Venes |
| 1974-75 | Frank Anderson | 1983-85 | Harold J. Hoffman |
| 1975-76 | Kenneth Shulman | 1985-87 | William R. Cheek |
| 1976-77 | E. Bruce Hendrick | 1987-89 | David G. McLone |
| 1977-78 | Frank Nulsen | 1989-91 | Donald H. Reigel |
| 1978-79 | Luis Schut | 1991-93 | R. Michael Scott |
| | 1993-95 | Arthur Marlin | |

Annual Winter Meeting Sites

- | | | | |
|------|----------------|------|--------------------------|
| 1972 | Cincinnati | 1985 | Houston |
| 1973 | Columbus | 1986 | Pittsburgh |
| 1974 | Los Angeles | 1987 | Chicago |
| 1975 | Philadelphia | 1988 | Scottsdale |
| 1976 | Toronto | 1989 | Washington, DC |
| 1977 | Cleveland | 1990 | San Diego & Pebble Beach |
| 1978 | Philadelphia | 1991 | Boston |
| 1979 | New York | 1992 | Vancouver, BC |
| 1980 | New York | 1993 | San Antonio, TX |
| 1981 | Dallas | 1994 | St. Louis, MO |
| 1982 | San Francisco | 1995 | Pasadena, CA |
| 1983 | Toronto | | |
| 1984 | Salt Lake City | | |

Acknowledgments

The Joint Section on Pediatric Neurological Surgery of The American Association of Neurological Surgeons and the Congress of Neurological Surgeons gratefully recognizes the support of the following exhibitors for the 1994 Pediatric Annual Meeting.

<p>Acra-Cut, Inc. 989 Main Street Acton, MA 01720 (508) 263-2210</p>	<p>Booth 13</p>	<p>Elekta Instruments, Inc. 8 Executive Park West, Suite 809 Atlanta, GA 30329 (404) 315-1225</p>	<p>Booth 6</p>
<p>American Silk Sutures, Inc. 82 Sanderson Avenue Lynn, MA 01902 (617) 592-7200</p>	<p>Booth 20</p>	<p>HEYER-SCHULTE NeuroCare L.P. 8400 Lakeview Parkway, Suite 600 P.O. Box 390 Pleasant Prairie, WI 53158-0390 (414) 947-4900</p>	<p>Booth 29</p>
<p>Bremer Medical, Inc. 4801 Dawin Road Jacksonville, FL 32207 (904) 730-8559</p>	<p>Booth 16</p>	<p>Hydrocephalus Association 870 Market Street, Suite 955 San Francisco, CA 94102 (415) 776-4713</p>	<p>Booth 31</p>
<p>Camino Laboratories, Inc. 5955 Pacific Center Blvd. San Diego, CA 92121-4309 (619) 455-1115</p>	<p>Booth 23</p>	<p>InnerSpace, Inc. 1923 S.E. Main Street Irvine, CA 92714 (714) 250-2329</p>	<p>Booth 28</p>
<p>Carl Zeiss, Inc. One Zeiss Drive Thornwood, NY 10594 (914) 681-7792</p>	<p>Booth 21</p>	<p>KLS-Martin L.P. 11239-1 St. Johns Industrial Parkway Jacksonville, FL 32246 (800) 625-1557</p>	<p>Booth 17</p>
<p>Codman/Johnson & Johnson Professional, Inc. 41 Pacella Park Drive Randolph, MA 02368 (617) 986-3311</p>	<p>Booths 14 & 15</p>	<p>MedaSonics 47233 Fremont Blvd. Fremont, CA 94538 (510) 623-0626</p>	<p>Booth 25</p>
<p>Cook Incorporated 925 South Curry Pike P.O. Box 489 Bloomington, IN 47402 (812) 339-2235</p>	<p>Booth 22</p>	<p>Midas Rex Instruments 3000 Race Street Fort Worth, TX 76111-4116 (800) 433-7639</p>	<p>Booth 30</p>
<p>Cordis Corporation 14201 NW 60th Avenue Miami Lakes, FL 33014 (305) 824-2651</p>	<p>Booth 24</p>	<p>Moller Microsurgical 9 Industrial Park Waldwick, NJ 07463 (201) 251-9592</p>	<p>Booth 18</p>

National Hydrocephalus Research Fdn. 1670 Green Oak Circle Lawrenceville, GA 30243 (404) 995-7334	Booth 32	Radionics, Inc. 22 Terry Avenue Burlington, MA 01803 (617) 272-1233	Booth 27
National Medical Specialty, Inc. 203 Avenue B Youngwood, PA 15697 (800) 547-7463	Booth 26	TiMesh, Inc. 76 Spectrum Road Las Vegas, NV 89101 (702) 459-1100	Booth 10
Neuro Navigational Corporation 3180 Pullman Street Costa Mesa, CA 92626 (714) 557-9111	Booth 5	Walter Lorenz Surgical, Inc. 1520 Tradeport Drive Jacksonville, FL 32218-2480 (904) 741-4400	Booth 4
Phoenix Biomedical Corp. P.O. Box 80390 Valley Forge, PA 19484 (610) 539-9300	Booth 3	W.B. Saunders Company 701 Hemmingway Lane St. Charles, MO 63304 (314) 926-9505	Booth 9
PMT Corporation 1500 Park Road Chanhassen, MN 55317 (612) 470-0866	Booth 11	Wild Microscopes, Div. of Leica, Inc. 24 Link Drive Rockleigh, NJ 07647 (800) 526-0355	Booths 1 & 2
PS Medical 125 Cremona Goleta, CA 93117 (805) 968-1546	Booths 7 & 8		

**Officers of the Joint Section on Pediatrics
of
The American Association of
Neurological Surgeons
and the
Congress of Neurological Surgeons**

Chairman:	Arthur Marlin
Secretary-Treasurer	John P. Laurent (1997)
Executive Council:	R. Michael Scott (immediate past chairman, 1993) Bruce B. Storrs (1995) A. Leland Albright (1996) Paul Steinbok (1995) Kenneth R. Winston (1996)
Membership Committee:	Walker Robinson, Chairman (1994) Jerry Oakes Richard Coulon, Jr.
Rules and Regulation:	Leslie Sutton, Chairman (1994)

Ad hoc Committees

Committee for Resident Travel Fellowship:	Ken Winston, Chairman William Bell Bruce Storrs Timothy Mapstone
Committee for Publication:	Richard Coulon, Jr., Chairman Leland Albright Andrew Parent John D. Ward William O. Bell Stephen J. Haines

Committee for CPT Codes: Peter Carmel, Co-Chairman
Joseph Piatt, Jr., Co-Chairman
Charles Duncan
Ann Flannery
Stephen Haines
Arnold Menezes
Andrew Parent
Jogi Pattisapu

Committee for Child Advocacy: Hector James, Chairman
Patricia Aronin
Bruce Storrs

Committee for Guidelines: Thomas Luerssen

**Program of the
Pediatric Section
23rd Annual Meeting**

TUESDAY, DECEMBER 6, 1994

4:30 PM—8:00 PM

Registration, Promenade Coatroom

6:30 PM—8:00 PM

Welcoming Reception, Rose Garden I

WEDNESDAY, DECEMBER 7, 1994

6:30 AM—5:00 PM

Registration, Promenade Coatroom

7:00 AM—8:15 AM

BREAKFAST SEMINARS

Current Management of Hydrocephalus I:

Marion L. Walker, MD

Room: Directors Row 41

Diagnosis and Management of Congenital Spinal Disorders I:

David G. McLone, MD, PhD

Room: Promenade E

Management of Spasticity I:

Bruce B. Storrs, MD

Room: Director's Row 43

Current Treatment Protocols for Pediatric Brain Tumors I: CCG:

R. Alexander Sanford, MD

Room: Promenade F

Epilepsy I:

Warwick J. Peacock, MD

Room: St. Louis H

Trauma I: Brain Injury:

Ann-Christine Duhaime, MD

Room: Director's Row 46

7:45 AM—8:30 AM

Continental Breakfast and Exhibits, Promenade D

8:30 AM—8:45 AM

Opening Remarks—Arthur E. Marlin, MD

Welcome—T.S. Park, MD and Ralph G. Dacey, Jr., MD
Promenade A,B,C

SCIENTIFIC SESSION I—Promenade A,B,C

Moderators: Michael R. Scott, MD/William O. Bell, MD

8:45 AM—9:00 AM

1. CSF Output Through EVD in Hydrocephalic Children
Takasumi Yasuda, MD, Tadanori Tomita, MD,
David G. McLone, MD, Keiji Kawamoto, MD,
Mark Donovan, Chicago, IL

9:00 AM—9:15 AM

2. Anatomical and Physiological Considerations of Third
Ventriculostomy
Charles Teo, MD, Kate Pihoker, MD, Sharon Ratcliffe, RN,
Frederick Boop, MD, Little Rock, AR

9:15 AM—9:30 AM

3. Neuroendoscopic Third Ventriculostomy instead of Shunt
Revision
Robert Jones, MD, M. Vonau, B. C. T. Kwok, W. A. Stening,
Sydney, Australia

9:30 AM—9:45 AM

4. Development of an MR Image Guided Ventriculoscope for
Complex Endoscopic Procedures
Patrick Rhoten, MD, Mark Luciano, MD, PhD,
Gene Barnett, MD, Cleveland, OH

*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.

9:45 AM–10:00 AM

5. CSF Accumulator and Diversionary Device
Gary Magram, MD, Wilmington, DE

10:00 AM–10:30 AM

COFFEE BREAK AND EXHIBITS, Promenade D

10:30 AM–10:45 AM

6. The Significance of 'Asymptomatic Shunt Contamination'
Paul Steinbok, MD, Doug Cochrane, MD, John Kestle, MD,
David Schiefele, MD, Vancouver, BC

10:45 AM–11:00 AM

- *7. Outcome and Cost Analysis in Pre-term Infants with Mas-
sive Grade IV Germinal Matrix Hemorrhage and Progres-
sive Hydrocephalus
Harold Pikus, MD, William Gans, BS, Ehud Mendel, MD,
Michael L. Levy, MD, J. Gordon McComb, MD,
Los Angeles, CA

SCIENTIFIC SESSION II—Promenade A,B,C

Moderators: J. Gordon McComb, MD/Paul M. Kanev, MD

11:00 AM–11:15 AM

- *8. Ventriculo-subgaleal Shunts: Definitive Treatment for Pro-
gressive Post-hemorrhagic Hydrocephalus
Salim Rahman, MD, Charles Teo, MD, Frederick Boop, MD,
Little Rock, AR

11:15 AM–11:30 AM

9. Management of Trapped/Isolated Fourth Ventricle
Jogi V. Pattisapu, MD, Kay Taylor, RN, BSN,
Revathi Narayanan, BE, Orlando, FL

11:30 AM–11:45 AM

10. Does Practice Make Perfect (in Treating Hydrocephalus)?
D. Douglas Cochrane, MD, John Kestle, MD,
Dewey Evans, MD, Paul Steinbok, MD, Vancouver, BC

11:45 AM—12:00 PM

- *11. The Rabbit Model for Infantile Hydrocephalus: Regional Differences in the Cortical Metabolic Response to Hydrocephalus and to Shunting
Monica C. Wehby-Grant, MD, Charles E. Olmstead, PhD,
Warwick J. Peacock, MD, David Hovda, PhD,
Robin S. Fisher, MD, Hai-Lang Duong, Los Angeles, CA

12:00 PM—12:15 PM

12. Effects of Progressive Hydrocephalus on Neurotransmitters and Gene Expression in an Animal Model of Aqueductal Stenosis
James P. McAllister, II, PhD, Robert W. Connelly, MS,
Hazel C. Jones, PhD, Neil G. Harris, PhD, Cleveland, OH

12:15 PM—12:30 PM

13. Lobar Hemorrhages (LH) in Full-term Neonates
William C. Hanigan, MD, PhD, Frank C. Powell,
Gerald Palagallo, MD, Tim C. Miller, MD, Peoria, IL

12:30 PM—1:30 PM

LUNCH AND EXHIBITS (ON OWN)

EXECUTIVE MEETING (LUNCH)—Director's Row 28

SCIENTIFIC SESSION III—Promenade A,B,C

Moderators: Yoon S. Hahn, MD/Dennis L. Johnson, MD

1:30 PM—1:45 PM

14. Pial Synangiosis for Moyamoya Syndrome in Children
P. David Adelson, MD, R. Michael Scott, MD, Boston, MA

1:45 PM—2:00 PM

15. Change in Level of Myelomeningocele Defect in the Past Twenty Years
Esther L. Wylen, MD, Edward J. Kosnik, MD,
R. W. O'Shaughnessy, MD, Columbus, OH

2:00 PM—2:15 PM

16. A Novel Approach to Understanding the Molecular Mechanisms of Spina Bifida
Timothy M. George, MD, Chandra S.K. Mayanil, PhD,
Michael Partington, MD, Paul A. Knepper, MD, PhD,
David G. McLone, MD, PhD, Chicago, IL

2:15 PM—2:30 PM

17. Agenesis of the Lumbosacral Spine: Clinical Features, Imaging Characteristics and Embryogenesis
Michael D. Partington, MD, Curtis L. Harlow, MD,
Carol M. Rumack, MD, Gary Thieme, MD, Denver, CO

2:30 PM—2:45 PM

18. Split Cord Malformations and Retained Endodermal Derivatives
Dachling Pang, MD, FRCS(C), Peter P. Sun, MD,
Sacramento, CA

2:45 PM—3:00 PM

19. Clinical Signs and Symptoms as Indicators for Retethered Spinal Cord in Congenital Spinal Dysraphism
Patricia A. Gelnar, MD, Jeffrey A. Winfield, MD, PhD,
Syracuse, NY

3:00 PM—3:15 PM

20. Clinically Significant Diastematomyelia with a Median Septum Associated with Myelomeningocele
W. Jerry Oakes, MD, Lewis W. Harris, MD, Birmingham, AL

3:15 PM—3:45 PM

COFFEE BREAK AND EXHIBITS—Promenade D

SCIENTIFIC SESSION IV—Promenade A,B,C

Moderators: John P. Laurent, MD/Bruce A. Kaufman, MD

3:45 PM—4:00 PM

21. Comprehensive Intraoperative Mapping and Monitoring of Sensory, Motor and Urogenital Functional Integrity During Surgery of Conus/Cauda
Nobu Morota, MD, Vedran Deletis, Rick Abbott, MD,
Fred J. Epstein, MD, New York, NY

4:00 PM—4:15 PM

- *22. Bad Outcome Following Tethered Cord Surgery
Fred J. Epstein, MD, Diana Leahu, MA, MS, IV,
Rick Abbott, MD, Jeffrey H. Wisoff, MD, New York, NY

4:15 PM—4:30 PM

23. Sleep Apnea in Patients with the Chiari II Malformation
Michael J. Chaparro, MD, Robert Cohn, MD, Tara Green,
RN, BSN, CCRN, Todd Greenberg, Dayton, OH

4:30 PM—4:45 PM

24. Hindbrain Hernia (Chiari I Malformation) Secondary to Partial Sacral Agenesis with Meningocele
Dean Karahalios, MD, Christos Tsonidas, MD,
Harold L. Rekate, MD, Phoenix, AZ

4:45 PM—5:00 PM

25. Progressive Deterioration in Brain Stem Function Following Decompression of Chiari II Malformation
Harold L. Rekate, MD, Patricia Teaford, MD,
Michael Kappy, MD, Phoenix, AZ

5:00 PM

BUSINESS MEETING—Promenade A,B,C

THURSDAY, DECEMBER 8, 1994

7:00 AM—8:00 AM

BREAKFAST SEMINAR

Special Breakfast Symposium: A Practice Management Seminar—Promenade A,B,C
Mr. Douglas Present, President, Douglas Present Associates, Inc., New York, NY

7:30 AM—5:30 PM

Registration, Promenade Coatroom

7:45 AM—8:30 AM

CONTINENTAL BREAKFAST AND EXHIBITS—
Promenade D

SCIENTIFIC SESSION V—Promenade A,B,C
Moderators: Paul Steinbok, MD/Joseph H. Piatt, MD

8:30 AM—8:45 AM

26. Chiari I Malformation and Headache: Who Should Undergo Operation?
Michael H. Handler, MD, Fred Epstein, MD,
Jeffrey Wisoff, MD, Rick Abbott, MD, Denver, CO

8:45 AM—9:00 AM

27. Posterior Fossa Decompression for Arnold Chiari Malformation and Achondroplasia Without Dural Opening
Kent D. Yundt, MD, T. S. Park, MD, Bruce A. Kaufman, MD,
St. Louis, MO

9:00 AM—9:15 AM

28. Encephaloceles of the Anterior Cranial Fossa: Management and Outcome
James T. Rutka, MD, PhD, FRCSC, Robert McFarlane, MD,
Robin P. Humphreys, MD, James M. Drake, MD,
Harold J. Hoffman, MD, Toronto, Ontario

9:15 AM—9:30 AM

29. Isolated Dandy-Walker Formation in Three Siblings: Further Support of Autosomal Recessive Inheritance
Alexa Canady, MD, C. E. Harper, D. J. Aughton,
D. E. Seubert, Detroit, MI

9:30 AM—9:45 AM

- *30. The Relationship Between Cerebellar Development and Function in Children with Dandy-Walker Malformations
Peter C. Gerszten, MD, A. Leland Albright, MD,
Pittsburgh, PA

9:45 AM—10:00 AM

31. Medically Intractable Epilepsy of Frontal Lobe Origin in Children
Antonio R. Prats, MD, Trevor Resnick, MD, Glenn Morrison,
MD, Raquel Pasaron, MSN, ARNP, Miami, FL

10:00 AM—10:30 AM

COFFEE BREAK AND EXHIBITS—Promenade D

SCIENTIFIC SESSION VI—Promenade A,B,C

Moderators: Thomas G. Luerrsens, MD/John D. Ward, MD

10:30 AM—11:00 AM

SPECIAL LECTURE—Susan E. Mackinnon, MD
“Brachial Plexus Surgery: Birth Brachial Plexus Injury”

11:00 AM—11:15 AM

32. Functional Hemispherectomy for Drug Resistant Seizures
John M. Whitley, MD, PhD, Joseph R. Smith, MD,
Pat D. Jenkins, PA-C, Y. D. Park, MD, Augusta, GA

11:15 AM—11:30 AM

- *33. Pathologically Proven Brain Tumors in Patient's with
Temporal Lobe Epilepsy and Subtle MRI Findings
Richard A. A. Day, MD, Lyn Carey, MD, Salt Lake City, UT

11:30 AM—11:45 AM

34. Functional Mapping and Electrocorticography during Tumor Resections
Paul M. Kanev, MD, Philadelphia, PA

11:45 AM–12:00 PM

35. Randomized Trial of Selective Dorsal Rhizotomy with Physio/Occupational Therapy vs. Therapy Alone for Children with Spastic Diplegia
James M. Drake, FRCSC, F. Virginia Wright, MSc,
Elizabeth M. H. Shiel, MASc, Stephen Naumann, PhD,
PEng, John H. Wedge, MD, Toronto, Ontario

12:00 PM–12:15 PM

36. What Does Selective Dorsal Rhizotomy Do for Upper Extremity Function in Spastic Diplegia?
Joseph H. Piatt, Jr., MD, Cathleen E. Buckon, OTR-L, MS,
Susan S. Thomas, MA, Michael D. Aiona, MD,
Portland, OR

12:15 PM–12:30 PM

37. Pre-rhizotomy Dorsiflexion as a Predictor of Independent Ambulation for Children with Spastic Cerebral Palsy
Michael R. Chicoine, MD, T. S. Park, MD,
Stephanie M. McClure, PT, Patricia E. Gaffney, PT,
Madeleine R. Ortman, RN, George P. Vogler, PhD,
Bruce A. Kaufman, MD, St. Louis, MO

12:30 PM–12:45 PM

38. Focal Neurologic Dysfunction Associated with Shunt Malfunction in Achondroplastic Dwarfs
Robert A. Sanford, MD, Karin Muraszko, MD,
Michael Fromke, MD, Memphis, TN

12:45 PM–1:00 PM

- *39. Achondroplasia with Cervicomedullary Compression: Evaluation and Surgical Treatment
Glenn L. Keiper, Jr., MD, Bernadette Koch, MD,
Kerry R. Crone, MD, Cincinnati, OH

FREE AFTERNOON

6:30 PM—7:30 PM

RECEPTION—Rose Garden

7:30 PM—Midnight

ANNUAL BANQUET—St. Louis Ballroom E,F,G,H

FRIDAY, DECEMBER 9, 1994

7:00 AM—8:15 AM

BREAKFAST SEMINARS

Current Management of Hydrocephalus II:

Marion L. Walker, MD

Room: Director's Row 41

Diagnosis and Management of Congenital Spinal Disorders II:

David G. McLone, MD, PhD

Room: Promenade E

Management of Spasticity II:

Bruce B. Storrs, MD

Room: Director's Row 43

Epilepsy II:

Warwick J. Peacock, MD

Room: Promenade F

Current Treatment Protocols for Pediatric Brain Tumors II: POG:

Jeffrey H. Wisoff, MD

Room: St. Louis A

Trauma II: Spinal Cord Brachial Plexus and Peripheral Nerve:

John P. Laurent, MD

Room: Director's Row 46

7:30 AM—5:30 PM

Registration, Promenade Coatroom

7:45 AM—8:30 AM

CONTINENTAL BREAKFAST AND EXHIBITS—
Promenade D

SCIENTIFIC SESSION VII—Promenade A,B,C

Moderators: Jerry W. Oakes, MD/Leslie N. Sutton, MD

8:30 AM—8:45 AM

40. Pediatric Lumbar Disc Surgery: Eighteen Patients under 15 Years of Age
John Shillito, Jr., MD, Boston, MA

8:45 AM—9:00 AM

41. Comparison of Syringo-pleural and Syringo-subarachnoid Shunting in the Treatment of Syringomyelia in Children
Jean-Pierre Farmer, MD, Olivier Vernet, MD,
José Luis Montes, MD, Montreal, Quebec

9:00 AM—9:15 AM

42. Pediatric Cervical Spine Screw Fixation
Douglas Brockmeyer, MD, Ronald Apfelbaum, MD,
Richard Tippets, MD, Marion Walker, MD, Lyn Carey, MD,
Salt Lake City, UT

9:15 AM—9:30 AM

43. Comparison of Operative Versus Non-operative Treatment of Functional Lambdoid Synostosis
Michael Levy, MD, J. Gordon McComb, MD,
Karin Wells, MD, William Gans, BS, Corey Raffel, MD, PhD,
Gerald Sloan, MD, Los Angeles, CA

9:30 AM—9:45 AM

44. Surgical Correction of Sagittal Craniosynostosis:
Complications of Pi Procedure
Adrian K. M. Lo, MD, Paul M. Kanev, MD, Philadelphia, PA

9:45 AM—10:00 AM

45. CT Morphometric Analysis of Occipital Flattening Following Lambdoid Strip Craniectomy: Deformation or Lambdoid Synostosis?
Mark S. Dias, MD, David M. Klein, MD, Buffalo, NY

10:00 AM—10:30 AM

COFFEE BREAK AND EXHIBITS—Promenade D

10:30 AM—11:00 AM

PAOLO RAIMONDI LECTURE—

Blaise F. D. Bourgeois, MD

“Presurgical Evaluation of Pediatric Epilepsy Surgery”

SCIENTIFIC SESSION VIII—Promenade A,B,C

Moderators: Alexa I. Canady, MD/Timothy B. Mapstone, MD

11:00 AM—11:15 AM

- *46. Experimental Acute Subdural Hematoma in Infant Piglets
E. Shaver, MD, A. C. Duhaime, MD, L. Gennarelli, MD,
R. Barrett, Philadelphia, PA

11:15 AM—11:30 AM

- *47. Infant Head Injury Data Base: 20 Year Experience in the
Post-Computed Tomography Era
John G. Piper, MD, Michael G. Muhonen, MD,
Matthew A. Howard, III, MD, B. A. Bell, MD,
David Uttley, MD, Iowa City, Iowa

11:30 AM—11:45 AM

- *48. Improved Outcome for Accidental Traumatic Brain Injury in
Childhood Using “Standard” Therapy, Aggressively Applied
James Callahan, MD, Robin Bowman, MD,
Thomas G. Luerssen, MD, Indianapolis, IN

11:45 AM—12:00 PM

49. Surgical and Non-surgical Treatment of Traumatic Epidural
Hematomas in Children
David J. Donahue, MD, Jason Brodkey, MD,
Robert A. Sanford, MD, Donna Swain, MD,
Michael S. Muhlbauer, MD, Elizabeth Kirk, RN,
Memphis, TN

12:00 PM–12:15 PM

50. Frontal Lobe Changes After Severe Diffuse Closed Head Injury in Children: A Brain Morphometric Study of MRI
Harvey S. Levin, PhD, Derek Bruce, MD,
Phillip Berryhill, BS, Matthew Lilly, MA,
Dianne Mendelsohn, MD, Gilbert Hillman, PhD,
Baltimore, MD

12:15 PM–12:30 PM

- *51. The Role of Apnea in Severe Nonaccidental Head Injury
Dennis Johnson, MD, Raymond Baule, MD,
Danielle Boale, MD, Hershey, PA

12:30 PM–1:30 PM

LUNCH AND EXHIBITS (ON OWN)

SCIENTIFIC SESSION IX—Promenade A,B,C

Moderators: James T. Rutka, MD/Frederick A. Boop, MD

1:30 PM–1:45 PM

- *52. High-grade Astrocytomas in Children
Jeffrey W. Campbell, MD, Ian F. Pollack, MD,
A. Julio Martinez, MD, Barbara Shultz, RN, BSN,
Pittsburgh, PA

1:45 PM–2:00 PM

53. Results of Stereotactic Radiosurgery for Treatment of Recurrent Ependymoma
Liliana C. Goumnerova, MD, N. J. Tarbell, MD,
A. Alexander, MD, Peter Black, MD, P. Barnes, MD,
R. M. Scott, MD, J. S. Loeffler, MD, Boston, MA

2:00 PM–2:15 PM

54. Outcome Following Multidisciplinary Management of Visual Pathway Gliomas
Leslie N. Sutton, MD, Pat Molloy, MD, Heidi Sernyak,
Peter Phillips, MD, Roger Packer, MD, Philadelphia, PA

2:15 PM–2:30 PM

55. Chordomas in Children

A. Reisner, MD, Samuel F. Ciricillo, MD, Paul G. Matz, MD,
A. James Barkovich, MD, Michael S. B. Edwards, MD,
San Francisco, CA

2:30 PM– 2:45 PM

56. The Therapeutic Potential of Enhanced Chemotherapy
Delivery via Osmotic Opening of the Blood-Brain Barrier
in Pediatric Brain Tumor Patients

Edward A. Neuwelt, MD, Suellen A. Dahlborg, RN, JD,
Annie Grummel, RN, ANP, Victoria Strider, RN, CNS,
John Crossen, PhD, Simon Roman-Goldstein, MD,
Mara Tableman, PhD, Portland, OR

2:45 PM–3:00 PM

*57. Dynamics of the Frequency of Developmental Abnormalities
and Brain Tumours in Children Before and After the
Chernobyl Disaster

Yuri A. Orlov, MD, DSc, Sergey Y. Rasskazov, MD,
Kiev, Ukraine

3:00 PM–3:30 PM

COFFEE BREAK AND EXHIBITS—Promenade D

SCIENTIFIC SESSION X—Promenade A,B,C

Moderators: Harold L. Rekate, MD/Tadamori Tomita, MD

3:30 PM–3:45 PM

58. Pitfalls of Segmental Gadolinium Enhancement of Pediatric
Posterior Fossa Tumors

Robert A. Sanford, MD, James Langston, MD,
Brett Gunter, MD, Memphis, TN

3:45 PM–4:00 PM

59. Surveillance Imaging in Children with PNET

Michael L. Levy, MD, William Gans, BS, Ehud Mendel, MD,
Harold Pikus, MD, Corey Raffel, MD, PhD,
J. Gordon McComb, MD, Los Angeles, CA

4:00 PM–4:15 PM

60. Magnetic Resonance Imaging Within 24 Hours of Craniotomy for Tumor in Children
Allen Oser, MD, Bruce A. Kaufman, MD, T. S. Park, MD,
Christopher Moran, MD, St. Louis, MO

4:15 PM–4:30 PM

61. Treatment of Childhood High Grade Glioma with Dose Cyclophosphamide
Geoff McCowage, MD, Henry S. Friedman, MD,
Herbert E. Fuchs, MD, PhD, Durham, NC

4:30 PM–4:45 PM

62. Protein Kinase C Isozymes in Malignant Glioma Cell Lines
Timothy B. Mapstone, MD, G. Yancey Gillespie, PhD,
Jui-Chang Tsai, MD, Sumon Bharara, MS,
Corey K. Goldman, MD, Birmingham, AL

4:45 PM–5:00 PM

63. Intracranial and Orbital Complications of Pediatric Sinusitis
Walker L. Robinson, MD, M. Rothman, MD,
M. Mittelman, MD, Greg Heacock, MD, F. Mihari, MD,
P. Haney, MD, Gregg Zoarski, MD, W. Gray, MD,
D. Rigamonti, MD, Y. Numaguchi, MD, Baltimore, MD

5:00 PM

Closing remarks and adjournment

Poster Session

Promenade Precon East

1. "Posterior Fossa Craniopharyngioma Presenting with Deafness: Report of Three Cases and Review of the Literature." Peter W. Carmel, MD, FACS, E. Sander Connolly, Jr., MD, Christopher J. Winfree, BA, New York, NY
2. "Strangulation Injury in Childhood." William C. Hanigan, MD, PhD, Robert A. Sabo, MD, Kelly Flessner, RN, Jean Rose, RN, Mary Aaland, MD, Peoria, IL
3. "Cerebrovascular Hemodynamics in Children Following Strangulation Injury." William C. Hanigan, MD, PhD, R. A. Sabo, MD, K. Flessner, RN, J. Rose, RN, M. Aaland, MD, J. Aldag, PhD, Peoria, IL
4. WITHDRAWN
5. "Andrew Arendt—First Pediatric Neurosurgeon in Russia." Boleslav L. Lichterman, Moscow, Russia
6. "Cerebrospinal Fluid Shunts Do Not Grow Old." Joseph H. Piatt, Jr., MD, Portland, OR
7. "Split Notochord Syndrome: Duplication of Spinal Column, Spinal Cord and Large Bowel with Associated 'Mature Teratoma'—An Attempt at Twinning?" Nizam Razack, MD, Larry K. Page, MD, Miami, FL
8. "The Biomechanics of Hydrocephalus—A Numerical Model." Samuel Neff, MD, Ravi Subramaniam, PhD, Camden, NJ
9. "Simulation of Normal Cranial Growth and Craniosynostosis Using Non-linear Finite Element Analysis." Samuel Neff, MD, Ravi Subramaniam, PhD, Camden, NJ
10. "Reflections on the Natural History of Lipomyelomeningocele." Paul M. Kanev, MD, Karin S. Bierbrauer, MD, Philadelphia, PA
11. "Development of Subcortical Pathways in the Mammalian Basal Ganglia: The Thalamostriatal Projection." Cornelius H. Lam, MD, Abbas F. Sadikot, MD, PhD, Montreal, Quebec

12. "Upper Body Motor Improvement Following Selective Dorsal Rhizotomy: A Patient/Parent Survey." Frederick Boop, MD, Mark Cobb, MD, Charles Teo, MD, Sharon Ratcliffe, RN, Little Rock, AR
13. "Percutaneous Endoscopic Shunt Recanalization—A Laboratory Model." Jogi V. Pattisapu, MD, Kay Taylor, RN, BSN, Revathi Narayanan, BE, Orlando, FL
14. "The Influence of Electric Fields on a Model Epileptic Focus." Duc H. Duong, MD, Taeun Chang, Steven J. Schiff, MD, PhD, Washington, DC
15. "*CDK-4* Amplifications and *MTS-1* Deletions Are Not a Common Feature in an Unselected Panel of Pediatric Brain Tumors." Joseph Petronio, MD, C. David James, PhD, Ju He, MD, Jim Allen, PhD, Atlanta, GA
16. "Expression of Heme Oxygenase and Hsp72 mRNA in Rat Brain After Focal Cerebral Ischemia." Leslie N. Sutton, MD, Ellen G. Shaver, MD, Frank A. Welsh, PhD, Eric L. Zager, MD, Philadelphia, PA
17. "Mutational Analysis of the p53 Tumor Suppressor Gene in Pediatric Astrocytomas." Bruce S. Chozick, MD, Arno H. Fried, MD, Providence, RI
18. "The Back of the Head: A Novel Approach to Lambdoid Synostosis." Richard S. Polin, MD, Mark E. Shaffrey, MD, Christopher Bogaev, MD, John A. Jane, MD, PhD, Charlottesville, VA
19. "Determinism, Control, and Anti-Control in a Model Epileptic Focus." Steven J. Schiff, MD, PhD, Duc H. Duong, Taeun Chang, Kristin Jerger, Mark L. Spano, William L. Ditto, Washington, DC
20. "Management of Postoperative Pain in Pediatric Patients." David F. Jimenez, MD, Rick Boyer, MD, Constance Barone, MD, Jo Anne Kirk, RN, Columbia, MO

Scientific Abstracts

1. CSF Output Through EVD in Hydrocephalic Children

Takasumi Yasuda, MD, Tadanori Tomita, MD,
David G. McLone, MD, Keiji Kawamoto, MD,
Mark Donovan (Chicago, IL)

Continuous hourly CSF output through external ventricular drainage (EVDs) were examined in 92 patients. The Becker External Drainage and Monitoring System II (PS Medical) were used for EVDs. Patients included 56 males and 36 females. Of this group, 20 patients had an EVD on two separate occasions, and 4 patients had an EVD on three separate occasions. In total, 120 EVDs in 92 patients were monitored. At the time of investigation, the mean age of patients was 4.53 years, (6 days to 15.67 years) and the mean body weight was 16.72 kg, (2.5 to 69.0 kg.). The conditions that required EVDs included 69 cases of shunt infection, 18 of shunt malfunction, 16 of hydrocephalus, 12 of brain tumor, and 5 others. Prior to the EVDs, 96 cases had been treated with CSF diversion shunt, and 24 cases had no previous CSF shunt. The mean duration of EVD was 269.2 hours, (25 to 774 hours). The mean height of the drainage from the mid-head was 10.04 cm., (0 to 22.78 cm.).

The hourly CSF output were recorded in all cases and reviewed for analysis according to various factors: patients age, sex, body weight, height of the drainage and presence of CSF infection. The mean hourly output of EVD was 8.12 ml/hour, (0.14 to 26.54 ml/hour). The standard deviation of hourly CSF output ranged from 0.42 to 10.77 ml/hour. Regression analysis indicated that age, body weight, and sex appeared to correlate with CSF hourly output. Using the natural logarithm of age, and of body weight, these predictors accounted for 48% of the variability in hourly output. The regression equation is as follows:

$$\text{Hourly output} = 2.6 - 2.2(\text{Sex} = \text{female}) + 0.911 \text{ Log (Age)} + 2.30 \text{ Log}(\text{body weight}); S = 3.44$$

The results produced by this study may lead to better clinical management for hydrocephalic children and may help design more physiological shunt device.

2. Anatomical and Physiological Considerations of Third Ventriculostomy

Charles Teo, MD, Kate Pihoker, MD, Sharon Ratcliffe, RN,
Frederick Boop, MD (Little Rock, AR)

Endoscopic third ventriculostomy is rapidly becoming a widely accepted treatment for non-communicating hydrocephalus. It has been associated with low morbidity and mortality, although potentially lethal and lethal complications have been infrequently reported. The procedure requires fenestration of the floor of the third ventricle immediately posterior to the infundibular recess, just anterior to the mammillary bodies and in the midline. Theoretically, a lesion here, in the presence of ventriculomegaly and a very thin floor, should avoid damage to hypothalamic structures. However, when the floor is not transparently thin, this area of the third ventricle is acutely eloquent. The hypothalamus governs all homeostatic processes and is thus essential for maintenance and continuation of a species. It is the executor of the autonomic nervous system and the endocrine system. It has a profound influence on affective behavior, although it occupies only 0.5% volume of the human brain. Should we be creating lesions through this vital structure with impunity? The authors present a prospective study performed on twenty consecutive patients undergoing third ventriculostomy. Hypothalamic function was assessed pre-operatively using basal temperature, weight, sleep patterns, hunger and thirst mechanisms, growth hormone, cortisol and CRH, gonadotropic hormone and challenge tests. The tests were then repeated postoperatively with an average follow-up period of 6 months.

The results of this study and our experience with over fifty endoscopic third ventriculostomies would suggest that the procedure may not be as safe as previously reported.

3. Neuroendoscopic Third Ventriculostomy Instead of Shunt Revision

Robert Jones, M. Vonau, B. C. T. Kwok, W. A. Stening
(Sydney, Australia)

We have revised our patients treated 1978–1994 by third ventriculostomy instead of shunt revision. The criteria for selection were similar to those not previously shunted. Absorbative capacity was not assessed preoperatively. Some attenuation of the floor was required but downward bulging was not. Adequate ventricular size was achieved by the shunt malfunction or surgical increase of intracranial pressure. 39 of the 41 in the non adult group had Heyer Schulte shunts with Antisiphon device placed long term. In three patients shunts were placed following cure of meningitis in infancy and in two ventriculostomy was successful. Normal intracranial pressure with a non functional or no shunt was regarded as a success.

With the lowering of the age for inclusion in Group A from 24 to 6 months, the poorer outlook in this young group is emphasised. Despite the handicap of a higher incidence of abnormalities in the myelomeningocele group, the results are gratifying. We believe that the long continued relatively normal intracranial pressure maintained by the Heyer Schulte system with the Antisiphon device helps the development of the patients absorptive mechanism.

Results

Group A.	Age Onset	Ventriculostomy	Number	Successful	Failure
A.	Under 6 mos	Under 6 mos	3	1	2
B1.	Under 6 mos	6 mos–18 yrs myelomeningocele	13	12	1
B2.	"	" other causes	15	8	7
C.	Over 6 mos	6 mos –19 yrs	10	8	2
D.	20 yrs and over at presentation		8	5	3
			49	34	15

4. Development of an MR Image Guided Ventriculoscope for Complex Endoscopic Procedures

Patrick Rhoten, MD, Mark Luciano, MD, PhD,
Gene Barnett, MD (Cleveland, OH)

With improvements in endoscopy, the “ventriculoscope” is increasingly being used as a tool for fenestration of cysts, biopsy and ventriculostomy. Even with direct visualization, however, orientation and navigation of the endoscope is difficult in children with abnormal anatomy, within small ventricles or in search of small MRI-identified ventricular lesions. The ability to know where the tip the endoscope is within the brain during the procedure should greatly enhance its effectiveness and safety.

We report here on the successful adaptation an image-guided stereotactic wand (IGSW) to the ventriculoscope in six patients. In this system the tip of the rigid ventriculoscope can be localized on an intraoperative computer MR image via a frameless and armless system. Two of these patients had multi-compartmental hydrocephalus and the third had a tumor lining the lateral and third ventricles. In three patients the wand was used in planning ventricular access and the optimal trajectory in performing a third ventriculostomy. The IGSW was also useful in navigation through multiple cysts and septae in our patients with multicompartmental hydrocephalus. Intraoperative MRI guidance aided the identification of small enhancing areas in a patient with a tumor that lined the third ventricle. Because the computer guidance is used not only during the endoscopic procedure but also with the obturator during ventricular access it minimizes uncertainty in the access to small ventricles.

In conclusion, the MRI image guided ventriculoscope is a useful tool in complex endoscopic procedures. The system is helpful in planning trajectory, navigation, and localizing pathology.

5. CSF Accumulator and Diversionary Device

Gary Magram, MD (Wilmington, DE)

A cerebrospinal fluid shunt includes an inner tube for supplying the fluid only from the brain ventricles to the peritoneum region of a subject and an outer tube arranged so the fluid remains resident in the outer tube without flowing to the peritoneum region. Fluid in the outer tube exerts pressure through a wall of the inner tube on the fluid in the inner tube to regulate flow of the fluid through the inner tube to the peritoneum region. This shunt regulates CSF flow relatively independently of whether the subject is upright or lying down, and somewhat independently of pressure pulses within the subject, due e.g. to coughing or sneezing. The pressure responsive deformable walls lessen the chance for occlusion of fluid within the shunt. The outer tube can function as a fluid accumulator, helping to maintain the intracranial CSF volume.

6. The Significance of 'Asymptomatic Shunt Contamination'

Paul Steinbok, MD, Doug Cochrane, MD,
John Kestle, MD, David Schiefele, MD
(Vancouver, BC)

The purpose of this study was to determine the significance of 'asymptomatic shunt contamination', defined as positive bacteriologic culture from a ventricular shunt component, in the absence of a positive CSF culture and/or clinical evidence of infection.

Out of 304 VP shunt revisions, 26 cases of 'asymptomatic shunt contamination' were identified, and reviewed retrospectively. In all but one case no antibiotics were instituted because of the positive culture. The most common infecting organisms were staph. epidermidis (12), propionibacterium species (7), and corynebacterium (3). Of 12 cases with staph. epidermidis, eight went on to have a further shunt revision, while one of 10 cases with propionibacterium or corynebacterium needed a further revision. 'Asymptomatic shunt contamination' was identified at elective shunt lengthening in four (staph. epidermidis 2, propionibacterium 2), and none needed further revisions; 'asymptomatic contamination' was found during a revision for mechanical problems (i.e.: broken or disconnected shunt) in 10, and of these, three of four with staph. epidermidis, but none of six with propionibacterium (4), corynebacterium (1) or peptostreptococcus (1), went on to further revision; the remaining 12 cases were associated with shunt revisions for shunt obstruction, and 9 of these required further revisions (staph. epidermidis 5/6, propionibacterium 1/1, corynebacterium 0/2, micrococcus 1/1, alpha-hemolytic streptococcus 1/1 and staph aureus 1/1).

We conclude that 'asymptomatic shunt contamination' associated with shunt blockage or with staphylococcal organisms is highly predictive of further shunt malfunction or infection, but otherwise such a bacteriologic finding is of little consequence.

7. Outcome and Cost Analysis in Pre-term Infants with Massive Grade IV Germinal Matrix Hemorrhage and Progressive Hydrocephalus

Harold Pikus, MD, William Gans, BS, Ehud Mendel, MD,
Michael L. Levy, MD, J. Gordon McComb, MD
(Los Angeles, CA)

The benefit of aggressive medical management and surgical intervention in pre-term infants with massive Grade IV intracranial hemorrhage has been questioned based upon the poor outcome of this group of patients in spite of such therapy. To further delineate this problem we reviewed the records of neonates in this category as to outcome and initial hospital cost.

The medical records at our institution from 1977–1987 were reviewed to find premature neonates who had sustained massive hemorrhagic infarction of one hemisphere in addition to having blood in both ventricles, and progressive hydrocephalus.

During the study period a total of 52 such patients were identified of which only 19 (5 females and 14 males) survived. Intellectual function was found to be greater than 2 standard deviations (SD) below the mean in 14/19, at 2 SD below the mean in 1/19, between 1-2 SD below the mean in 1/19, and 1 SD below the mean in 3/19. Motor function was as follows: 12/19 had marked spastic quadriparesis, 2/19 moderate spastic quadriparesis, 3/19 spastic hemiplegia, 1/19 spastic diplegia, and 1/19 mild spastic hemiparesis. Eleven/nineteen had a chronic seizure disorder. The first-hospitalization cost for the group of 52 patients exceeded, on average, \$100,000 per patient.

As we have previously reported, logistic regression analysis determined that the grade of hemorrhage was the only significant predictor of cognitive and motor outcome. Most premature neonates with massive intracranial hemorrhages do not survive, and the outcome in those that do is so poor and the cost so high that it appears justified to withhold maximum treatment in selected cases.

8. Ventriculo-subgaleal Shunts: Definitive Treatment for Progressive Post-hemorrhagic Hydrocephalus

Salim Rahman, MD, Charles Teo, MD,
Frederick Boop, MD (Little Rock, AR)

As the survival rate of premature infants increases, so does the incidence of post-hemorrhagic hydrocephalus. It is becoming one of the most common causes of hydrocephalus in the pediatric population. The incidence of intraventricular hemorrhage is greater than 45% in infants less than 1500 gms. The optimum treatment remains controversial. The number of lumbar punctures that may be performed are limited, serial ventriculostomies are said to cause porencephaly, standard ventriculo-peritoneal shunts either block with highly proteinaceous CSF or cause necrotizing enterocolitis (NEC) and intraventricular fibrinolytics are still experimental. Ventriculo-subgaleal shunts were first proposed as a means of temporarily diverting CSF in a more physiological manner for those infants less than 1500 gms who would not tolerate a shunt operation. The shunt could then be converted into the definitive VP shunt when the infant had gained the desired weight. The authors present a series of sub-galeal shunts performed at the Arkansas Children's Hospital that were intended to be first stage operations for eventual VP shunts but instead, served as the definitive procedure in over 50% of the infants. We will discuss the demographics, indications, operative technique, complications and results and propose a theory for this phenomenon based on the law of Laplace. Finally, we would like to advocate ventriculo-subgaleal shunting as the procedure of choice in the premature infant, less than 1500 gms, with progressive post-hemorrhagic communicating hydrocephalus in whom serial lumbar punctures and ventricular taps have failed.

9. Management of Trapped/Isolated Fourth Ventricle

Jogi V. Pattisapu, MD, Kay Taylor, RN, BSN,
Revathi Narayanan, BE (Orlando, FL)

Isolated or trapped fourth ventricle is commonly seen in most pediatric neurosurgical practices. Management of this situation is sometimes difficult, associated with significant morbidity, and occasional mortality. We describe our experience with 19 children (ages 3 mos. to 8 yrs.) who were treated for this condition, with various operative techniques. Children with Dandy Walker malformation and posterior fossa arachnoid cysts were excluded from this study.

The children presented with apnea/bradycardia, retrocollis, stridor, increasing spasticity and loss of motor control, and poor feeding behavior. Six patients were asymptomatic, two of which required surgery for increasing fourth ventricle size with brainstem compression (4 are being followed conservatively).

Twenty-four operations were required in 15 patients to initially treat the condition. Eight patients required shunting of the fourth ventricle, 2 directly into the posterior fossa, and 6 with supratentorial insertion of the ventricular catheter (5 of these children underwent prior ventriculostomy and communication). Craniotomy was performed in three patients who failed endoscopic communication. Cyst communication using endoscopic techniques was adequate in 4 patients with subsequent decrease in fourth ventricle size. Supratentorial fourth ventricular shunting using endoscopy or ultrasound appears to be quite successful in our series.

After a mean observation period of 17 months, 8 children are doing extremely well, 3 had a good result, and 3 had a fair improvement in the condition. One child died of unrelated causes secondary to prematurity. Multiple procedures, often including shunt revisions, are frequently required after the initial treatment for the condition.

Based on our experience, an algorithm for evaluation and management of the trapped fourth ventricle will be presented. The primary etiology determines the eventual outcome in these children, although some improvement can be achieved by timely intervention. This study confirms the complex management problems often encountered in caring for these children.

10. Does Practice Make Perfect (in Treating Hydrocephalus)?

D. Douglas Cochrane, MD, John Kestle, MD,
Dewey Evans, MD, Paul Steinbok, MD
(Vancouver, BC)

Purpose: To evaluate the role of institutional experience in treating pediatric hydrocephalus with ventricular shunts.

Methods: In Canada, federal requirements mandate hospital reporting of admissions and surgical procedures to the Canadian Institute of Health Information which in turn can provide diagnoses, procedures and patient demographics for population studies. All pediatric discharges, between March 1991 and April 1993 were reviewed to determine the failure and infection rates of ventricular shunts inserted for hydrocephalus and to determine whether the patient volume of a treating institution affected these rates. Chi square and actuarial methodologies were used.

Results: There were 2237 patients admitted on 2431 occasions to Canadian hospitals. Shunt operations were performed on 3527 occasions. Excluding removals, 3121 operations were analyzed from nine pediatric, 28 teaching and 19 community hospitals. In the study period, three hospitals performed over 200 operations (40% of operations), 8 hospitals between 100-200 procedures (41%) and 27 hospitals less than 100 (19%).

Analysis confirmed the sensitivity of shunt failure to patient age at operation (first year failure rate if less than 2 years - 40%, those over 2 years - 30%) and the presence or absence of infection.

The "experience" of an individual institution was not an independent predictor of shunt failure. Infection rates from high volume institutions (3%) were less than from low volume facilities (9%) ($p=0.01$) in children less than 2 years.

Conclusions: Data on failure rate suggests that low and high volume hospitals perform equally, however the differences in infection rates argue for specialty institutions.

11. The Rabbit Model for Infantile Hydrocephalus: Regional Differences in the Cortical Metabolic Response to Hydrocephalus and to Shunting

Monica C. Wehby-Grant, MD, Charles E. Olmstead, PhD,
Warwick J. Peacock, MD, David Hovda, PhD,
Robin S. Fisher, PhD, Hai-Lang Duong
(Los Angeles, CA)

We have recently demonstrated considerable cerebral glucose utilization (CMR_{glu}) and oxidative metabolic capacity (OMC) in the compressed cortical mantle of the hydrocephalic rabbit. In the present study we show that there are significant regional differences in the cortical maturation after the induction of hydrocephalus and in response to ventriculoperitoneal shunting.

Rabbits were made hydrocephalic at 4-6 days of age by an intracisternal injection of 100 μ l of kaolin. Control (N=12), Hydrocephalic (N=16) and Shunted (N=9) were studied at survival periods between 36 and 160 days. Awake animals received 200 μ Ci of [14C]-2-deoxy-D-glucose. Coronal frozen sections (20 μ) were processed for quantitative 2DG autoradiography, cytochrome oxidase histochemistry, and cresyl violet histology.

In the control animals both CMR_{glu} and OMC peaked at around 30 days and then decreased with age in all cortical regions. In the experimental animals there was a rostral caudal progression in the thinning of both the cortical white and gray matter and in the magnitude of the recovery after shunting, with occipital cortex showing the least. In the hydrocephalics CMR_{glu} remained high in all cortical areas with the anterior cortex being highest. The highest CMR_{glu} was seen in the frontal cortex of the shunted animals. In both operated groups the OMC showed an initial increase in the younger animals followed by an age related decrease. There was a trend to a rostral to caudal decrease. These data suggest a complex interaction between the increased intracranial pressure, cortical maturation and the subsequent response to VP shunting.

12. Effects of Progressive Hydrocephalus on Neurotransmitters and Gene Expression in an Animal Model of Aqueductal Stenosis

James P. McAllister, II, PhD, Robert W. Connelly, MS,
Hazel C. Jones, PhD, Neil G. Harris, PhD
(Cleveland, OH)

In an attempt to determine the onset of the first neuronal response, and possibly of irreversible neuronal pathology, during infantile hydrocephalus, the present study has examined the expression of heat shock protein (hsp70), the immediate early gene v-fos, glutamic acid decarboxylase (GAD), the synthetic enzyme for GABA, and neuron specific enolase (NSE), a marker for neurons in the H-Tx rat model of aqueductal stenosis. Affected H-Tx rats develop ventriculomegaly prenatally which progresses rapidly during the first postnatal month. In this study, fresh frozen tissue from rostral neocortex, caudal neocortex, and combined neostriatum and basal forebrain was obtained from 4 hydrocephalic and 4 normal animals at 6, 12 and 21 days of age, corresponding to mild, moderate and severe stages of ventriculomegaly. Northern blot analyses indicated that v-fos and hsp70 expression were unchanged at all time points, except for a 30% reduction of v-fos expression at 21 days in all brain areas. In contrast, GAD expression was elevated significantly only in the neostriatum at 6 days. No differences in GAD were noted in the cerebral cortex at any age. Taken together, these data suggest that gene expression in the cerebral cortex is relatively unaffected by progressive ventriculomegaly, which contrast sharply with other morphological findings. However, changes in hsp70 and IEGs may require more severe ventriculomegaly or may have occurred transiently at other time points. Further results for NSE and other time points will be presented and discussed.

13. Lobar Hemorrhages (LH) in Full-term Neonates

William C. Hanigan, MD, PhD, Frank C. Powell,
Gerald Palagallo, MD, Tim C. Miller, MD
(Peoria, IL)

Previously described in adults, LH is defined as a subcortical hemorrhagic lesion peripheral to the basal ganglia. This analysis describes the presentation, diagnosis, and follow-up in four full-term infants with LH and summarizes clinical patterns in 22 infants included in earlier reports.

In a chart review from the previous 5 years, 4 (12.1%) infants with LH were identified out of 33 full-term neonates with intracranial hemorrhages. Prenatal and obstetrical histories were uncomplicated; all infants presented with seizures within 48 hours following birth. Perinatal asphyxia and isoimmune thrombocytopenia were associated with LH in two children. Although CT was sufficient for the diagnosis, MR evaluation provided assessment of specific cortical injury and age of hemorrhage. No infant underwent surgical intervention; 3 children reached developmental milestones at a mean follow-up of 3.3 years.

Differences in reportage prevented a complete analysis for all 22 infants included in earlier reports. Over 90% of infants presented with seizures; no sex or location bias was evident. LH was associated with perinatal asphyxia, neonatal coagulopathy, complicated assisted delivery, or hyperviscosity in 6 (27.3%) neonates while risk factors were not identified in 12 (64.5%) infants. Vascular lesions, cardiac, or septic embolization were not implicated in the development of LH. One neonate underwent unsuccessful surgical intervention; 4 children required CSF diversion for hydrocephalus. All infants with isolated LH showed normal development.

In summary, most full-term infants with LH presented with early onset seizures. Perinatal asphyxia and neonatal coagulopathies were described in 1/3 of infants; over 1/2 of children with LH showed no risk factors. No infant developed a recurrent hemorrhage. Surgical intervention was rarely required and developmental prognosis related to the severity of associated risk factors.

14. Pial Synangiosis for Moyamoya Syndrome in Children

P. David Adelson, MD, R. Michael Scott, MD
(Boston, MA)

In order to improve the postoperative clinical and angiographic results in children undergoing encephalo-duro-arterio-synangiosis¹ ("EDAS") for moyamoya syndrome, the senior author (R.M.S.) modified Matsushima's original surgical technique by opening the arachnoid widely over the cortical surface exposed at craniotomy and by suturing the donor artery adventitia directly to the pia with 100 monofilament nylon suture ("pial synangiosis"). Since 1985, this technique has been used in 47 procedures carried out in 24 children 18 years or younger, utilizing standardized anesthetic techniques previously described.² Clinical outcome was determined at postoperative follow-up ranging from one to nine years for 19 of 24 patients. Fifteen of these patients had excellent outcomes with no further TIA's or seizures. In the other 4, there was either slight improvement or no change. Five patients with less than one year follow-up were clinically stable. The single operative complication was a post-operative basal ganglia infarct in a neurologically unstable patient with neurofibromatosis and previous radiation for an optic glioma. Cerebral arteriograms were carried out one year post-operatively to determine the extent of collateralization of the operated hemispheres. Using Matsushima's grading scale,³ good to fair collateralization was seen in 27 of 28 operated sides (96%), a substantial improvement over the 61% reported previously by Matsushima for the EDAS procedure. This surgical modification appears to increase collateralization of the operated hemisphere from the donor superficial temporal artery, and has led to a satisfactory clinical outcome in this patient series.

¹Matsushima T, *et al.* *Surgical Neurology*. 1981; 15:313-320.

²Soriano SG, *et al.* *Anesthesia Analg*. 1993; 77:1066-70.

³Matsushima T, *et al.* *Neurosurgery*. 1992; 31: 401-405.

15. Change in Level of Myelomeningocele Defect in the Past Twenty Years

E. L. Wylen, MD, E. J. Kosnik, MD,
R. W. O'Shaughnessy, MD (Columbus, OH)

Based on a twenty-year experience at a large myelomeningocele treatment center, we hypothesized that the level of the spinal myelomeningocele defect has become lower over the last two decades. Methods: The 367 myelomeningocele patients operated on at Columbus Children's Hospital from 1974–1993 were categorized according to level of motor deficit. Percentage of patients in each motor category was compared between two time periods: 1974–1983 and 1984–1993.

Results: Of the 212 myelomeningocele patients treated between 1974 and 1983, 6% had a thoracic motor level, 20% thoracolumbar, 24% lumbar, 37% lumbosacral, and 12% sacral. The motor levels for the 155 patients operated on from 1984–1993 were 1% thoracic, 12% thoracolumbar, 17% lumbar, 54% lumbosacral and 16% sacral. The trend for the motor deficit to be lower on the spinal cord in patients born during the second epoch (1984–1993) was statistically significant ($p = 0.0005$ on the Cochran-Armitage Trend Test).

Conclusion: The spinal lesion of newborn myelomeningocele patients has become lower in our study population over the past twenty years, with a significant trend for proportionately more lesions to be lumbosacral or sacral rather than thoracic or upper lumbar in functional motor level. We conclude that the severity of myelomeningocele lesions has diminished, probably due to increased prenatal detection. Together with the high quality multidisciplinary care provided at specialized medical facilities, this situation is expected to enhance the quality of life and level of function of the myelomeningocele patient.

16. A Novel Approach To Understanding the Molecular Mechanisms of Spina Bifida

Timothy M. George, MD, Chandra S.K. Mayanil, PhD,
Michael Partington, MD, Paul A. Knepper, MD, PhD,
David G. McLone, MD, PhD (Chicago, IL)

A major problem in spina bifida research is understanding the molecular mechanisms which are responsible for normal neurulation and the molecular abnormalities causing neural tube defects (NTD). The purpose of this study was to clarify the role that the developmentally regulated paired-type homeobox gene, Pax-3, has on the process of neurulation. Mutants of Pax-3 have been found to be responsible for the development of the neural tube and neural crest defects in the *spotch* mouse and responsible for the abnormalities of neural crest cell derivatives in Waardenburgs Syndrome type II in humans. We found that administration of an antisense oligonucleotide to Pax-3 in neurulating chick embryos produces defects of primary and secondary neurulation. We targeted Pax-3 in the chick because the spatiotemporal pattern of expression correlates to critical time periods in the process of neurulation. In particular, the expression of Pax-3 in the developing nervous system is prior to neural tube closure in cells from the roof plate of the neural tube and those that become neural crest. Pax-3 is also expressed in the mesenchymal cells of the tail bud which are precursors for the secondary neural tube. The types of neurulation defects caused by the treatment with the antisense oligonucleotide are open caudal NTD, and sacral anomalies with tail defects indicative of abnormal secondary neurulation. Our findings reveal that Pax-3 indeed plays an important role in the process of neurulation. Future investigations are aimed at understanding the cascade of upstream regulating genes and downstream target sites of Pax-3.

17. Agenesis of the Lumbosacral Spine: Clinical Features, Imaging Characteristics and Embryogenesis

Michael D. Partington, MD, Curtis L. Harlow, MD,
Carol M. Rumack, MD, Gary Thieme, MD (Denver, CO)

Sacral agenesis, often a part of the caudal regression syndrome, is a well described entity which is etiologically linked with gestational diabetes in approximately 15% of affected individuals and is often associated with anomalies of the hindgut and urogenital system. This report describes three cases of complete agenesis of the entire lumbosacral spine in three individuals who were all infants of diabetic mothers. The first case is that of a thirteen-year-old male whose mother had a history of poorly-controlled diabetes, syphilis and ethanol abuse. The vertebral column ends at T12 and rests on the fused iliac wings. The hindgut and genitalia are anatomically normal and a single pancake kidney drains through a partially duplicated ureteral system. The child underwent bilateral hip disarticulation and uses a bucket prosthesis. The second case is that of a newborn preterm male whose mother had longstanding juvenile diabetes with moderate control. Prenatal ultrasound demonstrated the absence of the lumbosacral spine and also ventriculomegaly. MRI and ventriculoscopy confirmed that the intracranial anomaly was most consistent with semilobar holoprosencephaly and a ventriculoperitoneal shunt was placed because of increasing head size. There were twelve rib-bearing vertebrae, with several ribs fused. The urogenital system was normal and imperforate anus was treated by colostomy. There was no evidence of cysto-rectal fistula. In the third case, a pregnancy complicated by gestational diabetes was terminated at 23 weeks gestational age when ultrasound confirmed lumbosacral agenesis. Additional anomalies included bilaterally absent fibulae, a hemivertebra at T9 and fused ribs. The brain, kidneys and bladder were normal by ultrasound, and permission for autopsy was not granted.

We believe that this complex spinal anomaly is probably etiologically distinct from isolated sacral agenesis, which can be considered a defect of secondary neurulation, associated with other anomalies of the caudal eminence derivatives. The failure of spi-

nal development at upper lumbar levels implies that this defect also involves primary neurulation, despite being a skin-covered lesion. One possibility, therefore, is that this is another example of a disorder of gastrulation with a resulting combination of partial failure of primary neurulation and complete failure of secondary neurulation. However, the association with holoprosencephaly, which occurs at a much later point in embryogenesis, along with the relative paucity of associated anomalies of the hindgut and urogenital tract, might suggest that an independent defect in a control factor specific to neurodevelopment, such as a homeobox gene, may be involved as the primary etiologic mechanism.

18. Split Cord Malformations and Retained Endodermal Derivatives

Dachling Pang, MD, FRCS(C), Peter P. Sun, MD
(Sacramento, CA)

Split cord malformations (SCM) are associated with neuroenteric cysts, vertebral-intestinal and mediastinal-intestinal bands, and other endodermal derivatives dorsal to the primitive foregut. The original embryologic error in split cord malformation has been suggested to be failure of midline integration of prospective notochord cells which leads to the formation of an abnormal adhesion between the endoderm and ectoderm during gastrulation. Condensation of the surrounding pluripotential mesenchyme around this abnormal adhesion forms an endomesenchymal tract that bisects the notochord and overlying neural plate and potentially extends from the yolk sac to the cutaneoectodermal surface. The extent to which the endomesenchymal tract persists and differentiation of its endodermal elements account for the variety of retained endodermal derivatives seen with SCM. We present a series of seven patients with SCM and retained endodermal derivatives to illustrate the spectrum of developmental fates of the midline endodermal primordium.

The most common fate of the endodermal remnant is attrition due to lack of appropriate inducer molecules. When the endoderm does persist and in some cases undergo differentiation, four possible patterns may be seen: 1) Persistence and differentiation of the ventral (only) connection with the primitive gut, exemplified by the autopsy case of a neonate with a fibromesenchymal band connecting a C7 cleft cord, through the posterior mediastinum, to the apex of a large duplicated duodenal loop. 2) Persistence of the ventral connection with the primitive gut and differentiation of the spinal or perispinal endodermal remnant. A child with C3-4 SCM and C4 bifid vertebral body has a cervical prevertebral cyst connected to an intestinal band that caused duodenal obstruction and complete malrotation of the midgut. 3) Persistence and differentiation of the dorsal (only) connection with the cutaneous ectoderm, exemplified by a child with a cleft cord and an overlying dorsal neuroenteric cyst in continuity with a cutaneous sinus tract and dimple. 4) Differentiation of the endoderm into intraspinal neuroenteric cyst within the median cleft of a SCM without dorsal or ventral connections, found in 3 patients and a 24 week abortus.

19. Clinical Signs and Symptoms as Indicators for Retethered Spinal Cord in Congenital Spinal Dysraphism

Patricia A. Gelnar, MD, Jeffrey A. Winfield, MD, PhD
(Syracuse, NY)

Despite correlative efforts by pediatric neurosurgeons and neuroradiologists, including the use of CINE-MRI by our group, pre- and postoperative radiologic studies do not clearly predict the symptomatic retethered child. Therefore, the clinical indications necessitating reoperation need to be better defined. We have reviewed the clinical records of 27 children with congenital dysraphism who underwent lumbar exploration for untethering to address this question. This cohort included 16 meningomyeloceles (MM), 8 lipomas, 1 diastomatomyelia, 1 caudal migration, and 1 dermal sinus tract. No child in this group was initially evaluated for progressive scoliosis. The mean age at presentation was 5.5 years for the MM group and 5 years of age for the other children.

Gait deterioration, often first appreciated by the parents, occurred in 70%. On exam axial and proximal lower extremity muscle weakness were present, and a **Trendelenberg sign** (60%) was observed. Previously “**dry**” children between catheterizations were noted to require “**diapering**” in 40% of cases, and complaints of back and leg **pain** were present in 55%. Following untethering, changes in bladder function and symptoms of gait and pain disturbances improved in all children.

Dysraphic children should have fixed neurologic deficits. When presenting with segmental motor deficits above their initial level, functional bladder changes in the absence of a UTI, and/or complaining of back and leg pain, this indicates retethering. Gratifying improvement in these clinical symptoms can be expected following reoperation.

20. Clinically Significant Diastematomyelia with a Median Septum Associated with Myelomeningocele

W. Jerry Oakes, MD, Lewis W. Harris, MD
(Birmingham, AL)

The association of myelomeningocele with the split cord syndrome is well known but not well characterized. We report here 15 patients who presented with these two clinical entities. Eleven of the 15 were diagnosed months to years after the initial myelomeningocele closure, whereas four were diagnosed and surgically treated at the time of the initial spinal operation. At least three of the 15 patients had hemimyelia with the neural tube defect being present on only one of the two hemicords. Three of the four patients recognized at birth are community ambulators with the one exception being a child with a huge hydrosyringomyelia and associated flaccid paraplegia. Of the 11 patients diagnosed at an average of 7 years following closure of the myelomeningocele, all were potentially community ambulators after the closure, but only 45% (5/11) maintained their community ambulation skills after expressing the natural history of this association.

All of the patients with diastematomyelia with median septum occurred at the site of the placode or within one segment (usually cephalad). There was a high association of bony median septum with a focal area of hirsutism over the spine.

Based on this review, we suggest: 1) Routine spine radiographs prior to myelomeningocele closure (all patients diagnosed at birth had very suggestive plain radiography). 2) Exploration of the spine one level above and below the placode at the time of the initial myelomeningocele closure. 3) Removal of the median septum associated with diastematomyelia immediately after discovering this association rather than waiting for the individual patient to express what appears their own inevitable natural history. 4) Spine MRI or CT myelogram in all myelomeningocele patients with focal hirsutism.

The details of the clinical presentation and surgical technique used in these patients will be discussed.

21. Comprehensive Intraoperative Mapping and Monitoring of Sensory, Motor and Urogenital Functional Integrity During Surgery of Conus/Cauda

Nobu Morota, MD, Vedran Deletis, MD, Rick Abbott, MD,
Fred J. Epstein, MD
(New York, NY)

Surgery of the conus medullaris and/or cauda equina carries the risk of compromise to sensory, motor, and urogenital functions post-operatively. In order to prevent intraoperative injury to these critical functions, new neurophysiological techniques have been introduced.

These techniques can be divided into: mapping, in order to neurophysiologically locate specific structures; and monitoring, to supply feedback during surgery about the functional integrity of the nervous pathways/structures.

Somatosensory afferents from the lower extremities have been monitored by stimulating the tibial nerves and recording the evoked potentials (stationary wave) over the conus using epi/subdural electrodes.

Motor efferents have been mapped by directly stimulating the individual roots and recording the EMG or visually observed muscle twitches.

For preserving urogenital function, pudendal afferents have been mapped within nerve roots by recording with a hook electrode about the roots while electrically stimulating the dorsal penile/clitoral nerves. Monitoring of the integrity pudendal afferents/efferents has been achieved by continuously recording the bulbocavernosus reflex during surgery. In addition, "pudendal SEPs" have been recorded over the conus medullaris using an epi/subdural catheter following stimulation of the penile/clitoral nerves.

Combinations of these techniques were applied during surgeries for selective posterior rhizotomy (n=131), tethered spinal cord (n=107), and spinal cord tumor (n=27) between January 1990 and April 1994. We found that their use decreases postoperative complications and improves surgical results.

The technique of these studies will be discussed as will the incidence of postoperative motor, sensory and urogenital complications before and after introduction of these techniques.

22. Bad Outcome Following Tethered Cord Surgery

Fred J. Epstein, MD, Diana Leahu MA, MS IV,
Rick Abbott, MD, Jeffrey H. Wisoff, MD
(New York, NY)

Over the past four years, eighty-five patients underwent surgery for tethered cord at New York University Medical Center. Of this group, eight children were functionally more impaired post-operatively than pre-operatively as a result of the surgical manipulation to “free” the tether. An analysis of these eight patients has disclosed the “risk factors” common to the group. All eight patients underwent previous spinal cord de-tethering and had been neurologically stable for a period of time before starting to deteriorate again. The post-surgical functional impairment was manifest by localized pain, weakness of one extremity or impairment of bladder function. In addition, all of the patients in this group had a complex transitional lipoma which necessitated considerable dissection to free the neural structures from the surrounding dural tube. Finally, all patients with post-operative impairment were older than 6-8 years of age at the time of their surgery. Whereas much attention has been given to the safety of tethered cord surgery, there has been little effort to make an assessment as to what the hazards associated with surgery are and which patients are at risk for a poor outcome. It will be the intention of this presentation to offer an in-depth analysis of the multiple factors that are associated with poor outcome following spinal cord de-tethering. Our study methods include statistical analysis of functional scores based on neurological follow-up’s, mail-questionnaire and phone-survey data.

23. Sleep Apnea in Patients with the Chiari II Malformation

Michael J. Chaparro, MD, Robert Cohn, MD,
Tara Green, RN, BSN, CCRN, Todd Greenberg
(Dayton, OH)

While most neurosurgeons agree that decompression is indicated for life threatening respiratory compromise, many children with the Chiari II malformation have more subtle abnormalities. Over 70% of this population has an abnormal sleep pneumogram, compared with 6% of normal controls. Significant sleep apnea is often not clinically apparent. This group frequently requires supplemental oxygen and/or ventilatory support. We have reviewed the sleep pneumograms of children undergoing decompression over the past two years, and its response to surgery. Thirteen patients underwent decompression. Ages ranged from eight months to 20 years (average 7.4 years). Pre and postoperative sleep pneumograms were available on eight children. All children had additional indications for surgery. Of the eight for whom sleep pneumograms were available, all were abnormal. Five had central apnea, two had obstructive apnea, and one had central, obstructive, and mixed apnea. The shunts were evaluated in all patients and revised in four. None whose shunt was revised resolved their apnea. Surgery included lysis of arachnoid adhesions, re-establishment of CSF outflow from the fourth ventricle, and cadaveric duraplasty. One patient had a fourth ventricle-subarachnoid stent placed. There was no mortality. There was one postoperative pneumonia and one CSF leak. Seven of the eight either significantly improved, or totally resolved their sleep apnea. One patient required mechanical ventilation with room air preoperatively, and continued to require it postoperatively. Five required O₂ supplementation and two required CPAP preoperatively. None of these required O₂ or CPAP postoperatively. Sleep apnea is common in the Chiari II population and can respond well to decompression. A sleep pneumogram should be considered in all Chiari II patients, and when significantly abnormal, might be considered an indicator for surgery even in the absence of other symptoms.

24. Hindbrain Hernia (Chiari I Malformation) Secondary to Partial Sacral Agenesis with Meningocele

Dean Karahalios, MD, Christos Tsonidas, MD,
Harold L. Rekate, MD (Phoenix, AZ)

As part of an ongoing study of the pathogenesis of the Chiari I malformation, we have identified three patients in whom hindbrain herniation has been shown to be secondary to a large intrasacral meningocele due to partial sacral agenesis. In one of these patients, an MRI obtained prior to the child beginning to walk showed normal posterior fossa anatomy. A year later with the child showing clear-cut signs of lower extremity spasticity, a second MRI revealed a severe hindbrain hernia (Chiari I malformation).

Hindbrain hernia is due to a pressure differential across the foramen magnum or to direct distortion of the craniovertebral junction. In these cases the "sump" effect of the intrasacral meningocele created the pressure differential leading to hindbrain herniation. Presumably, the assumption of the erect stance position with the ability of the meningocele to distend led to the downward descent of the cerebellar tonsils.

In two of these patients symptoms including spasticity and lower cranial nerve deficits led to Chiari I compression with improvement. The third patient is asymptomatic and is being followed.

25. Progressive Deterioration in Brain Stem Function Following Decompression of Chiari II Malformation

Harold L. Rekate, MD, Patricia Teaford, MD,
Michael Kappy, MD (Phoenix, AZ)

Progressive deterioration in brain stem function frequently leading to death is occasionally seen in babies with spina bifida despite decompression of the Chiari II. This combined with postmortem studies showing severe disorganization of the ninth and tenth nerve nuclei have led some neurosurgeons to question the efficacy of this form of intervention.

We have recently identified three patients who presented with life-threatening lower cranial nerve and respiratory drive dysfunction who initially responded well to cervical laminectomy with dural patch grafting. Several weeks later they presented with increase in dysfunction of their lower cranial nerves, apnea leading to cyanosis and seizures. During the course of these episodes, hypoglycemia has been identified as the cause with serum glucose values falling to as low as eight mg/dl. Two of these three patients have responded to frequent or continuous feedings and supplemental treatment with glucagon.

One of these patients has had a second set of life-threatening symptoms with apnea and rigidity preventing external ventilation. Sleep studies and continuous EEG monitoring has led to the diagnosis of severe breath-holding spells in association with brain stem dysfunction. Installation of intranasal Versed has led to the ability to ventilate the child through these episodes.

Hypoglycemia and severe breath-holding are factors to be considered in babies who continue to deteriorate after decompression for Chiari II malformation.

26. Chiari I Malformation and Headache: Who Should Undergo Operation?

Michael H. Handler, MD, Fred Epstein, MD,
Jeff Wisoff, MD, Rick Abbott, MD (New York, NY)

The records of 67 pediatric patients with the Chiari I malformation were reviewed. Of these, 27 patients had headaches among their symptoms and a Chiari I malformation unrelated to other intracranial pathology. In 4, the malformation was felt to be unrelated to the headaches, and were excluded. In the rest, headaches were likely to be the only complaint; they accompanied other symptoms in only 5/23 patients (22%). There was a striking disproportion of younger children with a chief complaint of headache, 12/22 patients < 6 years old (54%), as opposed to 2/19 (11%) of children age 6-13 and 4/15 (27%) of children 14-20 at the onset of symptoms. Headache was typically suboccipital in location, often with associated neck pain (20/23, 87%), and less commonly frontal or bitemporal. Sudden sharp and transient pain induced by Valsalva or exertion was seen in 14 (61%). Operations were performed in 20 patients (87%). 13 (56%) were assessed by parents as "a cure," while 5 (22%) were "improved," but still have some headache. One patient is still limited by exertional headache, and another with bifrontal headaches had no improvement. 3 patients did not undergo an operation that was recommended; two of these have undertaken significant modifications of their behavior, giving up competitive sports and other vigorous activity. The third reconsidered that limitation and recently opted for surgery. We conclude that occipital headache or head pain is a common-presenting complaint in the Chiari I malformation, especially in younger children, and that it can confidently be expected to improve with operation. We cannot, however, conclude that a child with a Chiari I and headaches will necessarily progress to develop other, more ominous findings.

27. Posterior Fossa Decompression for Arnold Chiari Malformation and Achondroplasia Without Dural Opening

Kent D. Yundt, MD, T. S. Park, MD,
Bruce A. Kaufman, MD (St. Louis, MO)

Some anomalies of the posterior fossa and the craniovertebral junction can lead to compressive forces on the hindbrain causing apneic spells, cranial nerve dysfunction, and may lead to death. Standard treatment has involved bony decompression with suboccipital craniectomy or decompressive laminectomy in conjunction with duraplasty. Infants may not require duraplasty to achieve adequate decompression. We have tried to define a subset of patients, who do not require dural opening for adequate decompression by using intraoperative ultrasound to demonstrate adequate CSF space surrounding the hindbrain. Four symptomatic children underwent bony decompression, 2 with Chiari II malformations, one with a Chiari I malformation and one with achondroplasia. They aged 2 months to 2 years (mean 10 months). Three children presented with apnea and one child with stridorous respirations. The three children with Chiari malformations underwent decompressive laminectomies, and the child with achondroplasia underwent a suboccipital craniectomy. Following bony decompression, intraoperative ultrasound demonstrated expansion of the stenotic region with visible cerebrospinal fluid spaces anterior and posterior to the neural elements in all 4 children. Postoperatively all 4 children were asymptomatic. Two children had a return of their symptoms at 2 and 3 months post surgery and were reevaluated with MRI. The achondroplastic child had visible stenosis at the first cervical vertebra and underwent C1 decompressive laminectomy. Intraoperative ultrasound was again used to show adequate decompression and the dura was left intact. The child has remained asymptomatic for 4 months post surgery. The second child with a Chiari II malformation was noted to have compression of the cerebellum and brainstem and underwent a suboccipital craniectomy. The dura was again left intact, and the child has remained asymptomatic for 3 months. The other 2 children have remained asymptomatic for 5 months and 5 years.

Young children may have a more distensible dura that does not require duraplasty. We have used intraoperative ultrasound to show adequate hindbrain decompression, and avoided opening the dura. Hindbrain decompression without duraplasty can be effective treatment for Chiari malformations and achondroplasia.

28. Encephaloceles of the Anterior Cranial Fossa: Management and Outcome

James T. Rutka, MD, PhD, FRCSC, Robert McFarlane, MD, Robin P. Humphreys, MD, James M. Drake, MD, Harold J. Hoffman, MD (Toronto, Ontario)

Encephaloceles of the anterior cranial fossa are rare developmental lesions which can have serious neurological and aesthetic sequelae if left untreated. From a total of 114 encephaloceles treated surgically at the Hospital for Sick Children in the 15 years to 1994, the case records of 17 patients with sincipital and 5 patients with basal defects were reviewed retrospectively. The condition was evident at birth in 64% of patients, while the remainder presented with either cerebrospinal fluid rhinorrhea, nasal obstruction, or feeding difficulty. Hypertelorism affected 73% of patients. All encephaloceles were repaired transcranially, at a mean age of 2 years, usually by means of an intradural pericranial graft. Five children with gross hypertelorism underwent orbital translocation at the time of encephalocele repair. Of those not corrected, primary and secondary hypertelorism regressed in most instances where the encephalocele was treated before the age of 2 years. There were no deaths. The only case of CSF rhinorrhea occurred in a patient with a basal defect, in whom intradural repair was not possible because of adherence of diencephalic structures to the sac wall. Hypertelorism recurred in one patient after orbital translocation, requiring recorection 2 years later. One patient with untreated secondary hypertelorism failed to regress after the encephalocele was excised at the age of 4 months. Developmental outcome was normal in 59% of children, whilst 18% have mild mental or physical disability, and 23% are severely impaired. A child with a sincipital or basal defect and mild hypertelorism should have the encephalocele treated in early childhood to allow the facial skeleton to remodel with growth. When an encephalocele is accompanied by gross hypertelorism or a facial cleft, one-stage correction can be undertaken safely in early childhood with minimal mortality and acceptable morbidity.

29. Isolated Dandy-Walker Malformation in Three Siblings: Further Support of Autosomal Recessive Inheritance

Alexa Canady, MD, C. E. Harper, D. J. Aughton,
D. E. Seubert (Detroit, MI)

Isolated Dandy-Walker malformation (DWM) is etiologically heterogeneous. Occurrence of DWM in siblings has been reported occasionally; autosomal recessive inheritance has been suggested, but not proved (McK 220200). We report the cases of three siblings, monozygotic 3-year-old twin girls and their 3-month-old brother, all of whom have isolated DWM. The findings of this family provide further evidence for autosomal recessive inheritance of some cases of DWM.

The girls were diagnosed in the newborn period to have DWM and hydrocephalus at age 3 months. By age 3 years, their histories were further remarkable for postnatal growth retardation, mild to moderate developmental delay, and cytomegalovirus (CMV) viremia on two occasions; one twin also had congenital hypothyroidism, and the other, strabismus. Further investigation did not support a diagnosis of congenital CMV infection. Their brother was found to have DWM prenatally, which was confirmed postnatally. The brother's growth and development was normal at age 3 months. All three children have had normal chromosome analyses and renal monograms; the twins were shown to be monozygotic through "DNA fingerprinting." Maternal CT scan showed no evidence of DWM; the father has not undergone imaging studies.

The girls' growth retardation admits the possibility of an unrecognized syndromic basis for their DWM, but diligent investigation has yielded no candidate diagnosis, and the brother has no evidence of growth retardation. We therefore believe that our patients' DWM is isolated, and provides further support for an autosomal recessive mode of inheritance of DWM in some cases.

30. The Relationship between Cerebellar Development and Function in Children with Dandy-Walker Malformations

Peter C. Gerszten, MD, A. Leland Albright, MD
(Pittsburgh, PA)

Over the past decade, children with Dandy-Walker malformations have been reported to have better intellectual and cerebellar function rather than the poor function traditionally ascribed to them. To date, no study has addressed the relationship of cerebellar development (size) to either cerebellar function or intellect. To evaluate those relationships, we retrospectively studied the medical records and scans of 20 patients with Dandy-Walker malformations at our institution between 1978 and 1994. Patients were treated with ventriculoperitoneal (VP), cystoperitoneal (CP) or ventriculo-cystoperitoneal (VPCP) shunts. Intellectual and cerebellar function were determined from neurological and developmental testing. Cerebellar development was evaluated by measuring cerebellar and posterior fossa volumes from CT images; the ratio of cerebellar size to posterior fossa size was calculated from the most recent CT scan for each patient and was considered to reflect cerebellar development. The mean patient age at the time of the most recent scan was 5.5 years.

Cerebellar function was normal in 50% and intellectual function in 45% of patients. There was no correlation between cerebellar size and cerebellar function. Ratios in normal patients and in those with mild, moderate and severe cerebellar dysfunction were .63, .49, .57 and .51, respectively. There was no correlation between intellectual development and cerebellar size. Ratios were .62, .70, .49 and .52 in the same four patient groups. There was also no correlation between the type of shunt and the subsequent cerebellar size. Ratios were .60 for CP shunts, .62 for VP shunts and .63 for VPCP shunts. We conclude that there is no relationship between the cerebellar development evident on CT scans and the cerebellar or intellectual function of children with Dandy-Walker malformations.

31. Medically Intractable Epilepsy of Frontal Lobe Origin in Children

Antonio R. Prats, MD, Trevor Resnick, MD,
Glenn Morrison, MD, Raquel Pasaron, MSN, ARNP
(Miami, FL)

Seizures of frontal lobe origin are not a uniform entity rather represent a number of clinical seizure types related to region of seizure onset and subsequent spread pattern. Seizures of frontal lobe origin have different clinical presentations depending on the region of seizure onset. We have divided the frontal lobe into four separate regions and will describe differentiating features from seizures arising from the different areas. The four regions of the frontal lobe include the supplementary motor area, dorsal lateral portion of the frontal lobe, orbital frontal area, and the cingulate gyrus. The clinical semiology and illustrative cases from the four different regions will be presented. Pathology as well as the results of focal frontal lobe resections will be discussed. The present series consists of 27 patients who underwent frontal resections and were less than 12 years of age. This group was taken from a total of 185 which have undergone epilepsy surgery at Miami Children's Hospital. Of the 185 patients, 66 patients underwent extratemporal cortical resections. All patients in the series underwent invasive monitoring consisting of implantation of subdural electrodes as well as brain mapping. Patients who had lesions noted on their pre-operative radiographic evaluation had a higher probability of being seizure free following their resective surgery.

32. Functional Hemispherectomy for Drug Resistant Seizures

John M. Whitley, MD, PhD, Joseph R. Smith, MD,
Pat D. Jenkins, PA-C, Y. D. Park, MD (Augusta, GA)

Functional hemispherectomy for refractory seizures with associated hemiparesis is comparable to complete hemispherectomy in terms of seizure control, with fewer late complications. Seven patients (aged 8-17; 5 females, 2 males) with drug resistant seizures (1-30/day) were selected for functional hemispherectomy. All patients exhibited secondary generalized tonic-clonic seizures and either epilepsy partialis continua or complex partial, absence, or focal motor seizures. Seizures were the result of cerebral hypoxia resulting in cerebral palsy and mental retardation (4 patients), Herpes encephalitis (1 patient) and MCA thrombosis and infarction (2 patients). Functional hemispherectomy was performed in all cases (Rasmussen, *Can J Neurol Sci* 10:71-78, 1983). Post-operative periods were uneventful. Complications included one case of intraoperative DIC that subsequently resolved and one case of osteomyelitis treated with bone removal and cranioplasty. To date, 6 patients remain seizure-free and 1 patient has achieved a > 90% reduction in seizure activity. Follow-up periods range from 1 month to 6 years. These data suggest that functional hemispherectomy is effective in arresting seizures despite the etiology and can be performed safely with minimal morbidity.

33. Pathologically Proven Brain Tumors in Patients with Temporal Lobe Epilepsy and Subtle MRI Findings

Richard A. A. Day, MD, Lyn Carey, MD
(Salt Lake City, UT)

Early reported incidence of brain tumors occurring in the pediatric age group under treatment for epilepsy ranged from 0.2-0.3%. Although historically, the large majority of these patients harbored mesial temporal lobe sclerosis, more recent reports indicate a 12-25% incidence of neoplasia. A series of 10 patients with epilepsy harboring temporal lobe tumors will be presented. MRI examinations revealed subtle changes in the mesial temporal structures. Because of the the relatively benign appearance of these lesions on MRI, some of the patients experienced a delay in surgical treatment. Histopathological review revealed: astrocytoma (5), anaplastic astrocytoma (2), ganglioglioma (2), oligoglioma (1). This series suggests that patients with epilepsy and nonspecific MRI findings should be carefully considered for early surgical intervention.

34. Functional Mapping and Electrocorticography during Tumor Resections

Paul M. Kanev, MD (Philadelphia, PA)

Seizures are a common initial presentation of brain tumors especially when lesions are located within eloquent cerebral cortex. Resections may be guided by localization of functional cortex and electrocorticography (ECog) for identification and localization of epileptogenic cortex. During the last four years, we have utilized motor and language mapping techniques to maximize tumor resection and enhance the safety of surgery within eloquent tissues. Motor mapping was performed under general anesthesia with biphasic 60 Hz stimulation during craniotomies in 28 patients, 6 months-18 years of age. Speech and language testing was necessary in 5 patients, 12-17 years of age utilizing continuous infusion propofol sedation. Electrocorticography was recorded during each awake operation and during all craniotomies under general anesthesia. Subdural electrode grids were necessary in one patient with a left middle temporal epidermoid tumor who was too young for an awake operation. Cortical tissue was highly epileptogenic along the perimeter of the tumor in 18 cases and in 10 cases, distant epileptogenic foci were apparent. Epileptogenic cortex was excised in its entirety and all patients have remained seizure free on follow-up from 8-24 months. There was no added morbidity during the awake procedures or following functional mapping or electrocorticography. We conclude that a seizure focus may be quite distant from cerebral tumors and recommend electro-corticography for localization of epileptogenic cortex. Functional mapping of language and movement enhances the safety of tissue resection within eloquent cortex.

35. Randomized Trial of Selective Dorsal Rhizotomy with Physio/Occupational Therapy vs. Therapy Alone for Children with Spastic Diplegia

James M. Drake, FRCSC, F. Virginia Wright, MSc,
Elizabeth M.H. Shiel, MASC, Stephen Naumann, PhD,
PEng, John H. Wedge, FRCSC (Toronto, Ontario)

Although selective dorsal rhizotomy has been reported by a number of authors to be an effective treatment for the spasticity associated with cerebral palsy in children, it has not been subjected to a randomized trial to prove its efficacy over physiotherapy (PT) and occupational therapy (OT) alone. A control group is obviously important in a population that is undergoing rapid growth and development.

Twenty-four children aged 3.5 -7.5 years were enrolled in the study. Baseline assessments included the gross motor function measure (GMFM), an isometric contraction test, and gait analysis with a VICON system with force plate, in addition to standard assessments of spasticity and range of joint motion. Patients were then block randomized to either surgery (N = 12), or therapy (PT/OT) alone (N = 12). Therapy consisted of two 1 hr sessions per week. Rhizotomy patients received, in addition, 6 weeks of daily inpatient physiotherapy immediately post surgery. Measurements by independent therapist assessors were repeated at 6 months and at 1 year. Patients in the control group were offered surgery at that point.

At one year, rhizotomy patients had a mean GMFM score increase of 11.3 percentage points, vs. 4.3 in the control group ($p < .03$). There was a significant decrease in the EMG activity and torque resistance for forced dorsiflexion in the rhizotomy group. Although there were significant improvements by gait analysis of stride length, stride time, and gait velocity in the rhizotomy group, they were not statistically different from the control group. Two patients in the control group declined subsequent rhizotomy surgery, and two had orthopedic soft tissue releases, rather than rhizotomy, because of progressive muscle contracture during the evaluation period.

Selective dorsal rhizotomy with postoperative therapy (PT/OT) results in a significant increase in gross motor function at one year over therapy alone.

36. What Does Selective Dorsal Rhizotomy Do for Upper Extremity Function in Spastic Diplegia?

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Effects of selective dorsal rhizotomy (SDR) on upper extremity function are of interest from the standpoint of both clinical benefit and neurophysiological mechanism, but most descriptions of these effects have been qualitative and anecdotal. Objective, quantitative data are needed to define outcomes and to provide a firm basis for shaping parental expectations.

Twenty-six children ranging in age from 3.75 to 10.9 years underwent SDR for treatment of spastic diplegia. Upper extremity function was assessed by measurement of range of motion, manual muscle testing, measurement of grip strength, grading of resistance to quick stretch, grading of movement patterns in standardized manual tasks, and standardized tests of visual-motor control and fine-motor function. Self-care skills in dressing, undressing, and toileting were graded on the basis of parental report. Evaluations were conducted one week prior to operation and one year following operation. Patients served as their own controls.

Overall, selective dorsal rhizotomy had little direct effect on upper extremity function. Range of motion, muscle strength, and muscle tone were unaffected. Grip strength improved significantly, even after control for maturation. Grading of movement patterns demonstrated significant improvements, but benefits from treatment could not be distinguished from the effects of maturation. Visual-motor control and manual dexterity skills were unaffected. Skills in dressing, undressing, and toileting improved significantly, but these benefits seemed attributable to diminished lower extremity tone and normal maturation of prehension patterns.

No inferences should be extended from this study of spastic diplegia to the question of upper extremity function in spastic quadriplegia.

37. Pre-rhizotomy Dorsiflexion as a Predictor of Independent Ambulation for Children with Spastic Cerebral Palsy

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Independent ambulation is one of the primary goals in the management of children with spastic cerebral palsy. Current measures available to maximize ambulatory skills include physical therapy, muscle and tendon releases, and selective dorsal rhizotomy (SDR). The ability to predict which children with spastic cerebral palsy will ultimately attain independent ambulation remains limited. We noted that children who were able to dorsiflex their feet prior to SDR appeared to be more likely to attain independent ambulation than those children who could not dorsiflex their feet preoperatively. This led to completion of a prospective study of 47 children with spastic cerebral palsy [quadriplegics (32%), and diplegics (68%)] using serial documentations of foot movements in isolation and gait scores (graded 0.0-5.0 using a standard ambulation assessment protocol). SDR was performed between age 2 to 6 years (mean 3.57) with a follow-up period ranging from 1.5 to 22 months (mean 7.3). Univariate regression models were used to determine whether 5 different variables [age, preoperative gait score, preoperative dorsiflexion, diagnosis (quadriplegic or diplegic), and length of follow-up] could be used to predict the child's ability to independently ambulate after SDR. Preoperative gait score ($p < 0.001$), preoperative dorsiflexion ($p < 0.01$), diagnosis ($p < 0.001$), and length of follow-up ($p < 0.01$) all correlated directly with postoperative gait score, whereas age did not. This data suggests that dorsiflexion can be used as a predictor of independent ambulation after SDR for children with spastic cerebral palsy.

38. Focal Neurologic Dysfunction Associated with Shunt Malfunction in Achondroplastic Dwarfs

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Michael Fromke, MD (Memphis, TN)

We have encountered an unusual syndrome of focal neurologic deficit produced by shunt malfunction in hydrocephalic achondroplastic dwarfs. The focal deficit accompanied the varied signs and symptoms of increased intracranial pressure. Two of the four developed cranial nerve dysfunction (VI, VII, IX, X) and hemiparesis at the time of shunt malfunction. One child cleared completely two weeks after proximal shunt revision; the second has persistent bilateral VI, VII nerve palsy six years after shunt revision.

Three of the four children had transient focal deficit associated with over-drainage (slit ventricle) syndrome, defined as transient shunt malfunction of abrupt onset completely clearing within hours. Two were successfully treated with siphon control devices, the third required vault expansion in order to control transient episodes of severe intracranial pressure measured with Camino monitor. Two of the three continue to experience vague episodes of transient headache and personality change. MRI scans are unremarkable except for small posterior fossa and foramen magnum.

All four children are achondroplasts who demonstrated progressive ventricular dilatation and macrocrania and underwent ventriculoperitoneal shunting before twelve months of age. The case histories will be presented along with theories as to the etiology of this unique clinical presentation of shunt malfunction in achondroplastic dwarfs.

39. Achondroplasia with Cervicomedullary Compression: Evaluation and Surgical Treatment

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Kerry R. Crone, MD (Cincinnati, OH)

The association between sudden infant death and cervicomedullary compression in patients with achondroplasia has been described. Prospective evaluation of the craniocervical junction with magnetic resonance imaging (MRI) has been recommended for infants with achondroplasia to identify patients at risk. Since 1989, the authors prospectively evaluated 11 infants (average age 13 weeks) with achondroplasia who were asymptomatic for cervicomedullary compression on initial evaluation. MR findings included foramen magnum stenosis with effacement of the subarachnoid spaces, mild to moderate ventriculomegaly, and signal change in the spinal cord from severe cord compression. Two patients with severe cord compression underwent immediate decompression. Two asymptomatic patients developed opisthotonic posturing within 3 months of evaluation and underwent foramen magnum decompression. Decompressive surgery included suboccipital craniectomy, atlantal laminectomy, and duraplasty. Surgery revealed forward extension of the squamous portion of the occipital bone, thickened posterior rim of the foramen magnum, and a dense fibrotic epidural band. There were no complications from surgery. All 11 patients remain asymptomatic at follow up (mean 3 years, 2 months; range 2 months to 6 years) and no patient has required a diversionary shunt procedure for hydrocephalus. Patients are monitored with MRI scans at 2-year intervals. The authors recommend early MR scanning for infants with achondroplasia to determine if there is cervicomedullary compression. With early recognition, an immediate decompression can be performed safely and avoid serious complications associated with spinal cord compression, including sudden infant death. Early decompression may restore normal cerebrospinal fluid circulation at the foramen magnum and reduce the potential for diversionary shunt procedures.

40. Pediatric Lumbar Disc Surgery: Eighteen Patients Under 15 Years of Age

John Shillito, Jr., MD (Boston, MA)

Review of all disc operations on patients under 20 years of age between the years 1959 and 1994, has identified 58 patients. Eighteen of these had their surgery under the age of 15. The youngest was 10-8/12. Five were pre-pubertal. Thirteen of the 18 patients had protrusion of the L5-S1 disc. Initial symptoms involved back pain only or almost painless kyphoscoliosis in 14. Four complained initially of sciatic pain; another four never had sciatic pain.

The location of the disc was central in 13 cases. There were no ruptured discs. The posterior spinal ligament was ossified in six cases requiring bone instruments to uncover the disc space.

Details of the surgery and the follow up history will be given.

41. Comparison of Syringo-pleural and Syringo-subarachnoid Shunting in the Treatment of Syringomyelia in Children

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Olivier Vernet, MD, José Luis Montes, MD
(Montreal, Quebec)

Case records from The Montreal Children's Hospital with the diagnosis of *shunted syrinx* were retrospectively reviewed. From 1984 to 1994, 31 patients had their syrinx treated by (SP) syringopleural (19 cases/Group A) or (SSA) syringo-subarachnoid (13 cases/Group B) shunting. One patient was included in both groups. Associated diagnoses were: In Group A, 2 Chiari I and 14 Chiari II malformations, 14 shunted hydrocephalus, 13 Spina Bifida aperta and 3 occulta; and, in Group B: 5 Chiari I and 2 Chiari II malformations, 3 shunted hydrocephalus, 2 Spina Bifida aperta and 5 occulta. Eight Group A and 6 Group B patients had undergone prior Chiari decompression. Motor deficits predominated in both groups. Pachymeningitis was a uniform operative finding.

Neurological follow-up shows 11 Group A patients improved and 8 stabilized, whereas on MRI, 8 cavities collapsed and 10 were markedly reduced. One patient was reoperated for pleural effusions, and one for shunt displacement. In Group B one patient improved, 8 stabilized, 3 worsened, and one was lost to follow-up. Radiologically, one cavity collapsed, 6 reduced significantly, 2 were unchanged, and 3 enlarged. Four patients were offered reoperation for neurological and/or radiological deterioration, one refused.

We conclude that SP shunting is superior to SSA shunting in treating syringomyelia, that Chiari decompression is suboptimal at controlling it, that perimedullary pachymeningitis may be an important etiological factor, and that SP shunting is a viable option for controlling syringomyelia in patients otherwise asymptomatic from their Chiari malformation.

42. Pediatric Cervical Spine Screw Fixation

Douglas Brockmeyer, MD, Ronald Apfelbaum, MD,
Richard Tippetts, MD, Marion Walker, MD, Lyn Carey, MD
(Salt Lake City, UT)

From July 1986 to August 1993 we performed 24 pediatric cervical spine screw fixation procedures on 23 patients 16 years of age or less. The types of cervical instrumentation procedures performed were as follows: Anterior cervical plates – 12, Posterior C1-2 screw fixations – 8, Posterior lateral mass plates – 2, Odontoid screw fixation – 2. The mean age of all patients was 14.2 (range 6 to 16). Indications for surgery included traumatic instability in 20 cases, congenital instability in one case, two cases of postoperative swan neck deformity, and one reoperation for early graft and hardware failure. Six of the 23 patients had persistent instability following previous failed fusions (3 with 1 prior surgery, 2 with 2 prior surgeries, and 1 with 3 prior surgeries). Eight patients had improvement of their neurological status following surgery and 15 remained at their preoperative level of neurological function. No patient was worse neurologically after operation. There were no long term instrumentation, graft or fusion failures. Two complications occurred. One was the aforementioned graft and hardware failure requiring reoperation, the other was a superficial wound infection treated successfully with antibiotics. We feel that cervical spine fixation techniques have increased our ability to stabilize the pediatric cervical spine and have proven to be safe and effective.

43. Comparison of Operative Versus Non-operative Treatment of Functional Lambdoid Synostosis

Michael Levy, MD, J. Gordon McComb, MD,
Karin Wells, MD, William Gans, BS,
Corey Raffel, MD, PhD, Gerald Sloan, MD
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Regardless of the cause of the asymmetry and whether or not imaging studies show abnormality of the lambdoid suture, the decision to therapeutically intervene in the presence of a functional unilambdoid closure is based solely on degree of the deformity.

Over a 6 year period, 30 patients underwent operative correction for unilambdoid synostosis. Complications included a transient VII nerve palsy, Salmonella Group C1 sepsis post-operatively, and the need to re-operate one patient to fill a bony defect. The cosmetic result were good to excellent for the group. The total medical cost averaged almost \$30,000 per patient.

For the past 2 1/2 years, 41 patients under a year of age with functional unilambdoid synostosis have been referred for an individually molded headband which has been worn for 3-6 months. Twenty-eight infants required 1 band, 9 required 2 bands, and 4 needed 3 bands for optimal therapy. Complications consisted of a minor blistering of the scalp in 1 patient and skin irritation in a few others, necessitating discontinuance of the wearing of the headband until the skin was healed and reduction of the pressure point within the headband. Five (11%) patients were non-compliant with the headband therapy. The cosmetic results were equivalent to that with surgical intervention. The total cost for each headband was \$2,500.

The use of headband is a cost effective way of treating functional unilambdoid synostosis in the infant under 1 year of age and eliminates the need for surgical intervention.

44. Surgical Correction of Sagittal Craniosynostosis: Complications of the pi (II) Procedure

Adrian K. M. Lo, MD, Paul M. Kanev, MD
(Philadelphia, PA)

Many techniques are available for correction of sagittal craniosynostosis. The pi procedure effects an immediate correction of the scaphocephalic skull and excellent cosmetic results have been achieved. The procedure has been criticized because of greater potential surgical complications. We have completed a retrospective analysis of our experience with the pi procedure to determine the morbidity of the technique. Sixty children underwent correction of scaphocephaly during the last 5 years. There were 48 males and twelve females; average patient age was 9.2 months. The modified prone position with bean-bag head support was used in 55/60 cases. Accompanied by barrel-stave and radial osteotomies the reverse procedure was performed in 23 patients with frontal pulling in 37 patients. The average AP skull reduction was 1.5 cm and mean blood loss was 96 cc, 11 cc/kg, replaced in 48 patients. Complications included 2 dural injuries, repaired without difficulty. Air embolism was not detected by Doppler or end-tidal monitoring. One child had a single postoperative seizure. An acrylic cranioplasty was required in one child two years postoperative for repair of a persistent bone defect. We conclude that the morbidity of the pi procedure is limited and compares favorably with other repair techniques. No complications were encountered from the sphinx position and air embolic events were not recorded. We consider the pi procedure the technique of choice for correction of sagittal craniosynostosis in patients older than three months.

45. CT Morphometric Analysis of Occipital Flattening Following Strip Craniectomy: Deformation or Lambdoid Synostosis?

Mark S. Dias, MD, David M. Klein, MD (Buffalo, NY)

Between 1987 and 1992, 30 infants aged 1.4 to 13 months (mean 7.3 months) underwent unilateral lambdoid strip craniectomy for occipital plagiocephaly. Males outnumbered females (22:8) and right sided occipital flattening was significantly more common than left sided flattening (25:5). The deformity was noticed at an average age of 3.2 months; 16% of the infants had an asymmetry at birth. Positional preferences (a distinct tendency to lie preferentially on the back, in most cases with the head turned to the ipsilateral side) were described in 79% of infants for whom this information was available, and torticollis was present in 10%.

Pre and post-operative CT scans were analyzed using several morphometric measurements. Asymmetries were measured between the flattened and contralateral sides, both posteriorly and anteriorly, using a translucent grid placed over the CT slice showing maximum asymmetry. The average maximum asymmetry between the flattened and contralateral sides was 24% posteriorly and 16% anteriorly. Significant improvements were seen post-operatively ($p < 0.05$).

We propose a unifying theory which incorporates a common pathogenesis for both deformational plagiocephaly and most cases of lambdoid synostosis. According to this hypothesis, intra-uterine and/or post-natal deformational forces are responsible for the primary calvarial deformation. These forces initially act in a reversible manner to produce the typical rhomboidal or parallelogram-shaped skull deformity. However, with continued deformation, more enduring secondary pathological changes may eventually occur in the lambdoid suture and basicranium and may be more difficult to correct even if the offending deformational forces are removed or reversed. Future efforts should be directed toward similarly assessing the results of both non-operative treatments such as positional changes and molding helmets, and more aggressive surgical treatments that have been advocated for this disorder.

46. Experimental Acute Subdural Hematoma in Infant Piglets

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R. Barrett (Philadelphia, PA)

Traumatic acute subdural hematoma is associated with high mortality in the pediatric population, especially in infants, yet the pathophysiology remains poorly understood. The objective of this study was to develop an infantile model of acute subdural hematoma in a gyrencephalic animal, to see whether the large "infarctions" seen in rodent models would be reproduced. Twelve 10-day-old piglets were studied. A 5 mm burr hole was made in the right frontal skull, and a small silastic tube was inserted into the subdural space and secured with cyanoacrylate. A craniotomy (1.5 x 1.75 cm) was made in the right parietal bone with the dura left intact (closed cranial window). Injection of 2, 3, or 5 ml autologous, non-heparinized blood was accomplished over 7 minutes through the silastic tube. During the subdural injection, intracranial pressure rose to 62 ± 8 mm Hg, and returned to baseline within one hour. Mean arterial blood pressure increased transiently. One animal demonstrated bilateral posterior limb weakness for 24 hours; all other animals were neurologically normal. Animals were sacrificed after 24 or 72 hours. Cresyl violet and hematoxylin and eosin staining demonstrated extensive areas of necrosis under the hematoma in all cases in which 5 cc were instilled and survival was 72 hours (N=7). Zones of necrosis were sharply delineated from surrounding normal brain. No selective neuronal loss was noted in the non-necrotic cortex or in the hippocampus. This is the first reported pediatric model of acute subdural hematoma. This model confirms the finding of significant delayed neuronal loss underlying the clot in an immature animal, and can be used in future studies to investigate therapies designed to limit damage in this setting.

47. Infant Head Injury Data Base: 20 Year Experience in the Post-computed Tomography Era

John G. Piper, MD, Michael G. Muhonen, MD,
Matthew A. Howard, III, MD, B. A. Bell, MD,
David Uttley, MD (Iowa City, IO)

Atkinson Morley's Hospital provides exclusive neurosurgical care for southwest London (population 3 million) and was the first institution to employ computed tomography (CT). Between 1970 and 1990, 100 cases of infantile head injury ($\bar{\mu}$ age 9.2 months) were reviewed retrospectively in an attempt to predict long-term outcome from presenting signs and symptoms. The mechanism of injury included 61 falls, 21 cases of child abuse, and 10 motor vehicle accidents. Twenty-eight patients had subdural hematomas, 12 had cerebral edema without hemorrhagic lesion, eight had epidural hematomas, 4 had cerebral contusions, and 2 had intraventricular hemorrhage. Forty-five patients required operations, including evacuation of hematomas, elevation of depressed skull fractures, intracranial pressure monitoring, and shunt procedures. At a mean follow-up of 10.5 years, 73 patients were normal, 8 exhibited developmental delay, 7 had residual fixed neurological deficits and 12 patients were dead (two from unrelated illnesses). Magnitude of midline shift was significantly greater ($p < 0.01$) in fatal vs. nonfatal outcome. Average midline shift was 13.4 mm in those infants that died, 9.0 mm in those with residual deficits, and 1.8 mm in normals. Three patients with epidural hematomas exhibited midline shift up to 15 mm and made full recoveries. Those with fatal head injuries and subdural hematomas had significantly lower GCS (5.0 and 9.1 respectively) than normals (11.2). This review suggests that, exclusive of epidural hematomas, a poor outcome from infantile head injury can be predicted from the extent of midline shift and initial GCS.

48. Improved Outcome for Accidental Traumatic Brain Injury in Childhood Using "Standard" Therapy, Aggressively Applied

James Callahan, MD, Robin Bowman, MD,
Thomas G. Luerssen, MD (Indianapolis, IN)

Since 1989 all pediatric patients admitted for the management of traumatic brain injury have been treated with a standardized regimen aimed at keeping the ICP low and the systemic blood pressure, intravascular volume, and fluid and electrolyte parameters as normal as possible. Therapy of elevated ICP is escalated in response to changes in cerebral compliance, prior to deterioration of ICP and targeted to the presumed pathophysiology.

During this period, 420 patients were admitted for the management of nonpenetrating traumatic brain injury. Using GCS (after nonsurgical resuscitation) criteria, there were 64 (15%) severe injuries, 45 (11%) moderate injuries, and 311 (74%) mild injuries. Basic therapies included mild hypothermia ($T=34-35^{\circ}\text{C}$), sedation, muscular paralysis and ventilatory support. Graded escalations of therapies advanced through mild to moderate hyperventilation (PaCO_2 25-35) if indicated, osmotic diuresis, ventricular drainage, severe hyperventilation if indicated, barbiturates, and profound osmotic therapy using intravenous glycerol.

There were 16 deaths; an overall mortality of 4%. All head injury related deaths occurred in patients presenting with a GCS of 5 or less. Seven of the patients who died (43%), were brain dead on arrival and were supported only to undergo evaluation as organ donors. Therefore, the mortality for severe head injury (GCS 3-8) in patients treated was 9/57 or 16%. Furthermore, in the patient population with severe head injury, 12 were infants with nonaccidental injury. When the mechanism of severe brain injury was accidental, only 2 of 50 patients died.

In summary, aggressive medical therapy of elevated ICP and prevention of systemic complications has resulted in an extremely low mortality for accidental closed head injury in childhood. We will present the characteristics of the patient population and the treatment strategies.

49. Surgical and Non-surgical Treatment of Traumatic Epidural Hematomas In Children

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Robert A. Sanford, MD, Donna Swain, MD,
Michael S. Muhlbauer, MD, Elizabeth Kirk, RN
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In the past, traumatic epidural hematomas (EDH) in children have been treated aggressively with emergency surgery. Over the past 5 years, we have individualized treatment, avoiding surgery in neurologically stable children with small EDH demonstrated on CT scan without other intracranial injuries. Children with additional intracranial pathology, massive or enlarging clots, or deteriorating clinical status are surgical candidates.

From 1990 through 1993, 40 children were seen with traumatic EDH at our hospital. The records and radiographs of 34 were available for review. Eighteen children underwent surgical evacuation of their EDH. Sixteen were treated non-operatively. Average clot volume was over six times greater in children who underwent surgery than in those who were not operated. Length of hospital stay averaged 9.6 days for children undergoing surgery and 5.5 days for those whose EDH were treated nonoperatively. Outcome in the non-operated group was excellent in every case.

The presence of epidural hematoma on the patient's CT scan is not by itself an indication for surgery. Clinical grade, presence of additional intracranial pathology, and clot size should all be considered in decisions regarding surgery.

50. Frontal Lobe Changes after Severe Diffuse Closed Head Injury in Children: A Brain Morphometric Study of MRI

Harvey S. Levin, PhD, Derek Bruce, MD,
Phillip Berryhill, BS, Matthew Lilly, MA,
Dianne Mendelsohn, MD, Gilbert Hillman, PhD
(Baltimore, MD)

In view of the pathophysiology and biomechanics of severe closed head injury (CHI) in children, we postulated that the frontal lobes sustain diffuse injury, even in the absence of focal brain lesions detected by magnetic resonance imaging (MRI). This study quantitated the morphologic effects of CHI on the frontal lobes in children who sustained head trauma of varying severity. The MRIs of 14 children who had sustained severe CHI (Glasgow Coma Scale score of ≤ 8) were compared to the findings in a matched group of 14 children having sustained a mild head injury (Glasgow Coma Scale score of 13-15, unconsciousness of 20 minutes or less, normal neurologic findings, and no severe extracranial injury). The patients ranged in age from 5-15 years at the time of MRI, which was acquired at least three months postinjury. MRI revealed no focal areas of abnormal signal in the frontal lobes. Volumetric analysis disclosed that the total prefrontal cerebrospinal fluid (CSF) was increased and gray matter volume decreased in the severe CHI patients relative to the mildly injured comparison group. Gray matter volume was also reduced in the orbitofrontal and dorsolateral regions of the severe CHI group relative to the children who sustained mild head trauma. These volumetric findings indicate that prefrontal tissue loss occurs after severe CHI in children, even in the absence of focal brain lesions in this area. Nearly two-thirds of the children who sustained severe CHI were moderately disabled after an average postinjury interval of three years or more, whereas 12 of the 14 mild CHI patients attained a good recovery (two were moderately disabled) by the time of study. Although this initial study of brain morphometry after CHI in children was not designed to isolate the contribution of frontal lobe damage to residual disability, further research involving a larger sample is in progress to address this issue.

51. The Role of Apnea in Severe Nonaccidental Head Injury

Dennis Johnson, MD, Raymond Baule, MD,
Danielle Boale, MD (Hershey, PA)

Severe nonaccidental head injuries in children have a poor prognosis. The mechanism of injury is poorly understood because the injury is seldom witnessed, but shaking has been accepted as the most probable cause of injury. Dunhaim et al. have accumulated convincing clinical and experimental evidence that impact plays a pivotal role in the pathogenesis of a shaken baby syndrome. Common to both the shaking and the shaking-impact mechanisms are the high mortality and morbidity despite lack of direct parenchymal injury.

We have reviewed 30 cases of child abuse involving the central nervous system. Twelve of the cases were discarded because the records or films were inadequate or because there was inadequate documentation for child abuse. Of the remaining children, 44 percent demonstrated abnormal breathing at the scene of the injury, 78 percent of the children presented to the hospital with a seizure, 78 percent were intubated on admission, and 56 percent demonstrated clear evidence of ischemic infarction on neuroimaging studies. Nine children had suffered impact injuries as defined by the presence of a skull fracture and/or soft tissue swelling of the head. Nine other children had suffered shaking injuries as confessed by the perpetrator and evidenced by the lack of soft tissue swelling or skull fracture. There was no significant difference between the shaking and shaken-impact groups in the incidence of breathing abnormalities or radiographic ischemic changes.

We hypothesize that apnea is the trigger to the pathophysiologic cascade culminating in the clinical manifestations of the shaken baby syndrome and that the resulting ischemia/hypoxia is the fundamental brain insult rather than subdural hemorrhage, subarachnoid hemorrhage, parenchymal shear, or brain contusion. Moreover, apnea can be caused by shaking alone or by shaking-impact.

52. High-grade Astrocytomas in Children

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High-grade astrocytomas comprise roughly 10% of intracranial tumors in children, and these tumors have been reported to carry a better prognosis in children than adults. To determine factors associated with long-term survival, we reviewed the medical records of 31 children with non-brainstem high-grade astrocytomas who were treated at the Children's Hospital of Pittsburgh between 1975–1992. Histology was independently reviewed according to the WHO classification system by a neuropathologist unaware of the patients' outcome; neuroimaging was reviewed to determine extent of resection. Three patients who died perioperatively were censored from further analysis.

Median survival for the remaining 28 patients was 18.5 months with 10 patients (36%) still alive in March, 1994 (median followup: 58.5 mo.; range: 25-124 mo.). Median progression-free survival (PFS) was 10.5 months; 8 patients (29%) were without progression of disease (median: 66 mo.; range: 34-124 mo.). Extent of resection at initial surgical intervention was strongly predictive of PFS. 13 patients (48%) who underwent subtotal resection (< 90%) and 7 patients (26%) who underwent near total resection (90-99%) had median PFS of 5.5 months and 11 months respectively, results that are similar to those reported in adults. Only one such patient remained free of progression. In contrast, none of the 7 patients (26%) who achieved gross total removal of tumor confirmed by postoperative neuroimaging had progression of disease with a median followup of 72 months (range 34-124 mo.). Extent of resection (gross total vs. subtotal/near total) strongly correlated with both PFS and survival in multivariate analysis ($p = 0.0002$). Lobar location of tumor was also associated with improved PFS on univariate analysis ($p = 0.009$) but lost significance in multivariate analysis due to the greater correlation of extent of resection with PFS. In addition, patients with anaplastic astrocytomas had a significantly improved PFS when limiting the analysis to those with lobar tumors that were incompletely resected ($p = 0.018$).

Our results indicate that children with completely resected lobar high-grade astrocytomas have a strikingly better prognosis than children with radiologically evident residual tumor. These findings support the role of cytoreductive surgery in the treatment of non-brainstem high-grade astrocytomas in children. In addition, these results provide evidence that certain childhood malignant astrocytomas may constitute a biologically distinct group that by virtue of their location or growth characteristics are uniquely amenable to aggressive resection.

53. Results of Stereotactic Radiosurgery for Treatment of Recurrent Ependymoma

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From April 1988 until September 1993, 22 (21) patients with recurrent or residual (1) ependymoma were treated with stereotactic radiosurgery (SRS). There were 2 adults and the remaining patients were children. All patients had received prior conventional radiotherapy, 14 had received adjuvant chemotherapy. There were 8 anaplastic ependymomas. The site of disease treated was infratentorial in 17 patients and supratentorial in 5. The median dose was 1400 cGy administered in a single fraction prescribed to the 90% isodose line. Tumor volumes ranged from 1.24 cubic cm to 14.9 cubic cm. Follow-up ranged from 3 to 50 months. 18 patients developed radiographic changes consistent with effects of radiosurgery. 13 patients required steroids for symptomatic radionecrosis and 7 underwent reoperations. At time of surgery, necrosis only was found in 4 patients, predominantly tumor in 2 and both tumor and necrosis in one. There were 16 deaths. The remaining six patients are alive at 9, 10, 11, 12, 14 and 26 months following treatment with SRS. Two of them have had reoperations at which time no active tumor was identified histologically. Patterns of failure were both local (site of primary disease) and distant (supratentorial or spinal) with marginal failures occurring in 2 patients. We conclude that stereotactic radiosurgery can be administered as a mode of palliation in patients with recurrent/residual ependymoma. Symptoms of radionecrosis should be treated promptly with steroids and/or reoperation to prevent permanent lower cranial nerve dysfunction and its associated morbidity.

54. Outcome Following Multidisciplinary Management of Visual Pathway Gliomas

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Peter Phillips, MD, Roger Packer, MD (Philadelphia, PA)

The feasibility of radical surgery for astrocytomas of the optic chiasm/hypothalamus has recently been reported by several groups. Such surgery carries significant risks, however, including permanent damage to the pituitary gland, optic apparatus, hypothalamic structures, and carotid arteries. The benefits of radical surgery should thus be evaluated against standard therapy, as is usually done for new chemotherapeutic protocols, both in terms of efficacy and toxicity.

To this end, a retrospective review was performed of 33 patients treated at CHOP between 1976 and 1991 which met criteria which the author considered would have made them eligible for radical surgery in many centers today, but were actually treated with either no surgery or conservative surgery (< 50% resection) or biopsy followed by adjuvant therapy with local radiation therapy (28 pts) and/or chemotherapy with actinomycin-D and vincristine (18 patients). The review encompassed all patients with a globular enhancing mass of at least 2 cm in the hypothalamic/chiasmatic region, no evidence of involvement of optic radiations by CT or MRI scan, and follow-up of at least 3 years. All but 1 patient had tissue confirmation, confirming a low-grade or pilocytic astrocytoma, and 2 patients with malignant histology were excluded from analysis. The mean age at diagnosis was 6.2 years. Thirteen of the patients were 2 years of age or younger at diagnosis.

Five patients died, four of tumor progression and one of acute shunt malfunction. Two of the patients who ultimately died underwent radical removal of their tumors at recurrence following initial therapy, but went on to die anyway. The remaining patients were alive at last follow-up (3-19 years, average 9.6). Infants fared no worse than older children in terms of survival. Functional status of survivors was also reviewed. Of the 28 survivors, all but 3 patients have vision in at least one eye such that they can read. 11 require no endocrine medication. 16 are in, or have completed regular school. 10 patients are older than 18 years of age at last follow-up. One is lost to follow-up, but of the remaining 9, 5 graduated regular high school, 4 attended college, 5 hold down jobs. Poor prognostic factors for "quality of life" include NF1 and early age at XRT.

continued on next page

If radical surgery is to become standard care for children with low-grade astrocytomas of the hypothalamic/chiasmatic region, results will have to equal or surpass those of historical controls, both in terms of long term survival and functional outcome.

55. Chordomas in Children

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Paul G. Matz, MD, A. James Barkovich, MD,
Michael S. B. Edwards, MD (San Francisco, CA)

Chordomas are primary bone tumors that arise from notochordal vestigia. They typically present in adulthood, a feature that belies their derivation from embryonic tissue. They are rarely encountered in the pediatric population (< 16 years). There is little information regarding their clinical, radiographic or pathologic presentation, and no consensus regarding treatment.

The records of eighty-three patients with pathologically-proven chordomas treated at UCSF between 1981 and 1994 were reviewed to identify patients < 16 years of age. Three patients were identified. The medical literature from 1920 was reviewed to identify previously reported pediatric chordomas. We identified 45 clival chordomas, 10 vertebral chordomas, and 6 sacrococcygeal chordomas in patients < 16 years of age. The data on these 61 patients and on our 3 patients forms the basis of this report.

Unlike adults, chordomas in children occur most commonly in the spheno-occipital region (approximately 60% of cases). Long tract signs (65%) and cranial neuropathies (56%) are the most common presenting signs. Other presentations include torticollis and failure to thrive. A lack of contrast enhancement of a skull base tumor on MR is suggestive, but not pathognomonic for chordoma.

We believe that aggressive surgical resection of the tumor and postoperative proton beam irradiation is the treatment of choice for children with chordomas. Specific management difficulties involved in treating children with chordomas, including issues related to surgical accessibility, the role of adjuvant therapies, and stability of the developing spine, are discussed.

56. The Therapeutic Potential of Enhanced Chemotherapy Delivery via Osmotic Opening of the Blood-brain Barrier in Pediatric Brain Tumor Patients

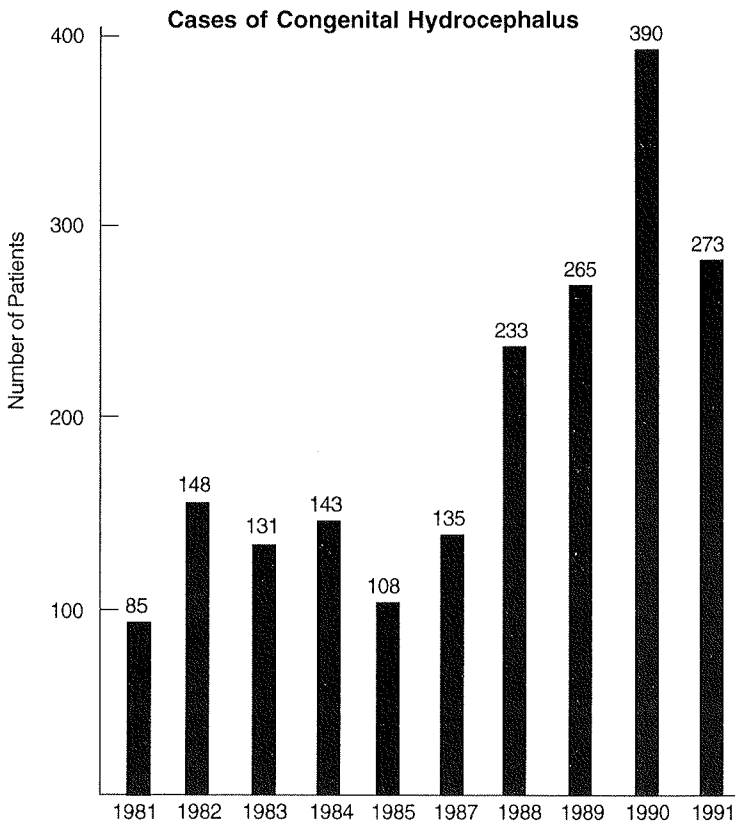
Edward A. Neuwelt, MD, Suellen A. Dahlborg, RN, JD,
Annie Grummel, RN, ANP, Victoria Strider, RN, CNS,
John Crossen, PhD, Simon Roman-Goldstein, MD,
Mara Tableman, PhD (Portland, OR)

A series of 22 pediatric patients with a myriad of intracranial malignancies [21 histologically confirmed including primitive neuroectodermal tumor (n=5); CNS lymphoma (n=4); germ cell tumor (n=3); brain stem glioma (n=3); high grade glioma (n=2); ependymoma (n=2); acute lymphocytic leukemia (n=2); and 1 radiographically documented with brain stem glioma] were entered into a combination chemotherapy regimen in conjunction with osmotic opening of the blood-brain barrier between August 1981 and May 1993 with follow-up to May 1994. Patients ranged in age from 2 to 18 years (median = 11 years) with 14 females and 9 males. Twelve patients received cranial radiation (including 3 with craniospinal radiation) prior to referral. These 22 patients underwent a total of 361 infusions (median = 16) with intraarterial methotrexate or carboplatin based chemotherapy with no procedure related mortality and minimal morbidity. Patients receiving carboplatin based therapy often experienced significant high frequency hearing loss. Eight patients had complete radiographic response (3 patients with primitive neuroectodermal tumor; 3 with CNS lymphoma; and 2 with germ cell tumor). Additionally, 3 of 4 brain stem glioma patients had an objective clinical response to treatment. The majority of patients underwent extensive baseline neuropsychologic testing with serial evaluations conducted on patients with complete response alive ≥ 1 year from initiation of treatment. Eight patients are currently alive 22 to 78 months from diagnosis including 5 with no evidence of disease. Patients with CNS lymphoma, primitive neuroectodermal and germ cell tumors often attain a complete response without cognitive loss and patients with brain stem gliomas have attained palliation. The durability of responses is currently being assessed and increased accrual is anticipated by establishing a multi-institutional blood-brain barrier treatment program.

57. Dynamics of the Frequency of Developmental Abnormalities and Brain Tumours in Children Before and After the Chernobyl Disaster

Yuri A. Orlov, MD, DSc, Sergey Y. Rasskazov, MD
(Kiev, Ukraine)

An analysis is presented of children with developmental abnormalities and brain tumours from 1981 through 1991. Congenital hydrocephalus, spinal and brain hernias numbered 3881, brain tumours – 1899 cases. The incidence of children asking medical advice with developmental abnormalities rose during the last five years by 63,7 % (hydrocephalus – 110,4 %, hernias – 29,3 %). The incidence of brain tumours independent of the location, malignancy grades and lace of residence of the patients in the territory of the Ukraine rose during the last five years by 51,2 %. The problem is raised of including the above-mentioned pathology to the State Register of Chernobyl accident sequaleae.



58. Pitfalls of Segmental Gadolinium Enhancement of Pediatric Posterior Fossa Tumors

Robert A. Sanford, MD, James Langston, MD,
Brett Gunter, MD (Memphis, TN)

Pediatric brain tumors generally enhance vigorously with intravenous Gadolinium on MR (magnetic resonance) imaging. Occasionally astrocytomas especially pilocytic type show no enhancement. The lack of tumoral enhancement presents significant problems for the neuroradiologist and neurosurgeon when attempting to determine postoperatively whether a gross total resection has been achieved. The authors have previously described the pitfalls encountered in the assessment of total resections and have demonstrated the efficacy of neuroimaging obtained within 36 hours post surgery.

In this presentation we describe 35 children with posterior fossa tumors in which a portion of the tumor enhances with Gadolinium on MR scanning (33 medulloblastomas, 2 ependymomas) while a portion failed to enhance.

During this period of time, 1989 to 1994, 121 posterior fossa tumors were resected. There were 67 medulloblastomas, 16 ependymomas, 36 astrocytomas, and 2 others. We have not encountered a low grade astrocytoma with partial enhancement.

The non-enhancing portion must be recognized as tumor preoperatively by the surgeon for adequate presurgical planning. The postoperative images must be obtained within 36 hours post resection and anatomical landmarks utilizing identical slices are necessary to accurately assess the degree of resection since lack of enhancement does not equate to total resection. In one child we performed stereotaxic biopsy to confirm gross total resection.

Illustrative cases and imaging guidelines will be suggested.

59. Surveillance Imaging in Children with PNET

Michael L. Levy, MD, William Gans, BS,
Ehud Mendel, MD, Harold Pikus, MD,
Corey Raffel, MD, PhD, J. Gordon McComb, MD
(Los Angeles, CA)

Controversy surrounds the benefit of routine surveillance magnetic resonance or computerized tomographic imaging for monitoring children with a resected primitive neuroectodermal tumor (PNET). A recent study reported that serial imaging studies detect only a small minority of recurrences and that no patient with a recurrence survived. We reviewed our experience of patients with PNET to determine the incidence of recurrent PNET detected by surveillance imaging alone compared to those children with symptoms from recurrent tumor, as well as the potential difference in survival time of the 2 groups.

The study group was 65 patients with PNET who presented to our institution from 1985–1993. Twenty-five patients (17 males, 8 females) with a mean age at the initial diagnosis of 5.0 years were found to have recurrent tumor (38%). Recurrent tumor was documented on routine imaging in 19 asymptomatic patients (76%), and in 6 (24%) who were symptomatic. Following recurrence, all but 6 patients underwent further treatment (chemotherapy, radiation, and additional resection of tumor in various combinations).

Recurrences were found in asymptomatic children on the average of 15.0 months after the initial diagnosis, and 4.7 months for patients with symptoms of recurrent tumor ($p \leq 0.01$). The survival was, on the average, 27.3 months for asymptomatic patients and 15.2 months for those who were symptomatic ($p \leq 0.05$).

This study found that 19/25 children were diagnosed with recurrent PNET by surveillance imaging before becoming symptomatic. In the future, better therapeutic modalities initiated early and before the onset of symptoms may alter the prognosis of patients with recurrent PNET.

60. Magnetic Resonance Imaging Within 24 Hours of Craniotomy for Tumor in Children

Allen Oser, MD, Bruce A. Kaufman, MD, T. S. Park, MD,
Christopher Moran, MD (St. Louis, MO)

MRI is used in the evaluation of patients with neoplastic CNS disease, with early post-operative scanning thought to allow better identification and quantitation of residual tumor. The accurate assessment of residual tumor may be compromised by MR's exquisite sensitivity to blood breakdown products and by non-neoplastic contrast enhancement. We retrospectively reviewed the non-enhanced and enhanced MR scans of 15 patients obtained within 24 hours of craniotomy. The ability to define residual tumor and the extent of non-neoplastic enhancement in the corticotomy and in non-contiguous sites was assessed.

The presence or absence of residual tumor could not be determined in 54% of the patients; only large amounts of residual tumor were easily seen. The short T1 signal of met-hemoglobin has been thought to take several days to develop, but was detected in nearly 70% of our studies. This signal often interfered with the ability to identify residual tumor or tumor enhancement. Enhancement of a corticotomy (through brain not contiguous with neoplasm) occurred in 67%. There was enhancement of the cranial meninges remote from the craniotomy site in 70% of the patients who had no disseminated neoplasm.

MRI within 24 hours of craniotomy can reliably define gross tumor resection, but accurate detection of small amounts of residual disease appears severely limited when using MRI alone, even if scanning occurs within 24 hours of surgery. The bright T1 signal of met-hemoglobin develops within this time period, and small amounts in the resection bed severely impaired the ability to identify residual tumor or enhancement. The high frequency of remote meningeal enhancement precludes use of only the immediate post-operative MR to diagnose disseminated neoplasm. Delineation of minimal residual neoplasm may require the surgeon to correlate intra-operative with MRI findings, or the use of as yet undefined unique MR techniques.

61. Treatment of Childhood High Grade Glioma with Dose Cyclophosphamide

Geoff McCowage, Henry S. Friedman, MD,
Herbert E. Fuchs, MD, PhD (Durham, NC)

Seventeen children (< 21 years old) were treated with high dose cyclophosphamide (2g/m²/dose for two consecutive days each month) followed by GM-CSF (250 ug/m² bid given subcutaneously) as therapy of newly diagnosed or recurrent high grade glioma. Patients treated for newly diagnosed tumors were required to have radiographic evidence of residual disease following initial surgical intervention. Twelve patients had glioblastoma multiforme (GBM), four with recurrent tumors and eight with newly diagnosed tumor. The patients with recurrent tumors had received surgical intervention (8), radiotherapy (3), and chemotherapy (3). Five patients had anaplastic astrocytoma (AA), three with newly diagnosed tumors and two with recurrent tumor. Four of these twelve patients with GBM demonstrated complete responses, all of whom had newly diagnosed tumor. No patient with AA demonstrated a response. Toxicity consisted of Grade 4 hematologic toxicity, primarily neutropenia in all patients.

These results suggest that cyclophosphamide may be an active agent against childhood GBM and warrants incorporation into a multi-agent adjunctive therapy regimen.

62. Protein Kinase C Isozymes in Malignant Glioma Cell Lines

Timothy B. Mapstone, MD, G. Yancey Gillespie, PhD,
Jui-Chang Tsai, MD, Sumon Bharara, MS,
Corey K. Goldman, MD (Birmingham, AL)

Protein kinase C (PKC) denotes a complex family of closely related serine/threonine protein kinase isoenzymes that can mediate a wide range of signal transduction processes in cells. While free fatty acids, notably phosphatidylserine, play a role in activation of all members of this complex family, *the conventional* (α , β_1 , β_{11} , γ) and *novel* (δ , ϵ , η , θ) PKC members are physiologically activated by diacyl glycerol (DAG) generated by binding of various ligands to their cellular receptors. The *conventional* isoforms require Ca^{++} for activation while the *novel* isoforms do not. The few *atypical* PKC isoforms (ζ , λ) described are both Ca^{++} and DAG-independent.

We have previously shown that malignant glioma cell lines stimulated with growth factors Epidermal Growth Factor (EGF), Platelet-derived Growth Factor-BB (PDGF-BB) or basic Fibroblast Growth Factor (bFGF) variably use PKC-mediated pathways for glioma cell growth promotion and to activate gene expression for Vascular Endothelial Growth Factor (VEGF), a potent mediator of tumor neovascularization and edema. Phorbol myristate acetate (PMA) and Ca^{++} can elicit a similar response and prolonged PMA pretreatment can down-regulate this response by 50%. These data suggest that DAG-independent PKCs may be involved. To narrow the search for specific PKC-mediated mechanisms that could serve as targets for PKC inhibitor drug therapy, we screened cell lines from 11 gliomas, 2 neuroblastomas and a meningioma for PKC protein and mRNA, using western blotting and reverse transcriptase-polymerase chain reaction (RT-PCR). PKC isoforms α , δ and ϵ were present in all cell lines by both techniques while PKC β_1 and β_{11} isoforms were notably absent in all glioma cell lines. However, one commercially available PKC β -specific antibody gave contradictory results due to an inappropriate cross-reactivity with an unknown protein of approximately 65-70,000 daltons. Several other antibodies to β_1 and β_{11} isozymes did not detect this molecule. PKC γ was expressed unequivocally in 8 of 11 gliomas while PKC ζ was seen unequivocally in 7 and marginally in 4. These data confirm and extend previous findings and provide a basis to examine the role of specific isozymes in VEGF activation *via* EGF, PDGF-BB or bFGF.

63. Intracranial and Orbital Complications of Pediatric Sinusitis

Walker L. Robinson, MD, M. Rothman, MD,
M. Mittelman, MD, Greg Heacock, MD, F. Mihari, MD,
P. Haney, MD, Gregg Zoarski, MD, W. Gray, MD,
D. Rigamonti, MD, Y. Numaguchi, MD (Baltimore, MD)

Upper respiratory infections and sinusitis are common problems in the pediatric age group. A small subset of those patients will develop severe intracranial and orbital problems despite antibiotic therapy. The authors performed a four year retrospective case review of all pediatric inpatients presenting with complicated sinusitis to a large urban university teaching hospital.

Intracranial or orbital complications of sinusitis were seen in 17 patients (ages 1-15 years, 14 males, 3 females) over a four year period. All patients presented with findings referable to the complications, during or just after completion of antibiotic therapy for URI, most within one week of beginning treatment. All patients had direct extension of infection from the sinuses to adjacent structures. Most presented with typical pediatric bacterial pathogens. The HIV status was initially negative in all cases. One patient subsequently converted to HIV positive over the next two years.

Computed tomography of the brain and/or orbit and/or sinuses was performed in all 17 patients, with 15 receiving intravenous contrast. 13 patients also had magnetic resonance imaging of the brain, all with Gd-DTPA. CT and/or MRI demonstrated the contiguous location in all 15 cases, with a bony defect seen in 11 patients.

All of the sinuses were involved in various combinations, although, no patient had disease limited to the maxillary sinuses. Treatment consisted of surgical drainage and long-term (8-12 weeks) intravenous antibiotic therapy.

CONCLUSION

Serious intracranial and orbital complications can occur secondary to sinusitis and/or URI in nonimmunocompromised pediatric patients despite antibiotic therapy thought to be adequate for typical childhood bacterial pathogens.

Patients typically presented early in the course of antibiotic therapy due to the complications from contiguous extension of infection from the paranasal sinuses to adjacent sites.

Scientific Posters

1. Posterior Fossa Craniopharyngioma Presenting with Deafness: Report of Three Cases and Review of the Literature

Peter W. Carmel, MD, FACS, E. Sander Connolly, Jr., MD,
Christopher J. Winfree, BA (New York, NY)

The authors report three cases of giant cystic craniopharyngiomas extending into the posterior fossa and initially presenting in childhood with either unilateral or bilateral deafness. Autopsy studies and recent reviews show that while four percent of craniopharyngiomas will have posterior fossa extension at initial operation, and twelve percent will subsequently develop this extension during their course, only one patient in the literature has been shown to present with deafness which preceded the more typical suprasellar signs and symptoms of increased intracranial pressure, endocrine disturbance, altered mentation, and visual deterioration. Together these cases will be presented, the literature on posterior fossa craniopharyngioma reviewed, and staged operative management will be discussed.

2. Strangulation Injury in Childhood

William C. Hanigan, MD, PhD, Robert A. Sabo, MD,
Kelly Flessner, RN, Jean Rose, RN, Mary Aaland, MD
(Peoria, IL)

Over the past four years, 7.4% of deaths due to strangulation in Peoria County, Illinois involved children under 18 years of age. Clinical review of a consecutive series of 12 children treated from 1985 to 1992 revealed an incidence of 33/10,000 ICU admissions with a 6:1 male bias. Accidental causes were seen in 6 children with suicide or auto-erotic causes prevalent in older children and adolescents. Five children had behavior disorders prior to injury. Six children required ventilatory assistance; 4 had pneumonia or respiratory distress syndrome. Intracranial pressure (ICP) monitoring in 3 children failed to reveal sustained elevations. Ten children were normal on follow-up; one child had mild sequelae and one child showed severe disability. Values below 8 on the initial Glasgow Coma Scale (GCS) and the requirement for ventilatory assistance were associated with neurologic sequelae. Published autopsy series indicated that 1-9% of strangulation deaths involved children; epidemiological descriptions were similar to our series. Clinical reports described 26 children with strangulation injuries. Cervical injury was not seen. Pulmonary edema occurred in 11 (42.3%) children; 7 died or showed severe sequelae. Nine (34.6%) children developed increased ICP; death or severe neurological sequelae occurred in all these cases. These clinical data suggested that the incidence of childhood strangulation was not uncommon and that pulmonary damage and elevated ICP were frequent complications. Initial values below 8 on the GCS were reasonable therapeutic guidelines for ICP monitoring; higher values indicated a good prognosis. Continued awareness of the potential for accidental injury in infants as well as self-destructive behavior in children with behavior disorders may reduce the occurrence of these injuries.

3. Cerebrovascular Hemodynamics in Children Following Strangulation Injury

William C. Hanigan, MD, PhD, R. A. Sabo, MD,
K. Flessner, RN, J. Rose, RN, M. Aaland, MD,
J. Aldag, PhD (Peoria, IL)

Continuous cerebrovascular monitoring was obtained in 2 children (10 and 13 years old) at 8-60 hours with global hypoxic-ischemic injury following strangulation. Regional CBF was measured every 15 minutes with a subdural diffusion probe, ICP, MAP, end tidal CO_2 , Pa_{CO_2} , Pa_{O_2} , and pH were measured in both children; cardiac output (CO) and index (CI), SvO_2 , and SaO_2 were measured in the second child. Dopamine infusion and hyperventilation tested autoregulation and CO_2 reactivity. Perfusion pressure (PP), intracranial resistance (IR), CO_2 reactivity, and statistical analyses were calculated with SPSS PC +V4.01 and Pearson correlations. Initial coma scores were 5 and 4. Both children demonstrated reactive hyperemia (mean CBF = 91.0 and 80.8 ml/100g/min) with mean CO_2 reactivities of 1.8 and 1.96. Significant increases for both variables occurred during observation. Mean PP was 66.8 and 72.2 mm Hg and positively related to CBF. Autoregulation was absent in the first child; significant positive responses of CBF to levels of Pa_{CO_2} were seen in both children. Mean IR was 0.72 and 0.95 mm Hg/mm/100g/min. ICP was not elevated but positively related to CBF for both children. CBF was not related to CO, CI, arterial pH, or Pa_{O_2} . In summary, reactive hyperemia associated with cerebral vasodilatation was seen in two children following global hypoxic-ischemic injury. Autoregulation was absent in one child. CO_2 reactivity showed gradual increases over time with intact but limited responses of CBF to levels of Pa_{CO_2} . ICP was not elevated but positively associated with levels of CBF suggesting that severe hyperemia or unregulated therapeutic elevations of PP may result in intractable elevations of ICP in noncompliant systems.

4. WITHDRAWN

5. Andrew Arendt—First Pediatric Neurosurgeon in Russia

Boleslav L. Lichterman
(Russian Postgraduate Medical Academy, Moscow)

First attempts of neurosurgical treatment of pediatric cases were reported in Russia in the middle of 19-th century. The articles on surgical correction of encephalocele and myelocele and treatment of hydrocephalus by repeated ventricular and lumbar punctures with subsequent tight bandaging of the head appeared in 1880-ies and 1890-ies Russian surgical periodicals.

But it was Andrew Arendt (1890–1965) who became first pediatric neurosurgeon. Pediatric beds appeared at the Burdenko Neurosurgical Institute in Moscow as early as 1935. Forty-bed pediatric neurosurgical department was opened there in 1946. It was headed by Andrew Arendt, who published the first monograph “Hydrocephalus and Its Surgical Treatment” in 1948. There he analysed about 100 hydrocephalic cases and described new approaches in their preoperative evaluation and surgical treatment. In order to differentiate communicating and occlusive forms of hydrocephalus he used a special liquorodynamic test by simultaneous ventricular and lumbar puncture. The occlusive forms were treated mostly by suprachiasmatic perforation of lamina terminalis. The lumboperitoneal drainage using omentum was advocated as an option for communicating hydrocephalus. Overall mortality rate was 10%.

Arendt’s impact on pediatric neurooncology should also be mentioned. In 1953 he reported 600 cases of brain tumors in infants and children. One third of them were emergency cases which had to be operated on because of increasing ICP and brain edema due to CSF blocade. Arendt proposed his own modification of prolonged (3-5 days) drainage of lateral ventricles prior to surgery.

He had several pupils and was a founder of Moscow school of pediatric neurosurgery. Arendt was the editor of the first Russian “Manual on Pediatric Neurosurgery” published in 1968 after his death.

6. Cerebrospinal Fluid Shunts Do Not Grow Old

Joseph H. Piatt, Jr., MD (Portland, OR)

Cerebrospinal fluid (CSF) shunt survival was studied using actuarial statistical techniques. Six hundred seventy one operations to insert or to revise CSF shunts were performed at Oregon Health Sciences University between 1976 and 1989. The cumulative survival of CSF shunts seemed to fall into two distinct phases: Through the first 8 months shunt survival fell rapidly to 68%. After this point shunts failed at a slower, steady rate through the end of the 10 year follow-up study period. The second phase of the cumulative survival curve conformed very closely to an exponential decay model with a monthly failure rate of 0.53%. There was great variance in measured monthly shunt failure rates, but regression analysis suggested only a very slight, upward trend from the eighth month through the tenth year; this trend did not attain statistical significance. Changes in the properties of shunt materials, deposition of debris within the lumen of the shunt catheter, and other gradual, time-dependent processes may play some role in late shunt failure, but statistical modeling of the late phase of the shunt survival curve suggests that such processes, which may be referred to in the aggregate as "growing old," account for only a small fraction of CSF shunt failures in follow-up as long as 10 years. The causes of late shunt failure are poorly understood.

7. Split Notochord Syndrome: Duplication of Spinal Column, Spinal Cord and Large Bowel with Associated "Mature Teratoma" — An Attempt at Twinning?

Nizam Razack, MD, Larry K. Page, MD (Miami, FL)

Split notochord syndrome includes a cleft of the vertebral column associated with malformation of the central nervous system and gastrointestinal tract. Fourteen cases involving the lumbosacral spine have been reported in the literature. We will report a female neonate who had intact function of her lower extremities, a posterior midline lumbar defect bounded by two complete spinal canals that contained two spinal cords. A meningocele, a large bowel fistula and a mature teratoma protruded through the cleft. The baby is doing well after repair of the anomaly and placement of a ventriculoperitoneal shunt. We will discuss the embryological and neurosurgical aspects of this case, which appears to bridge the gap from split notochord to fetus-in-fetu.

8. The Biomechanics of Hydrocephalus—A Numerical Model

Samuel Neff, MD, Ravi Subramaniam, PhD
(Camden, NJ)

This report describes a model which simulates ventricular deformation and the development of brain edema in hydrocephalus. The basic mechanics of ventricular distension can be described using computer modeling techniques, but previous work has been limited by the difficulty of incorporating cerebrospinal fluid flow dynamics and interstitial edema.

The model determines the interactions among the deformation of porous brain parenchyma, the movement of interstitial fluid through extracellular spaces, fluid flow in and out of blood vessels, and fluid production and drainage in the ventricles. Using finite-element numerical techniques, an iterative process alternately solves for the fluid dynamics and mechanical deformation until convergence is reached.

The model consists of elastic blocks representing cellular conglomerates of white and gray matter, with a viscous, incompressible interstitial fluid in the intervening spaces. Blood vessels with porous boundaries are incorporated into the fluid model to simulate the exchange of fluid between the interstitial space and blood vessels. The ventricular area consists of fluid elements with source (or sink) terms that simulate the production (or withdrawal) of cerebrospinal fluid.

The input geometry for the calculation is a two-dimensional axial cut of the brain obtained from the computed tomographic scan of a patient.

The results show that incorporating current knowledge of cerebrospinal and interstitial fluid dynamics into models allows for better understanding of the biomechanics of hydrocephalus.

Work supported by the resources of the Pittsburgh Supercomputing Center under the Biomedical Initiative, Grant #DMB920019P, and through a University of Medicine and Dentistry of New Jersey Faculty Research Support Grant.

9. Simulation of Normal Cranial Growth and Craniosynostosis Using Non-linear Finite Element Analysis

Samuel Neff, MD, Ravi Subramaniam, PhD
(Camden, NJ)

The scientific basis for the treatment of craniosynostosis rests on an extensive body of empirical and experimental evidence that has allowed the delineation of qualitative principles of skull growth. Using a computer model, we build on these principles to demonstrate the response of the growing skull to disease states and predict the results of therapeutic interventions.

We use an elastoplastic finite-element formulation to model the growth of the skull. We defined points on the cranium and skull base of a neonate, then interpolated additional points, and use these to define elastoplastic elements representing bone and suture. The effect of brain growth is incorporated as a constant outward pressure, resulting in a distracting force on the sutures. The sutures have a time- and position-dependent plasticity. During the simulated growth of each model, the edges of the sutures harden (Young's modulus increases) while the centers stretch according to their plasticity, resulting in an enlargement of the skull. Remodelling of the bone occurs through the action of a creep function. Calculated results consisting of 3-D skull shapes are rendered using a graphics workstation.

The basic model simulates the normal growth of the cranium. By constraining one suture, the model also demonstrates features of sagittal or coronal synostosis.

The results suggest that much of normal cranial shape and some of the pathology of cranial growth can be explained by the principle of growth at sutures according to the resultant of stresses from internal pressure generated by brain growth.

10. Reflections on the Natural History of Lipomyelomeningocele

Paul M. Kanev, MD, Karin S. Bierbrauer, MD
(Philadelphia, PA)

Lipomyelomeningocele (LMM) is the most common malformation leading to spinal cord tethering. With the recent decline in the prevalence of myelomeningocele because of folic acid supplementation, LMM may become the most common lesion of spinal dysraphism. The natural history of patients with untreated LMM however has not been established and ethical considerations have precluded randomized prospective study of the efficacy of surgical repair. The clinical characteristics of patients with LMM cared for at Children's Medical Center in Seattle, Washington, and Hospital for Sick Children in Toronto, Ontario, have been retrospectively analyzed to derive relationships of patient age, neurological function and the natural history of untreated lipomyelomeningocele. Sixty-five children patients (37%) had a normal neurological examination on initial presentation whereas focal deficits were present in 112 patients. Neurological deficits were progressive and inverse logarithmic deterioration occurred with increasing patient age. The plot intercept points predict **all** patients will eventually develop neurological deficits and that a small proportion of children will already have deficits at birth. Each child with intact examination retained normal neurological following LMM repair and release or cord tethering; complications of surgery were limited. Neurological deficits were not influenced by stalk attachment anatomy or size of the lipoma stalk, subcutaneous mass or intramedullary lipoma. Our analysis suggests that surgery on patients with intact function offers greater long term protection of critical function than is offered by conservative management and expectant care. We recommend repair of lipomyelomeningocele at the time of diagnosis regardless of patient age or neurological function.

11. Development of Subcortical Pathways in the Mammalian Basal Ganglia: The Thalamostriatal Projection

Cornelius H. Lam, MD, Abbas F. Sadikot, MD, PhD
(Montreal, Quebec)

The mechanism of the formation of the subcortical pathways in the developing brain is not well known. Such information may provide clues to the pathogenesis of infantile movement disorders and also have important implications for cell transplantation in the damaged adult CNS. This study looks at the development of the thalamostriatal pathway by using biotinylated anterograde tracers injected stereotaxically into the parafascicular and midline nuclei in newborn and neonatal rats aged one week apart. The animals were sacrificed under deep anesthesia by transcardial perfusion with aldehydes. The brains were sectioned and processed for revelation of tracers using immunohistochemical methods (avidin-biotin complex technique and diaminobenzidine tetrahydrochloride as a chromogen). Adjacent sections were processed for calcium binding protein (CaBPD-28k), a marker for the matrix compartment of the chemically heterogeneous mammalian striatum. We have determined that the thalamostriatal projection from the posterior intralaminar nuclei is established by P1 and is selective to the matrix compartment of the striatum. Further studies are under way which will determine the precise prenatal time of origin of the thalamostriatal pathway with specific attention to its relationship to the mosaic organization of the developing striatum.

12. Upper Body Motor Improvement Following Selective Dorsal Rhizotomy: A Patient/Parent Survey

Frederick Boop, MD, Mark Cobb, MD, Charles Teo, MD,
Sharon Ratcliffe, RN (Little Rock, AR)

Selective dorsal rhizotomy (SDR) has now gained acceptance as the procedure of choice for the remediation of spasticity related to cerebral palsy. Although the procedure is performed in the lumbar region, spasticity throughout the body appears to be improved. In order to assess how this impacts upon the quality of life of individuals having undergone this procedure, we performed a survey of 52 patients and their parents in whom we have long-term follow up. The survey involved a mailed questionnaire or telephone contact to determine whether SDR offered improvement in, no change, or worsened performance in ambulation, chewing, swallowing, speaking, balance, handwriting, or upper extremity dexterity. The survey was returned by 41/52 families (79%).

Results are tabulated as follows:

	<u>improved</u>	<u>no change</u>	<u>worsened</u>
chewing	20%	70%	2%
swallowing	20%	68%	5%
speaking	27%	66%	0%
balance	73%	22%	5%
handwriting	41%	41%	0%
ambulatory status	63%	10%	27%
overall	85%	7%	7%

This survey suggests that, in children with cerebral palsy, SDR may afford improvement in spasticity throughout the body. As such, SDR may afford benefits beyond that of improved ambulation alone. The specific implications of the survey results, parents comments, and the relationship between changes in ambulatory status and improvements elsewhere in the body will be discussed.

13. Percutaneous Endoscopic Shunt Recanalization— A Laboratory Model

Jogi V. Pattisapu, MD, Kay Taylor, RN, BSN,
Revathi Narayanan, BE (Orlando, FL)

A significant number of shunt malfunctions are due to proximal catheter occlusion. It has been shown that choroid plexus and fibroblasts have greater adherence to shunt components, and in-growth of these tissues frequently occlude the shunt lumen. The commonly used diagnostic shunt tap may be modified to perform endoscopic intraluminal shunt recanalization.

A laboratory model was developed to simulate proximal catheter occlusion, and the feasibility of endoscopic recanalization was explored. Twenty-four ventricular catheters were placed in fibroblast gel cultures and implanted in the dorsal subcutaneous tissue of 10 laboratory rats. After 1, 2, and 4 weeks, intraluminal dissection was performed using 0.5mm endoscopes and specially developed needle bipolar electrocautery. Distal occlusion with a Fogarty/PTCA balloon allowed forceful irrigation, facilitating the dissection and protecting the distal shunt mechanism from coagulation debris. Thermocouples were placed in the agar and tissues to measure temperature and define safety parameters. Microscopic analysis for structural damage of shunts was performed

The experimental design reproduced anatomical features of proximal shunt occlusion, and the shunt lumen was recanalized under direct visualization confirming shunt patency. Earlier laboratory studies from our institution confirmed the feasibility of intraluminal laser dissection of shunts during a diagnostic shunt tap.

Once refined, this minimally invasive therapeutic shunt tap may be considered in certain patients with proximal shunt malfunctions

14. The Influence of Electric Fields on a Model Epileptic Focus

Duc H. Duong, MD, Taeun Chang,
Steven J. Schiff, MD, PhD (Washington, DC)

Electric fields are well known to influence the synchrony of neuronal populations. Whether electric fields can modify the activity of an epileptic focus has to our knowledge never been explored. In this report, we examine the effect of pulsed dc electric fields on the frequency of spontaneous bursting in a model epileptic focus. We employ the high potassium hippocampal slice, which generates spontaneous burst firing activity similar to interictal spikes in the CA3. Electric fields were generated from platinum subdural electrodes placed in the perfusion bath. We performed 378 experimental trials on 10 slices from 10 rats and examined the effect of field polarity, current intensity and stimulation duration on firing frequency. The average interburst interval did not correlate significantly with polarity (one-way ANOVA, $p = 0.96$). Average interburst interval showed a significant correlation with stimulus duration at 200 and 400 ms when the slices were placed horizontally with the CA3 oriented towards the positive electrode ($p = 0.030$ and 0.004 , respectively). As a function of current, there was significant average interval changes for currents of 4, 6 and 8 ma ($p = 0.024$, < 0.001 and < 0.001 , respectively). Multiple regression analysis showed average interval correlated positively with both stimulus duration and current ($R^2 = 0.66$ with $p < 0.0001$ and $R^2 = 0.064$ with $p = 0.0028$, respectively). We conclude that the CA3 burst firing activity in high potassium can be altered by electric fields. These findings may be applicable to human focal epilepsy.

15. *CDK-4* Amplifications and *MTS-1* Deletions Are Not a Common Feature in an Unselected Panel of Pediatric Brain Tumors

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Recent work demonstrates that mutations and deletions of Multiple Tumors Suppressor-1 (*MTS-1*), a proto-oncogene located on chromosome 9p21, occur in a very large percentage of melanomas, astrocytomas, esophageal cancers and other tumors of diverse origin. Unpublished work in our laboratory shows that alterations in either the *MTS-1* gene product (p16), or its ligand, cyclin-dependent kinase-4 (*CDK-4*) are found in nearly all glioma cell lines derived from adult tumors that have been tested to date. *CDK-4* gene amplifications are also found in approximately 14% of primary glioblastomas and malignant astrocytomas, but are not common in low-grade adult primary tumors. Accordingly, we have begun screening primary pediatric brain tumors without regard to level of malignancy or cell type in order to determine if the cyclin dependent kinase-p16 pathway is involved in the development or progression of these malignancies. Preliminary screening of genomic tumor DNA by polymerase chain reaction (PCR) amplification of all four *MTS-1* coding exons reveals no homozygous *MTS-1* deletions in a series of 12 tumors tested (including 3 pilocytic or low-grade astrocytomas, 1 anaplastic astrocytoma, 1 glioblastoma, 1 neuroblastoma, 1 neuroectodermal carcinoma, 1 ependymoma, 1 neurofibroma, and 1 hamartoma). Using similar PCR amplification techniques, we have been unable to detect any *CDK-4* gene amplifications. Hybridization analysis using a *CDK-4* DNA probe confirms that there are no highly amplified *CDK-4* genes in any of the tumors tested. Direct DNA sequencing, Northern hybridization, and PCR-single strand conformation polymorphism (PCR-SSCP) analyses, currently underway, will further define the role of this *p16-CDK-4* system in the development of pediatric brain tumors.

16. Expression of Heme Oxygenase and Hsp72 mRNA in Rat Brain After Focal Cerebral Ischemia

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Heat-shock proteins are induced during cerebral ischemia and may be protective. Expression of the 72kDA heat-shock protein, hsp72 during ischemia has been documented to reduce infarct volume. Other heat-shock proteins, such as heme oxygenase may be induced during ischemia and confer protection. The objective of this investigation was to evaluate the expression of heme oxygenase mRNA as well as that of hsp72 after transient focal ischemia.

A blunted suture model was used to produce right MCA occlusion in Wistar rats for 1 and 2h. After recovery for 2 and 24h, expression of heme oxygenase and hsp72 mRNA was detected using *in situ* hybridization. Histology was evaluated by acid fuchsin staining. Strong hsp72 mRNA expression was detected in all animals in the 2h recovery group. In contrast, after 24h recovery, hsp72 mRNA expression was present only in MCA region of right cortex, while heme oxygenase was induced in the basal ganglia, in the perimeter of an infarct zone.

This study demonstrates that heme oxygenase mRNA is expressed after 24h in a different region of the brain than that of hsp72 mRNA. This is the first study to demonstrate *in vivo* heme oxygenase mRNA expression after cerebral ischemia. Heme oxygenase catalyzes the initial step of heme metabolism in which heme is converted to bilirubin, which may act as an oxidant to limit damage by free radicals produced during ischemic conditions. Future studies of the heme oxygenase pathway may result in a clinically useful method of reducing infarct size after cerebral ischemia.

17. Mutational Analysis of the p53 Tumor Suppressor Gene in Pediatric Astrocytomas

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Multiple gene abnormalities occur in human astrocytomas. Inactivation of the p53 tumor suppressor gene by mutation is linked to the malignant progression of adult astrocytomas. However, the role of p53 mutations in pediatric astrocytomas is not well-defined. In order to assess the involvement of p53 inactivation in pediatric astrocytomas, tissues from 12 juvenile pilocytic astrocytomas (JPAs) and 4 diffuse, fibrillary astrocytomas (2 low-grade astrocytomas, 1 anaplastic astrocytoma, and 1 glioblastoma multiforme) were analyzed for the presence of mutations in exons 5, 7, and 8 of the p53 gene using single strand conformation polymorphism (SSCP) and sequence analysis of DNA amplified by the polymerase chain reaction. In addition, p53 protein immunohistochemistry using a monoclonal antibody (PAb 1801, Oncogene Science) was performed on paraffin-embedded tissues to detect p53 inactivation by binding of wild-type to mutant p53 proteins. None of the JPAs demonstrated abnormalities on SSCP analysis, DNA sequencing, or immunohistochemistry. Among the diffuse astrocytomas, 1/2 low-grade tumors contained occasional cells with p53 immunoreactivity, but neither tumor had a p53 mutation. However, strong p53 immunoreactivity was found in the anaplastic astrocytoma corresponding with a SSCP shift in exon 8 due to a frame-shift mutation in codon 273. p53 abnormalities were not detected in the glioblastoma multiforme. These data indicate that p53 inactivation does not contribute to JPA tumorigenesis. On the other hand, loss of p53 function by mutation is associated with the progression of some pediatric fibrillary astrocytomas, suggesting that the molecular pathways of tumorigenesis in adult and pediatric fibrillary astrocytomas are not necessarily mutually exclusive.

18. The Back of the Head: A Novel Approach To Lambdoid Synostosis

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True lambdoid synostosis appears to be an uncommon condition. On the other hand, positional flattening is commonly seen. Neither the indications for surgery nor the proper technique have been established. Our criteria for intervention are simple. In the presence of true radiographic synostosis we recommend surgery. With positional flattening, judgment made in concert with the parents as to the magnitude of the cosmetic deformity determines whether or not we will intervene. Although we have published previous descriptions of the technique, we feel the present methods, which are applicable for any situation in which the posterior part of the head is flat and a round projection is desired, provides optimum results.

The patient is positioned prone and a biparietal scalp incision made leaving periosteum with bone. Bilateral parasagittal strips are formed and the remaining bone over the sagittal suture carefully freed. After large parietal-occipital flaps are removed, a posterior osteotomy over the suture at the posterior fontanelle is made and using bone obtained from the strip craniectomies, the midline bone is expanded as a "natural bridge" and held in place using a single, long curved microplate. The parietal-occipital bone flaps are then sutured in place to conform to the new bone shape using barrel-stave osteotomies to round the lateral occipital region. Case reports and post-operative results are demonstrated.

19. Determinism, Control, and Anti-control in a Model Epileptic Focus

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Following the recent theoretical prediction that chaotic physical systems might be readily controllable, there has been successful application of this technique to physical and biological (cardiac) systems. One of the hallmarks of the human epileptic brain are interictal spikes. The high potassium *in vitro* hippocampal brain slice preparation exhibits population burst-firing activity that shares many physiological similarities with interictal spikes. We sought to determine whether such *in vitro* neuronal bursting activity was controllable.

Transverse slices 400 μm thick were prepared from the hippocampus of 125-150 gm female Sprague-Dawley rats, and placed in an interface perfusion chamber at 32-35°C. Following the introduction of 8.5 mM KCl in the perfusate, trials were conducted of combinations of chaos control, periodic pacing, and the inverse of chaos control which we term - *anti-control*.

Ninety-one experimental trials were performed on 22 slices from 9 rats. Good control of this neuronal circuit was achieved in 14/52 chaos control trials, 8/19 trials using periodic pulses, and in 5/21 attempts at anti-control.

This is the second successful report of control of a chaotic biological system, and the first attempt in brain. Anti-control offers the ability to break up periodic behavior. Such techniques may be applicable to human epileptic foci.

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(Portions of this study are in press in Nature).*

20. Management of Postoperative Pain in Pediatric Patients

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A significant amount of pain and discomfort can be associated with complex surgical procedures (craniofacial, spinal, etc.). Appropriate pain control is paramount in this patient group during the early postoperative period. A protocol using a continuous intravenous infusion of Dilaudid® at a rate of 0.001-0.003mg/kg/hr was instituted in 29 patients during the first 24 hour postop period. There were 18 males and 11 females. The mean age was 6.5 years (2.9 months-16 years). Twenty patients underwent craniofacial surgical procedures, 5 patients had spinal procedures, 3 patients had tethered cord release and 1 patient had a craniotomy for brain tumor. Using a pediatric pain scale, parental and physician observations, all patients were found to have adequate and sufficient levels of analgesia and comfort. There were no complications associated with this pain control regiment. The use of intravenous Dilaudid drip in the pediatric populations appears to be an effective, safe and consistent way of obtaining and maintaining analgesia during the early postop period in pediatric patients.

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