Section on Pediatric Neurological Surgeons of the American Association of Neurological Surgeons

18th Winter Meeting Program

November 28 — December 1, 1989 Washington, D.C.
Section on Pediatric Neurological Surgery of the American Association of Neurological Surgeons

18th Annual Meeting

Willard Inter-Continental Hotel
Washington, D.C.
November 28–December 1, 1989

This program has been approved by the Joint Committee on Education of the American Association of Neurological Surgeons and Congress of Neurological Surgeons for a maximum of 15 hours of Category 1 credit toward the Continuing Education Award in Neurosurgery
Paolo Raimondi Lecturers

E. Bruce Hendrick--1978
Paul C. Bucy--1979
Floyd Gilles--1980
(Panel Discussion)--1981
(Panel Discussion)--1982
Derek Harwood-Nash--1983

Anthony E. Gallo, Jr--1984
Frank Nulsen--1985
William F. Meacham--1986
Dale Johnson--1987
Joseph Volpe--1988

Schulman Award

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

Arno Fried--1984
A Laboratory Model of Shunt Dependent
Hydrocephalus

Anne Christine Duhaime--1985
The Shaken Baby Syndrome

Robert E. Breeze--1986
CSF Formation in Acute Venticulities

Marc R. Del Bigio--1987
Shunt-induced Reversal of Periventricular
Pathology in Experimental Hydrocephalus

Scott Falci--1988
Rear Seatlap belts.
Are They Really ‘Safe’ for Children?

Pediatric Section Chairmen

Robert L. McLaurin--1972-73
M. Peter Sayers--1973-74
Frank Anderson--1974-75
Kenneth Shulman--1975-76
E. Bruce Hendrick--1976-77
Frank Nulsen--1977-78
Luis Schut--1978-79

Fred Epstein--1979-81
Joan L. Venes--1981-83
Harold J. Hoffman--1983-85
William R. Cheek--1985-87
David G. McLone--1987-89
Donald H. Reigel--1989-
Annual Meeting Sites

Dallas 1981
San Francisco 1982
Toronto 1983
Salt Lake City 1984
Houston 1985
Pittsburgh 1986
Chicago 1987
Scottsdale 1988
Washington 1989

Program of the Pediatric Section
18th Winter Meeting

American Association of Neurological Surgeons

TUESDAY, NOVEMBER 28, 1989

6:00 p.m. - 8:00 p.m.
Registration Desk - Foyer

6:00 p.m. - 8:30 p.m.
Reception - Crystal Room

7:00 p.m.
Exhibits Set Up - Buchanan Room

WEDNESDAY, NOVEMBER 29, 1989

7:00 a.m. - 8:00 a.m.
Registration Desk - Foyer

7:00 a.m. - 8:00 a.m.
Continental Breakfast - Exhibits Area

8:00 a.m. - 8:10 a.m.
Welcoming Remarks - David C. McCullough, M.D.,
Annual Meeting Chairman and Edward R. Laws, M.D.,
Chairman, Department of Neurosurgery, George
Washington University

* Indicates Resident Paper
9:30 a.m. - 10:00 a.m.
COFFEE BREAK

10:30 a.m. - 12:15 p.m.
SCIENTIFIC SESSION II - Ballroom

SPINE AND CRANIOVERTEBRAL JUNCTION -
Moderators:
William Cheek, M.D.
Edward Kosnick, M.D.

6. "Tethered Cord As a Cause of Scoliosis in Children With A Myelomeningocele", J. Herman and D. McLone, Chicago, IL


17. "Shunted Aqueduct Hydrocephalus: Control of Overdrainage", E. Foltz, Orange, CA


2:30 p.m. - 3:00 p.m.
COFFEE BREAK

3:00 p.m. - 4:15 p.m.
SCIENTIFIC SESSION IV - Ballroom

HYDROCEPHALUS AND CYSTS: - Moderators:
Alexa Canady, M.D.
Jerry Oakes, M.D.

20. "Management of Persistent Venticulomegaly Due to Altered Brain Compliance", E. Altschuler, D. Pang and E. Stephanian, Pittsburgh, PA


22. "MRI Analysis of Shunt Function", E. Frank, M. Buonocore, L. Hein, Sacramento, CA
**27.** "Dandy-Walker Syndrome: Experience with Thirty-One Cases", R. Osenbach and A. Menezes, Iowa City, IA

**28.** "Neonatal Piglet Hippocampal Protein Synthesis Deficit During Reperfusion Following Global Cerebral Ischemia", J. Gidday and T. Park, Charlottesville, VA

**29.** "Cerebellar Evoked Potentials Recorded from the Rat", R. Hurlbert and C. Tator, Toronto, ONT

**30.** "Cortical Localization in the Young Child with Epilepsy", G. Morrison, M. Duchowny, T. Resnick and L. Alvarez, Miami, FL

**31.** "Cranial Remolding After a Wide Midline Strip Cranietomy in Sagittal Craniosynostosis", Y. Hahn, D. McLone, M. Radkowski, Chicago, IL

**32.** "Bloodless Dissection in Pediatric Craniotomies and Craniofacial Surgeries", K. Manwaring and S. Beals, Phoenix, AZ

10:00 a.m. - 10:30 a.m.

**COFFEE BREAK**

10:30 a.m. - 12:15 p.m.

**SCIENTIFIC SESSION VI - Ballroom**

**TRAUMA AND INTRACRANIAL HEMORRHAGE** - Moderators:

- Mark O'Brien, M.D.
- Richard Coulon, M.D.
FREE AFTERNOON

6:30 p.m.
   RECEPTION - Pre Function Area

7:30 p.m.
   BANQUET - Ballroom

FRIDAY, DECEMBER 1, 1989

7:00 a.m. - 8:00 a.m.
   Continental Breakfast - Foyer

8:00 a.m. - 10:15 a.m.
   SCIENTIFIC SESSION VII - Ballroom

VASCULAR DISORDERS AND DORSAL RHIZOTOMY -
Moderators:
   Parker Mickle, M.D.
   Harold Rekate, M.D.


41.  "Stereotactic Resection of Pediatric Vascular Malformations", M. Partington, D. Davis and P. Kelly, Rochester, MN

**BRAIN TUMORS - Moderators:**
Edward Laws, M.D.
Donald Reigel, M.D.


50. "Fourth Ventricle Astrocytomas in Childhood", T. Tomita, D. McLone and M. Yasue, Chicago, IL

51. "Choroid Plexus Tumors: Trends in Diagnosis and Management", C. Dickman, H. Rekate, S. Coons and P. Johnson, Phoenix, AZ


53. "Cavernous Angiomas in Children", M. Scott, Boston, MA

12:00 p.m. - 1:00 p.m.
**LUNCHEON** - Pierce Room

1:00 p.m. - 2:30 p.m.
**SCIENTIFIC SESSION IX** - Ballroom

**BRAIN TUMORS - Moderators:**
Dennis Johnson, M.D.
Peter Carmel, M.D.

54. "Pediatric Pituitary Tumors", S. Haddad, A. Menezes and J. VanGilder, Iowa City, IA
Chiasmal/Hypothalamic Gliomas in Childhood with Chemotherapy: An Emergency Experience with Modified Regimens", J. Petronio, M. Cortesos and V. Levin, San Francisco, CA

"Glial and Pediatric Brain Tumors", K. Kivelä, V. Johnson and W. Hall, Seattle, WA

"Ovarian Cysts as a Prognostic Factor in Tumours", D. Schofield, J. Geyer and M. Berger, Seattle, WA

"The Search for the PNET Gene", C. Raffel, Los Angeles, CA

"Growth Factor Receptors on Pediatric Brain Tumors", W. Hall, M. Merrill and R. Youle, Pittsburgh, PA

"O-6-Alkyguanine-DNA-Alkyltransferase in Human Medulloblastoma: Relationship With Chloroethylnitrosourea Resistance", M. Berger and F. All-Osman, Seattle, WA

Scientific Abstracts

1. SPINAL CORD ABNORMALITIES IN ASSOCIATION WITH CLOACAL EXTROPHY AND CAUDAL REGRESSION SYNDROMES

William O. Bell, M.D., I.T. Thomas, M.B., B.Ch. (Winston-Salem, NC)

The association between congenital anomalies of the distal spinal cord and the distal vertebral column, sacrum, hindgut, and urinary tracts is poorly understood. However, on the basis of current theories on the interrelationships of the caudal cell mass, hindgut, and distal urinary tracts, it is logical to assume that maldevelopment of one will affect development of the others.

Over the last ten years at our institution, we have examined six children with either caudal regression or cloacal extrophy in association with a truncated spinal cord, myelomeningocele, or spinal lipoma. The pathogenesis of these anomalies will be discussed in light of the findings for this unique group of patients.
ANOMALIES ASSOCIATED WITH
ATIONS OF THE
EXSTROPHY AND TERMINAL
AL COMPLEX: A PRELIMINARY

Arthur Arand, M.D., William Ball,
M.D. (Cincinnati, OH)

malformations of the anorectal complex are
associated with urinary tract and skeletal
systemic anomalies. Occasionally, intraspinal anomalies have
also been associated with anorectal anomalies. However, a prospective evaluation of
patients with anorectal anomalies and anorectal malformations has not been
reported. We report our preliminary findings.

Twenty-seven patients (age birth to 17 years) with anorectal anomalies were studied prospectively using
metrizamide myelography and more recently, magnetic resonance imaging. Four patients were
identified as having a Malformations of the anorectal complex: Anorectal Malformations
association and two patients had Down's syndrome. Thirteen of the 15 patients with anorectal anomalies outside the central
spinal canal were evaluated. The position of the conus medullaris in these patients was studied. Urodynamics of the lower urinary tract was performed in
all patients. The incidence of intraspinal anomalies, we believe, is associated with anorectal malformations
and the intraspinal axis. Investigation of patients at Children's Hospital Medical Center with anorectal malformations continues.

3. THE MALFORMED MERMAID: CLOACAL
EXTROPHY AND TERMINAL
MYELOCYSTOCELE

Alan R. Cohen, M.D., Mary L. Anderson, M.D. (Boston,
MA)

Associations of uncommon developmental abnormalities can provide unique information about normal embryologic
processes. The authors report their experience with 2 unusual associated malformations: cloacal extrophy and
terminal myelocystocele.

Cloacal extrophy is an extraordinarily rare congenital
malformation characterized by evagination of the intestines
between 2 bladder halves, imperforate anus and omphalocele. During the past 3 years 5 children with
cloacal extrophy were examined at the New England
Medical Center. All 5 children were found to have occult spinal dysraphism, and in each case the specific
neurologic abnormality was a terminal myelocystocele.

The terminal myelocystoceles were evaluated with
T1-weighted magnetic resonance scans of the
thoracolumbar spine. In each case the study showed a
tethered cord traversing a meningocele with localized
cystic dilatation of the caudal central canal surrounded by
fat. There was a variable degree of sacral dysgenesis.

The degree of neurologic dysfunction correlated with the
size of the spinal lesion. Four children underwent surgical
obliteration of the terminal myelocystocele and release of
the tethered cord, all without change in neurologic status.
Histology demonstrated an ependyma-lined cyst surrounded by fat.
and terminal myelocystocele are each anomalies. The striking frequency with which they occur suggests a common defect of the hind gut. Terminal myelocystoceles arise from an undifferentiated cell mass at the cloacal membrane. In early development this gives rise to the cloaca and allantois, and is involved in bowel and bladder development. A focal tailbud mass causes closure of the posterior neuropore and results in association of anorectal malformation with occult spinal dysraphism. Terminal myelocystoceles are demonstrated as part of a spectrum of hind gut dysgenesis.

4. Determination of the Incidence and Clinical Significance of the Association Between Anorectal Malformations and Spinal Dysraphic States

Brad Mullin, M.D., Edward J. Kosnik, M.D. (Columbus, OH)

Recent reports have linked anorectal malformations with anomalies causing progressive neurologic deficit and sacral spinal defects. These reports are in contrast to previous reports which had considered these anomalies static. Consequently, these authors are recommending neurologic screening and possible neurosurgical intervention. In order to evaluate the natural history of these associated anomalies the patient population presenting to the Columbus Children's Hospital with imperforate anus and cloacal extrophy during the previous 18 years has been reviewed. These cases were then searched for patients who also carried the diagnoses of tethered spinal cord, myelomeningocoele, lipomyelomeningocoele, spinal cord lipoma, spina bifida, urinary incontinence and urinary retention. During this period, there have been 780 cases of imperforate anus and 15 cases of cloacal extrophy. Associated with the 780 cases of imperforate anus, there have been 2 cases of myelomeningocoele, 1 case of neurogenic bladder and no documented cases of tethered spinal cord. Associated with cloacal extrophy there have been 3 cases of myelomeningocoele, 1 case of imperforate anus with myelomeningocoele, 1 case of imperforate anus with myelomeningocoele, 1 case of urinary retention with imperforate anus and no cases of tethered cord. This data suggests that these associations, if
5. **INTRAUTERINE REPAIR OF EXPERIMENTAL DYSRAPHISM: IMPLICATIONS FOR THE TREATMENT OF MYELOMENINGOCELE**

Dan S. Heffez, M.D., John Aryanpur, M.D., John M. Freeman, M.D., Grover Hutchins, M.D. (Baltimore, MD)

Previously, we reported that, in the fetal rat, intentional exposure of the spinal cord to amniotic fluid results in paraplegia, kyphosis and necrosis of the spinal cord, (Pediatric Section Meeting, AANS, 1988). In the present study, we evaluated the feasibility of intrauterine surgery to repair the experimental dysraphism.

The Sprague-Dawley rat fetus underwent a 3 level thoracic laminectomy on day 18 of gestation. The dura was opened. In all cases, the fetal skin incision was left open and the fetus replaced in the uterus leaving the spinal cord in direct contact with the amniotic fluid. In the experimental group, the fetal skin incision was closed on day 19 of gestation in order to cover the spinal cord. Control rats underwent either a sham wound closure or no second procedure at all. In this group, therefore, the spinal cord remained exposed to the amniotic fluid. Gestation continued until term.

Each of the 6 rats from the experimental group was born with normal hind limbs and tail. Their wounds were completely healed. Spinal cord cyto-architecture was well preserved. Each of the 5 sham operated rats and each of the 8 controls not re-operated upon had severe deformities and weakness of the hind limbs and tail. In these rats, the skin incision had not
THE TETHERED CORD AS A CAUSE OF SCOLIOSIS IN CHILDREN WITH A MYELOMENINGOCELE

James M. Herman, M.D., David G. McLone, M.D. (Chicago, IL)

Of 100 patients with myelomeningocele and a tethered spinal cord, 51 patients presented with progressive scoliosis. After untethering, follow-up was obtained over an average of 4.1 years.

Five patients progressed requiring a fusion (all had a curve greater than 50°), 15 patients remained stable, and 31 patients showed improvement of at least 7° in their curvature with a range from 7° to 32°. Thirteen of the patients who improved had hydromyelia which was treated prior to or at the time of untethering. This left 18 patients who had improvement in their curvature from untethering in the absence of hydromyelia. Evaluation of these patients revealed the following: 1) seventy eight percent were female; 2) ninety percent of the patients had the spinal defect in the thoracic-lumbar or lumbar area; 3) all but one patient had a pre-operative curvature less than 50°; 4) maximum improvement occurred within six months after the untethering; and 5) post-operative motor improvement was noted in all 18 patients and gait improvement in 16 patients.

Implicating tethered cord as the cause of scoliosis, a significant number of these patients obtained stabilization or improvement from untethering of the spinal cord alone.
regurgitation, tracheal aspiration, and gastroesophageal reflux. The pathophysiology of these swallowing impairments and their relation to the symptomatic Chiari malformation is discussed.

Postoperative outcome with regard to swallowing function correlated with the severity of preoperative symptoms. All five patients with mild swallowing impairment showed rapid improvement after surgery. Six patients with more severe impairment, but without other signs of severe brainstem compromise such as central apnea, total bilateral abductor vocal cord paralysis, or quadriparesis also improved, albeit more slowly; all had resolution of swallowing dysfunction, confirmed in five by serial barium cine-esophagograms and motility studies. In contrast, the outcome in the four patients who developed other signs of severe brainstem compression before surgery was poor; only one patient showed significant improvement in swallowing function. Early recognition of the swallowing dysfunction and its significance and expeditious intervention are therefore crucial in insuring a favorable neurologic outcome.
PROGRESSION OF THE CHIARI MALFORMATION

Case B. Storrs, M.D., Jeffrey G. McLone, M.D. (Chicago, IL)

Children with myelomeningocele (MMC) may present with progressive brainstem deformation due to the mechanism for clinical deterioration attributed to diabetes insipidus and progressive brainstem deformation. Thus, children with myelomeningocele (MMC) were studied with serial MRI (3.5 years to 5.1 years). The average follow-up period was 24.6 months. To examine the progression of the Chiari II malformation, McRae’s line was reviewed and the distance between the foramen magnum and the posterior aspects of the cervical vertebrae was measured. The McRae’s line in the ratio B/A was 0.14 (STD 0.12 vs. 0.16 cm.) in the pediatric population versus the adult population. The McRae’s line in the pediatric population was 0.14 (STD 0.12 vs. 0.16 cm.) in the pediatric population versus the adult population. The McRae’s line in the pediatric population was 0.14 (STD 0.12 vs. 0.16 cm.) in the pediatric population versus the adult population.

9. ATLANTO-AXIAL INSTABILITY IN CHILDREN

Michael Muhonen, M.D., Arnold H. Menezes, M.D. (Iowa City, IA)

The occipital atlanto-axial region is the most complex in the axial skeleton. The developmental anatomy varies with age and the various stresses applied to this region. Atlanto-axial instability is more commonly seen in the pediatric population that suffers from developmental abnormalities, inflammatory processes, and traumatic events. In this presentation we review our experience over the past 12 years for this entity. 130 children were seen for atlanto-axial instability ranging in age from birth to 16 years. The most common causes were developmental abnormalities of the odontoid process (hypoplasia, os odontoideum), atlantoaxial instability and segmentation failures of the cervical spine, metabolic disturbances, Down’s syndrome, trauma, and inflammatory states. Patients presented with a wide spectrum of complaints ranging from neck pain to quadriplegia. Neurodynamic investigations included plain radiographs, dynamic polytomography, MRI, and traction. CT myelography was used prior to the advent of MRI imaging. The biomechanics of each individual case was assessed. Immobilization was used as a primary mode of treatment in traumatic and inflammatory states. Irreducible lesions underwent decompression with the ultimate goal of having a stable fusion in all patients. There was no mortality, and the long-term follow-up has shown neurological recovery and no changes in the growth patterns.
The results of this study demonstrate the high incidence of cervical spine instability following suboccipital decompression and cervical laminectomy for Arnold-Chiari syndrome in the myelomeningocele patient, but the clinical significance is unclear.

CERVICAL SPINE INSTABILITY FOLLOWING SUBOCCIPITAL DECOMPRESSION AND CERVICAL LAMINECTOMY FOR ARNOLD-CHIARI SYNDROME (Cont.)
A TECHNIQUE TO DECOMPRESS AND FUSE C1-C2 FOR SPINAL CORD COMPRESSION AND ALANTOAXIAL INSTABILITY (Con’t)

The described technique is a safe and effective method to treat patients with C₁-C₂ instability and spinal cord compression.
12. JUVENILE INTERVERTEBRAL DISC CALCIFICATION (JIDC): RECOGNITION AND MANAGEMENT (Cont')

eventual resorption of the disc calcification.

JIDC is generally a benign, self-limiting disease, seldom requiring operation. Recognition of the disorder is important to avoid unnecessary surgery. Resolution of symptoms and resorption of the disc calcification are the rule in symptomatic patients; recurrences are rare, as are residual radiographic changes.
14. IMPROVEMENT OF CORTICAL MORPHOLOGY BY VENTRICULOOPERITONEAL SHUNTS IN EXPERIMENTAL INFANTILE HYDROCEPHALUS

Lyn Carey Wright, M.D., (Salt Lake City, UT), Pamela M. Hale, B.S., (Philadelphia, PA), Steven D. Katz, B.S., James P. McAllister II, Ph.D. (Salt Lake City, UT)

As a sequel to our previous descriptions of the pathological changes that occur in the cerebral cortex during infantile hydrocephalus, the present study has evaluated the cytological and cytoarchitectural effects of surgical decompression. Hydrocephalus was induced in 4-11 day old kittens by intracisternal injection of 25% kaolin and monitored by ultrasonography. At 11-15 days post-kaolin (mean 12.7 days) animals with hydrocephalus received low pressure VP shunts (PS Medical). Shunted animals were monitored by ultrasound and sacrificed at 1, 2 and 4 weeks post-shunt. Normal age-matched animals served as controls. Tissue from cortical area 4 (motor), 22 (association) and 17 (visual) was processed for light microscopic analysis. Ventriculomegaly developed consistently and rapidly so that at the time of shunt placement the mean ventricular (biparietal) index (VI) was 0.57 (range 0.45 to 0.72). Within 3 days post-shunt the VI had reached 0.34 (control mean = 0.35), and was accompanied by dramatic improvements in behavior and skull ossification. However, during the second week several animals developed shunt malfunctions which required revision. Thus, about one third of the animals experienced a second period of ventriculomegaly. At sacrifice, nearly all animals exhibited mild to moderate ventriculomegaly, with cortical mantles
15. SLIT VENTRICLE SYNDROME: ETIOLOGY AND TREATMENT

James Uselman, M.D., Edward J. Kosnik, M.D. (Columbus, OH)

At the Columbus Children’s Hospital during the period 1980 - 1989 approximately 500 patients were diagnosed and shunted for hydrocephalus. During that time period 29 children developed the slit ventricle syndrome requiring sub-temporal decompression. The children who required sub-temporal decompression were reviewed to possibly define an underlying common thread to attempt to predict which children would develop symptomatic slit ventricle syndrome. The etiology of hydrocephalus, number of shunt revisions prior to decompression, and age at which sub-temporal decompression was performed was recorded.

Intraventricular hemorrhage represented a disproportionately large number of children developing slit ventricle syndrome and ultimately required sub-temporal decompression.

Children with intraventricular hemorrhage and shunting are at increased risk to develop slit ventricle syndrome.
RELATION OF INTRACRANIAL PRESSURE WITH VENTRICULAR PRESSURE IN SLIT VENTRICLES SYNDROME

Eldon L. Foltz, M.D. (Orange, CA)

Increased recognition of overdrainage of CSF by ventricular shunts in hydrocephalus patients has focused attention on mechanisms. Whereas the "slit ventricle syndrome" is a diagnosis only by CT/MRI and low ICP by measurement, the "low ICP syndrome" is a serious symptom complex of severe headache, lethargy, emesis, and upward gaze - vision deficits associated with small to slit ventricles and strikingly low ICP when the patient is upright.

In our ongoing study of 38 patients with this low ICP syndrome, pre-operative ICP studies are the basis of determining the correction of ICP therapeutically needed. The shunted ICP correction has been achieved by using a zero pressure ventricular shunt system designed to control the upright ICP at normal negative levels (vertex as reference point). 34 patients responded very well, and symptoms disappeared promptly. CT scans showed enlarging ventricles in all 34, - follow-up now up to 18 months. The 4 patients with less than satisfactory responses required step-wise return to acceptable ICP with clinical stability.

The technical device in this ventricular shunt system which controls the upright negative ICP and corrects the clinical symptoms was originally designed as a "siphon control device", but in this system acts as a zero pressure device. It is effective in preventing overdrainage of CSF in VA or VP shunts because it controls the
18. MEDICAL MANAGEMENT OF SLIT VENTRICLE SYNDROME

William G. Obana, M.D., Neil Raskin, M.D., Philip H. Cogen, M.D., Michael S.B. Edwards, M.D. (San Francisco, CA)

Slit Ventricle Syndrome (SVS) is characterized by chronic recurring headaches associated with normal or subnormal ventricular volume in shunted hydrocephalic patients. There appears to be three pathophysiological mechanisms which can cause this syndrome: 1) intermittent shunt malfunction due to an entrapped catheter between collapsed walls of ventricles or a partially obstructed shunt; 2) intracranial hypotension due to overdrainage or increased siphon effect with growth; and 3) paroxysms of increased intracranial pressure due to increased cerebral blood flow in the presence of decreased intracranial buffering capacity and normal shunt function. These patients have subnormal ventricular volume, small subarachnoid spaces, small calvariums, thickened skulls, and decreased compliance due to gliosis. We have treated the latter group with antimigrainous agents including imdral, midrin, elavil, penactin, and ergot derivatives. We report 4 patients who responded to antimigrainous therapy for SVS. There were three females and one male, ranging in age from 7 to 34 years. One had a single shunt operation, two had 4 shunt related operations, and one had 13 shunt related surgeries. The average time from the last shunt operation to the onset of headaches was 3 years. There was no characteristic location, frequency, or duration of these headaches. CT scans showed subnormal to normal ventricular volume and quantitative radionucleide shunt
normal in all patients. Two patients died at other hospitals with neurological deterioration. One had headaches with elavil and midrin, of with inderal, and one had got derivatives. One patient stopped side effects. We suggest that may be helpful in the treatment of with normal shunt function and due to paroxysms of increased from increased cerebral blood flow.

19. EXTERNAL VENTRICULAR DRAINAGE: A CLUE TO CSF SHUNT FUNCTION

James M. Drake, (Toronto, ON, Canada), Dr. Christian St. Rose, (Rue de Sevres, Paris), Dr. Marcia da Silva (MG, Brazil)

Little is known of the in vivo performance of Cerebrospinal Fluid (CSF) shunts. An external ventricular drain (EVD) most commonly implanted for the treatment of CSF shunt infection, functions very much like an implanted shunt.

We examined the minute to minute variation in EVD output in 9 children using a computerized monitoring system. There were wide fluctuations in flow rate, usually associated with activity, but some occurred with sleep. Flow rates in excess of 20 cc/hr were common and were sustained for several minutes. Periods of flow arrest also occurred.

To examine what other factors might contribute to EVD output, we reviewed the hospital records of 46 children who had received EVDs. The average EVD output was 6.33 cc/hr. EVD output increased with age and weight. Raising the height of the reservoir decreased EVD output. Patients infected with gram negative organisms or more than one organism had lower EVD output. The sex of the patient, the method of establishing the EVD, and the duration of the EVD had no effect. A model of the EVD output based on these parameters was constructed.
OF PERSISTENT VENTRICULOMEGALY DUE TO ALTERED BRAIN COMPLIANCE

(Tsing Ching Pang, M.D., Erick Gallego, Pittsburgh, PA)

...developing shunt malfunction are replaced by replacement with a shunt pressure to that of the original one, that each brain system adjusts itself to its own accustomed pressure. Shunting malfunctioning shunts show an increase in ventriculomegaly and neurological signs. Replacement of a new shunt with a pressure than the pre-failure value is probably explainable by altered brain compliance during the initial shunt obstruction.

With hydrocephalus secondary to a previous shunt, one which previously shunted with medium pressure presented with shunt obstruction, headache, and depression of consciousness, was treated with placement of a new shunt similar to the pre-failure valve. All 6 of these cases showed a reduction in ventriculomegaly and an increase in the compliance of that new shunt system with normal pressure. Moreover, the headaches and symptoms were unchanged or improved. The shunts were further revised with a new valve postulate that slow ventricular distention with a new shunt malfunction expelled...
21. THE SPECTRUM OF THE SYNDROME OF THE ISOLATED FOURTH VENTRICLE IN THE CHILD WITH HYDROCEPHALUS SECONDARY TO PREMATURITY AND INTRACRANIAL/INTRAVENTRICULAR HEMORRHAGE (Con’t)

had lost its normal shape and was rounded and was grossly out of proportion to the well decompressed lateral ventricles from the shunt procedure, at the time of diagnosis. All patients were treated with the placement of a fourth ventricle catheter through a paramedian occipital burr hole and connection to the existing ventriculoperitoneal shunt. Presentation will elaborate on the insidious forms of presentation of the disease process and the need for careful follow-up of the premature born with posthemorrhagic hydrocephalus, for this complication in the course of management.
23. TRANSCRANIAL DOPPLER
ULTRASONOGRAPHY FOR THE EVALUATION
OF SHUNT MALFUNCTION

William M. Chadduck, M.D., H. Mark Crabtree, M.D.,
James B. Blankenship, M.D. (Little Rock, AR)

Previous studies have demonstrated a high correlation
between clinically significant hydrocephalus and Resistive
Index (RI) as determined by transcranial Doppler
ultrasonography. Resistive Index is calculated by dividing
the difference between the peak systolic velocity and the
end-diastolic velocity by the peak systolic velocity.
Measurement of Resistive Index was attempted in 54
patients by insonation through the temporal squama or
orbits, during evaluations for ventriculo-peritoneal shunt
malfunctions; values were obtained in 51. Indications of
shunt malfunction in each patient included both clinical
and radiographic evidence of increased intracranial
pressure. Eleven patients referred for evaluation were
determined to have functional shunts, both by clinical
criteria and subsequent outcome. Shunt malfunctions
were confirmed in 40 of the other cases. Prior to shunt
revisions, these 40 patients had RI's of 71 +/- 10%.
following shunt revision, the RI's fell to 53 +/- 12%.
Eight patients in this group had pre-malfunction RI's of 47 +/-
5% determined during routine follow-up as outpatients;
when they subsequently presented with clinical findings of
shunt malfunction, their RI's had significantly increased.
Six of the 40 patients with shunt malfunctions had
essentially normal RI's (52 +/- %); their shunt malfunctions
were usually characterized by partial or intermittent
24. **SUPRASELLAR ARACHNOID CYSTS: CORRELATION OF SURGICAL MANAGEMENT WITH CT AND MRI SCAN FEATURES**

Andrew D. Parent, M.D., Ossama Al-Mefty, M.D. (Jackson, MS)

Suprasellar arachnoid cysts tend to present with an unusual number of symptoms and are relatively difficult to manage. With increasing frequency, these cysts are diagnosed by MRI. We are adding eight cases of such cysts managed at our institutions in the past 10 years.

Five patients were children whose ages ranged from 4 to 10 years. Hormonal abnormalities were identified in three with diabetes insipidus in two cases and precocious puberty in one. Gait ataxia was noted in three cases but only one had headaches and visual field problems. Three children had learning difficulties characterized by inattention and poor memory. Among the three adult patients, whose ages ranged from 23 to 82 years, visual field defects were noted in three cases and headaches in two. None had endocrine, intellectual, or gait problems.

All patients had CT scan and four had MRI scans. The five pediatric cases had hydrocephalus associated with the suprasellar arachnoid cysts. Two patients were initially managed by ventriculoperitoneal and cyst-peritoneal shunts. Four patients were initially managed by craniotomy, three of whom required subsequent ventriculoperitoneal shunt. Two patients were managed by transphenoidal fenestration of the cyst. There was no mortality in this group. Even after decompression of the cyst, diabetes...
both patients who had presented
suggest that intrasellar cysts with
extension respond to
A retrochiasmatic cyst is more
shunting than to
enous on all patients treated via
adenoidal surgery were reviewed.
udies did not provide new
the pathogenesis of these cysts.

25. **ANAEROBIC DIPHTHEROID INFECTION VERSUS CONTAMINATION - A STUDY OF CEREBROSPINAL FLUID CULTURES**

Paul J. Camarata, M.D., Stephen J. Haines, M.D. (Minneapolis, MN)

Propionibacterium acnes is an anaerobic, Gram positive rod often found as a contaminant in all types of cultures. The organism is prevalent in significant numbers on normal skin, and as such, is frequently found in relation to cerebrospinal fluid shunt aspirates. Partly because the pathogenicity of the organism is believed to be low and because it often takes several days for cultures to become positive, its presence in a CSF culture most often does not arouse clinical suspicion.

In an effort to identify those characteristics that might be useful in determining whether or not a CSF infection is indeed present, we examined the results of CSF cultures from January 1986 to June 1989.

Over this 30 month period, over 6300 CSF cultures were performed in our microbiology laboratory, yielding 770 different isolates. Of these, 102 cultures (13%) from 79 different patients were positive for anaerobic diphtheroids. The average time for the cultures to become positive was four days with a maximum of eight days. Ventricular shunts were present in patients in 40% of the cultures. Eight patients had multiple positive cultures, and six of these patients had shunts. These eight patients were treated with appropriate antibiotics for a recognized central nervous system infection, and 30 others
DIPHTHEROID INFECTION CONTAMINATION – A STUDY OF CEREBROSPINAL FLUID CULTURES

Of the 11 patients, 10 received antibacteriostics for other intercurrent infections, and the remainder of the patients received no specific prophylaxis for infection. Prognostic features of this patient population were noted, and an attempt was made to correlate them with the presence of an actual infection.

26. DELAYED CEREBROSPINAL FLUID SHUNT INFECTION IN CHILDREN

Steven J. Schiff, M.D., (Philadelphia, PA), W. Jerry Oakes, M.D. (Durham, NC)

Infections in cerebrospinal fluid shunts are most common within the first weeks following shunt insertion due to organisms implanted at surgery. We have observed unusual delayed infections occurring years or decades after shunt insertion.

Cases of shunt infection at our institution were reviewed from 1979 to 1987. Twelve cases were identified where infections occurred more than 6 months following shunt insertion, in children aged 6 mo. to 17 yr. Seven had recent surgery or infections that immediately preceded shunt infection. For five patients, no antecedent surgery or infection could be identified as a presumptive source of infection, the delay to infection being 13 months to 11 years; the organisms isolated included Propionibacterium in 3 patients, 2 of which had mixed Propionibacterium and Staphylococcus epidermidis infections, alpha-hemolytic Streptococcus in 1, and in another patient no organism could be identified. The risk of late onset of infection for patients with shunts was less than 1% per year.

The specter of shunt infection occurring years or decades following CSF shunt implantation argues for lifetime follow-up of such patients and underscores the routine need for anaerobic culture techniques when infection is suspected.
We reviewed thirty-one patients with Dandy-Walker syndrome treated between 1959-1989. There were 22 males with a mean age of 4.3 years. The presenting complaints included enlarging head (71%), fever (41%), ear complaints (26%), emesis (26%), diplopia (9%), and lethargy (9%), and seizures (6%). Twenty-six patients (83%) included ocular anomalies (11), mental retardation (11), gait impairment, and dysmetria (6), and seizures (2). Thirteen patients (41%) had hydrocephalus, and the abnormalities which included callosal agenesis (6) and cardiac anomalies (2) were confirmed by CT or MRI and by ventriculography.

Procedure included posterior fossa exploration (11), shunting of cyst (3), and ventriculocystostomy (10). Overall, there were 5 deaths, all from posterior fossa exploration, and 22 surviving patients. Eleven patients initially treated with a combined shunt and ventriculocystostomy had a mortality rate of 5/17, compared to 5/17 of the remaining patients. Twenty-two of the 23 surviving patients improved. We advocate combined ventriculo-cysto-peritoneal shunting as optimal treatment as this resulted in neurologic improvement in the majority of patients.
Similar derangements in amino acid incorporation and protein synthesis that persist even after six hours of reperfusion following ischemia also occur in hippocampus of adult animal models. Such deficits may be responsible, in part, for the ultimate neuronal death these selectively vulnerable hippocampal cells experience as a result of temporary cerebral ischemia.

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29. CEREBELLAR EVOLED POTENTIALS
RECORDED FROM THE RAT
(Con't)

mediation of these waves. Thresholds were substantially different between the cord, nerve and muscle responses; the mean ± s.d.) values were: CEP-C 4.08 ± 1.44; CEP-N 9.83 ± 3.60; and CEP-M 20.67 ± 3.79 (p = 0.0001). Unilateral cerebellar stimulation resulted in bilateral nerve and muscle responses. Left versus right cerebellar stimulation caused no consistent change in any of the potentials recorded from cord, nerve, or muscle. Dorsal column lesions, posterior hemisection, and bilateral lateral sectioning had little effect on the CEP-C while ventral hemisection abolished the response. In contrast, dorsal column lesions extinguished the CEP-N, and dorsal hemisection obliterated the CEP-M. Ventral hemisection spared the CEP-N and the CEP-M. Complete cord sectioning abolished all responses.

In conclusion, this is the first report of evoked potentials recorded following cerebellar stimulation in the rat and is the first to define the characteristics of the normal CEP. Monitoring of the cerebellar evoked potential provides a selective means of assessing the integrity of the ventral funiculus. This technique is potentially of great value for experimental spinal cord injury research and for the neurophysiological monitoring of the spinal cord in patients.
were operated on under local anesthesia (ages 6, 9, and 10) and they all did remarkably well through a long tedious session of cortical mapping prior to resection. Young children required a higher current to evoke a cortical response than did older children and the functional areas of speech and/or motor function rarely conformed to any preconceived anatomical precepts.

Thus, cortical localization can be accomplished even in the very young child. This experience has shown further neurophysiological differences in the young child and the information has been valuable when contemplating a resective surgical procedure.
31. CRANIAL REMODELING AFTER A WIDE MIDLINE STRIP CRANIECTOMY IN SAGITTAL CRANIOSYNOSTOSIS (Con't)

2. The biparietal area (lambdoid to lambdoid distance) expands more noticeably than bifrontal area (coronal to coronal distance).

3. All children except for 2 who had pre-existing secondary congenital defects (1 with absence of corpus callosum and the other with pre-operative mental retardation) had an "excellent" result as demonstrated by cephalometry, CT findings, aesthetic, and neuropsychological test.

4. Surgery can be performed safely with no complications, zero infection and no morbidity.
33. SPINAL CORD INJURY WITHOUT RADIOPHORIC ABNORMALITY (SCIWORA) IN CHILDREN

Richard K. Osenbach, M.D., Arnold H. Menezes, M.D.
(Iowa City, IA)

SCIWORA occurs frequently in children and accounts for up to 67% of injuries in some series. SCIWORA occurs due to unique anatomical and biomechanical features of the pediatric spine. We present our experience with 31 cases of SCIWORA in children between 1970 and 1988, representing 35% of pediatric spinal cord injuries.

Etiology of injury included birth trauma/fall (10 each), MVA/athletics (5 each), and child abuse (1). Mechanisms of injury included flexion (15), longitudinal traction (10), hyperextension (5), and repetitive flexion-extension (1) The cervical cord was involved in 26 (84%) cases, 19 in children below age 8. All 9 upper cervical injuries occurred below age 3. Most flexion injuries involved upper cervical levels in children below age 3; hyperextension injuries mainly involved the lower cervical cord in older children. All traction injuries occurred with birth trauma.

Neurologic presentation included complete cord injury (12), incomplete injury (11), central cord syndrome (6) and anterior cord syndrome (2). Delayed onset of neurologic deficit occurred in 7 children. Radiographic evaluation included plain and dynamic films with polytomography or CT to exclude occult fractures. Myelography, CT-myelography or MRI was performed to exclude disc prolapse or extradural...
had 2 months of immobilization dynamic studies to exclude latent outcome was related solely to the neurologic injury.

IOMRA should undergo MRI to optimal management includes all children with follow- up dynamic instability.

34. CEREBRAL BLOOD FLOW AND GLUCOSE METABOLISM IN EXPERIMENTAL BRAIN EDEMA

Leslie N. Sutton, M.D., David Barranco, M.D., Joel Greenberg, Ph.D., Stephen Dante, M.D. (Philadelphia, PA)

The relationship between white matter cerebral blood flow (CBF) and glucose metabolism (LCMRgl) was studied in a plasma infusion model of vasogenic edema in cats. LCBF as determined by iodoantipyrene was found to be significantly decreased in edematous white matter (17.3 ± 1.5 ml/100gm/min) when compared with contralateral control white matter (24.8 ± 1.8 ml/100gm/min). If the values for edematous brain were corrected for dilution, however, the LCBF averaged 25.3 ± 1.7 ml/100gm/min, which was the same as control.

LCMRgl was found to be significantly increased in plasma-infused white matter (16.3 ± 2.2umol/100gm/min) compared with control white matter (10.7 ± 1.3). This difference remained despite correction for dilution and recalculation of LCMRgl values based on altered kinetic constants found in edematous brain. A similar increase in LCMRgl was noted with saline infusion edema.

It is concluded that increased tissue water does not alter CBF, but does induce an increase in anaerobic metabolism.

Key words: brain edema, glucose, CBF, brain metabolism.
35. **RISK FACTORS OF MINOR HEAD INJURY IN CHILDREN**  
(Con't)

seizure, etc. are correlated with GCS or CCS.

Initial analysis showed the following observation:

1. Children with a loss of consciousness for more than 16 minutes had a 45 times greater risk of a poor outcome.

2. Of the 739 with GCS 13-15 and who were "alert" on admission, 99 (13.4%) had surgical lesions; 789 children (99.7%) had a good outcome except for 2 (0.3%) who had the so-called "Talk & Die" event.

3. Linear, basilar or closed depressed skull fractures did not affect the outcome. Children with diastatic and compound depressed skull fractures had a poor outcome in 50% and 14.3%, respectively.

4. Small punctate hemorrhage(s) or areas of contusion did not adversely affect the outcome compared to those with a normal CT.

5. Children with moderate or severe head injury had a 5 to 7 times higher risk of post-traumatic seizures than those with minor head injury.

6. Post-traumatic seizures had 2 times greater risk of poor outcome compared to those without seizures, however, post-traumatic seizures did not adversely affect a good outcome.
36. IS THERE A ROLE FOR IMMEDIATE OPERATIVE INTERVENTION IN ALL SEVERELY HEAD-INJURED CHILDREN?

Christopher Duma, M.D., Dennis L. Johnson, M.D.
(Washington, DC)

In the past decade improvements in the care of severely head-injured children have reached a disquieting plateau, and the therapeutic limits of managing intracranial pressure may have been reached. The clinical emphasis has changed to prevention and to expeditious delivery of care. We have previously shown that direct triage to a level 1 trauma center has a major impact on the mortality of head-injured children. Other authors have suggested that valuable time can be saved by bypassing CT and taking severely head-injured children with Glasgow Coma Score (GCS) of 3 or with signs of brainstem compression directly to the operating room for exploratory burr holes. Their preliminary results have shown a remarkable incidence of subdural hematomas (53%) and a slightly improved mortality rate in those who had hematomas.

We have looked at 41 consecutive children with GCS 3 to examine the value of immediate operative intervention. Children who were dead on arrival, who were intubated or pharmacologically paralyzed, or who were postictal were excluded. Thirty-four percent had other major injuries but all died of their head injuries. Motor vehicle accidents were the cause of injury in 58%; 29% were automobile passengers and 29% were pedestrians. Child abuse was responsible for 26% and bike accidents 9%. CTs were performed on all patients: 24% had an extracerebral hematoma greater than or equal to 5 mm in...
37. CONTINUOUS EXTERNAL DRAINAGE IN THE TREATMENT OF SUBDURAL HEMATOMAS OF INFANCY

Sarah J. Gaskill, M.D., W. Jerry Oakes, M.D., (Durham, NC), Arthur E. Marlin, M.D. (San Antonio, TX)

The treatment of chronic and subacute subdural hematomas in infancy has evolved since Ingraham and Matson's initial monograph in 1944. Classically, these have been approached in a stepwise fashion. Initially daily subdural taps are performed, followed as needed by burr holes and historically craniotomy for drainage and resection of subdural membranes. Subdural-peritoneal shunting has been advocated by a number of authors and recently was described by Litofsky, McComb, et al. as the treatment of choice for chronic subdural fluid collections in the pediatric population. The use of continuous external drainage in the treatment of infantile subdural collections has not been described in the literature, although it may be commonly used.

A series of 16 patients with chronic or subacute subdural hematomas treated with continuous external drainage is reviewed. Of these only 43.75% went on to require shunt placement. There were no complications in treatment. There was no clinical or laboratory evidence of infection in any case. Drains were left in place for seven days unless drainage markedly decreased at an earlier time at which point they were removed. No patient with early drain removal went on to subdural-peritoneal shunting. The outcome, measured by neurological examination, was
Preliminary Experience with Lumbar Drainage in Diffuse Pediatric Head Injury

Hillel Baldwin, M.D., Harold L. Rekate, M.D. (Phoenix, AZ)

We present our experience with the use of external lumbar subarachnoid drainage in 3 children with severe diffuse head injuries. All patients had admission Glasgow Coma Scale Scores of 8 or less and were initially treated with ventriculostomies. These children all manifested high intracranial pressures (ICP) refractory to maximal therapy including hyperventilation, lasix and mannitol, and barbiturate coma. In all patients ventricular drainage was at least attempted and in 2 of these patients drainage of cerebrospinal fluid (CSF) via the ventricular route was inadequate to control ICP. After the institution of lumbar drainage, all patients had an abrupt and lasting decrease in ICP. Two patients had conversion of their external lumbar drains to permanent lumbo-peritoneal shunts and are now recovering in rehabilitation facilities with functional outcomes. One patient died, most likely from uncontrolled ICP prior to institution of lumbar drainage.

We have formulated our rationale for lumbar drainage in diffuse head injury as follows: 1. It allows for the displacement of large volumes of CSF in the setting of collapsed ventricles that preclude drainage of adequate volumes to control ICP. 2. It encourages bulk flow from the brain extracellular fluid space into the ventricles where its removal from the system is enhanced by lumbar drainage. 3. Diffuse brain edema, indicated by high ICP,
39. COMPLICATIONS OF ECMO REQUIRING NEUROSURGICAL INTERVENTION

Jeffrey Oppenheimer, M.D., (Los Angeles, CA), John F. Vogt, M.D., (Pasadena, CA), J. Gordon McComb, M.D. (Los Angeles, CA)

Between May 1985 and June 1988 at Huntington Memorial Hospital, 150 neonates of or beyond 34 weeks gestation were placed on extracorporeal membrane oxygenation (ECMO). The mortality rate for the group without this therapy was expected to be about 90%.

All neonates had cranial ultrasonography prior to the initiation of ECMO and daily while on ECMO (range 1-12 days, mean 4.5 days). If an abnormality was noted on ultrasonography, an unenhanced computerized tomographic (CT) scan of the head was obtained during the ECMO procedure.

A total of 135 patients had CT scans while on ECMO or shortly following its termination. Fifteen patients had no ultrasonographic abnormalities while on ECMO and were transferred back to the referring hospital after completion of ECMO without having had a CT scan at this hospital.

Of the total 135 patients with CT scans, 31/135 (23.0%) were found to have an abnormality. Of this group 22/135 (16.3%) had intracranial hemorrhage, and 9/135 (6.6%) other findings. Hemorrhages were often at multiple sites.

Neurosurgical intervention was required in 6/150 (4.0%). Two patients had the placement of a ventriculostomy, one epidural tap, one a craniotomy and two the
Serial ultrasonographic evaluation of neonatal vein of Galen malformations to assess the efficacy of interventional neuroradiologic procedures

Samuel F. Ciricillo, M.D., Michael S.B. Edwards, M.D., Klaus G. Schmidt, M.D., Norman H. Silverman, M.D., Grant B. Hieshima, M.D. (San Francisco, CA)

Two-dimensional echocardiography complemented with color flow imaging and pulsed Doppler ultrasound was used to evaluate one fetus and five neonates with a vein of Galen malformation who presented at birth with severe high-output congestive heart failure and cranial bruits. Intracranial blood flow through the vein of Galen malformations, cardiac status, and direction of aortic blood flow were assessed before and after staged interventional neuroradiologic treatment with transarterial and transvenous embolization procedures. Color flow imaging in each infant displayed the major vascular anatomy, including feeding vessels and the patterns of filling of the vein of Galen malformations. Pulsed Doppler ultrasound performed on the descending aorta above the diaphragm showed the degree of diastolic flow reversal indicative of runoff into the vein of Galen malformations. A reduction in blood flow through the vein of Galen malformation was seen on color flow imaging in four patients treated successfully by embolic procedures. The ratio of diastolic retrograde flow velocity in the descending aorta to systolic antegrade velocity decreased from 0.51 ± 0.15 (mean ± SD) to 0.15 ± 0.20 (p < 0.05). Color flow imaging and pulsed Doppler ultrasonography...
41. STEREOTACTIC RESECTION OF PEDIATRIC VASCULAR MALFORMATIONS

Michael D. Partington, M.D., Dudley H. Davis, M.D., Patrick J. Kelly, M.D. (Rochester, MN)

The safety and efficacy of computer-assisted stereotactic resections of deep neoplasms has been well established. We report a series of 12 pediatric patients with supratentorial vascular malformations who underwent stereotactic resections at the Mayo Clinic between 1985 and 1988. The patients included 5 boys and 7 girls with a mean age of 8 years (range 3-16). Presenting symptoms were seizures in 8 children, hemorrhage in 3 and 1 lesion was incidentally diagnosed. Five patients had normal neurologic exams, 4 had hemiparesis, 2 had mental status changes only and 1 had a visual field defect.

All patients underwent stereotactic angiography and CT scanning—in 7 the lesions were angiographically occult. Computer-assisted stereotactic craniotomies were performed in all cases with no operative mortality or permanent morbidity. Follow-up was obtained in all cases at a mean interval of 25 months (range 5-45). No new deficits were detected in the previously normal patients. Of the remaining 7 patients, 6 had complete recovery of function and 1 was unchanged. In the 8 patients who presented with epilepsy, 7 children (87.5%) were seizure-free, of whom 3 were off anti-convulsants. The mean follow-up interval of these patients was 23 months (range 12-36). The other patient experienced a reduction in seizure
42. USE OF GAIT ANALYSIS IN PATIENT SELECTION FOR SELECTIVE DORSAL RHIZOTOMY

Leslie D. Cahan, M.D., (Orange, CA), Jan Adams, M.S.P.T., Jacquelin Perry, M.D., (Downey, CA), Lauren Beeler, R.P.T. (Trabuco Canyon, CA)

Selection of patients for selective dorsal rhizotomy (SDR) has been emphasized as being important to optimize results of this surgery. We have reviewed the pre- and postoperative instrumented gait analysis of 22 ambulatory patients who have undergone SDR looking for correlates of improvement after surgery that can be used to help in patient selection.

Good candidates for SDR have spasticity in calf, hamstrings, quadriceps and hip adductors. At least 3 out of these 4 muscles should show spasticity preoperatively. One patient who had spasticity only in hamstrings only showed improvement in knee motion, but no change in hip or ankle motion.

Assessment of the child walking barefoot should pay special attention to the ankle position. A good candidate for SDR has equinus foot position especially in the stance phase. Care should be taken to note that the equinus foot position is in fact due to spasticity and not contracture.

Characteristically these children walk in a "crouch gait". Two mechanisms contribute to the crouch: spasticity of the hamstrings and weakness of the calf muscle. To the extent that SDR alleviates hamstring spasticity, there will be decreased crouch postoperatively. If,
43. *ADJUNCTS IN THE EVALUATION AND TREATMENT OF SPASTICITY*

Ann Christine Duhaime, M.D., (Philadelphia, PA), J.
Parker Mickle, M.D., Michael Mahia, M.D. (Gainesville, FL)

While many children referred for evaluation for selective dorsal rhizotomy have clear-cut pure spastic diplegia, a number of pediatric and adult patients with less classical presentations provide diagnostic and therapeutic challenges to the neurosurgeon. These include patients with marked rigidity, dystonia, increased tone related to etiologies other than prematurity, overweight or weak patients, and those with total-body involvement such as opisthotonic posture. We have developed a screening procedure which entails creating a temporary afferent block by using 1/4% Marcaine instilled epidurally. A lumbar epidural catheter is used to instill the local anesthetic in adults while a caudal block is performed in children. Patients are monitored for skin temperature changes and plethysmographic widening of the pulse pressure in the lower extremities to test for the presence of sympathetic blockade, and muscle tone, strength, sensation, and abnormal movements are observed before, during, and after blockade. Based on the response to epidural blockade and other factors, patients are then recommended for selective dorsal rhizotomy, chemical rhizotomy using intrathecal 12% phenol solution in glycerol, or non-neurosurgical treatment. We present the rationale for this approach and report our preliminary results using this technique.
44. SELECTIVE DORSAL RHIZOTOMY - SOME TECHNICAL QUESTIONS (Con't)

was approximately equal. However, a slightly larger percentage of rootlets were sectioned on the left as compared to the right (79 versus 74.7 percent). This was true at each root level except for L3 and S2. The order of testing and sectioning does not appear to influence the likelihood of sectioning a rootlet. Likewise, rootlet size has no apparent effect on the response to stimulation. There is no apparent difference between constant current and constant voltage stimulation except that we have found motor threshold determination easier with the constant voltage stimulator. The threshold of sensory rootlets can be determined equally well with single or trains of stimuli.

Selective dorsal rhizotomy appears to be relatively insensitive to minor variations in technique. Further technical refinements probably will require a better understanding of the physiology underlying the abnormalities identified intraoperatively.
46. ALTERATION IN HIP SUBLUXATION FOLLOWING SELECTIVE DORSAL RHIZOTOMY IN CEREBRAL PALSY

Christopher I. Shaffrey, M.D., T.S. Park, M.D., Mark E. Shaffrey, M.D., Lawrence H. Phillips, II, M.D. (Charlottesville, VA)

Hip subluxation and dislocation are frequently present in patients with cerebral palsy. Currently, multiple orthopedic procedures are routinely performed with varying degrees of success attempting to prevent progressive hip incongruity. We examined whether selective dorsal rhizotomy alters hip incongruity in children with cerebral palsy.

Forty-three patients with spastic paraplegic or quadriplegic cerebral palsy have undergone selective dorsal rhizotomy with subsequent follow-up of longer than six months. All the patients had adduction and flexion contractures of the hip consistent with the severity and duration of muscle imbalance. The percentage of femoral head uncovering which is an index of hip subluxation was determined by serial hip x-ray analyses. It is widely accepted that normal patients have femoral head uncovering of less than 15%; patients at risk for progression to subluxation have uncovering of 15 to 33%; and actual subluxation is present when there is greater than 33% uncovering. Accordingly, the patients were divided into three groups, depending on the percentage of uncovering.

On preoperative examination, 7% of patients were normal, 60% were at risk, and 33% were subluxed. There were no patients with hip dislocation. Postoperatively, hips were
47. LONG-TERM FOLLOW-UP ON RESULTS OF SELECTIVE DORSAL RHIZOTOMY FOR THE RELIEF OF SPASTICITY IN CEREBRAL PALSIED CHILDREN

Richard H. Tippets, M.D., Marion L. Walker, M.D., Katerine L. Liddell, R.N., Diana L. Ploeger, RPT (Salt Lake City, UT)

Quantitative improvement in lower extremity range of motion and improvement in function was assessed in cerebral palsied children who underwent selective dorsal rhizotomy (SDR).

Twenty-two patients who have been followed at least two years after surgery were reviewed. After a pre-operative screening, patients underwent a uniform operative procedure utilizing intraoperative EMG. Limitation in range of motion (ROM) was quantitatively graded as severe, moderate, mild, or normal at the hamstrings, hip abductors, and ankle dorsiflexors and goals of attainment or improvement in quality of a posture or function were compared pre- and post-operatively.

Improvement in ROM was quantitated. Of the patients with severe involvement of hip flexion/extension, 50 percent improved. Of patients with moderate involvement of hip flexion/extension and ankle dorsiflexion/plantar flexion, all improved in their ROM. Over 80 percent of patients mildly affected in hip abduction/adduction and ankle dorsiflexion/plantar flexion were improved to normal. Generally, patients with severe limitation of ROM showed less improvement than those moderately or mildly affected. Approximately 80% of patients attained their goal of improvement in quality of function. No peri-operative or
48. ELECTROPHYSIOLOGIC EVIDENCE FOR AFFERENT FIBERS IN HUMAN VENTRAL NERVE ROOTS

Mark E. Shaffrey, M.D., Lawrence H. Phillips, II, M.D., Christopher I. Shaffrey, M.D., T.S. Park, M.D. (Charlottesville, VA)

The Law of Bell and Magendie holds that dorsal spinal roots mediate only sensation and ventral roots mediate only muscular and glandular activity. Cerebral palsy patients who undergo selective lumbosacral dorsal rhizotomy rarely demonstrate sensory impairment despite sacrificing a majority of dorsal rootlets. One tenable explanation postulates the existence of afferent fibers in the ventral spinal roots.

Fourteen children with spastic diplegia underwent intraoperative sural nerve (purely sensory) stimulation with subcutaneous electrodes placed at ankle level prior to receiving selective dorsal rhizotomy. Twelve patients had both legs tested, two patients had one leg tested. Ipsilateral ventral and dorsal root recordings were performed concurrently with sural nerve stimulation from the L-3 to S-2 levels using bipolar platinum hook electrodes. Responses were signal averaged and stored on disk. Onset latency, amplitude, and area under the response curve were measured.

Dorsal root responses were seen after sural nerve stimulation from the L-3 to the S-2 levels. The largest response amplitudes were seen at the S-1 level in 74%, the L-5 level in 15% and the S-2 level in 11% of legs tested.
49. THE POSTOPERATIVE DRAWINGS OF HARVEY CUSHING: THE PEDIATRIC BRAIN TUMORS

Eugene Rossitch, Jr., M.D., Matthew R. Moore, M.D., Peter McL. Black, M.D. (Boston, MA)

Harvey Cushing was a skilled surgeon and artist. As a surgeon, he performed over 2000 brain tumor operations and wrote classic monographs on meningiomas, acoustic neuromas and pituitary adenomas. His artistic talents were expressed in his postoperative drawings, of which brain tumors comprised a substantial portion.

As part of a project to recover many of Cushing's unpublished drawings, we are reviewing the archived surgical histories from the Peter Bent Brigham Hospital. Thus far we have found nearly one hundred of Dr. Cushing's drawings. His surgical histories are well documented containing not only the drawings, but also photographs of the gross and microscopic pathology as well as pre- and postoperative pictures of the patient.

About 25% of these sketches depicted operations performed on children. The most commonly drawn childhood tumors were craniopharyngiomas and gliomas of the brain stem and cerebellum. Less common drawings were of medulloblastomas, pituitary adenomas, and pineal region neoplasms. This presentation will focus on Cushing's pediatric cases and illustrate how he used these sketches to keep detailed records of his surgical experience.

We will also present sketches of tumor histology as drawn by Dr. Louise Eisenhardt, Cushing's pathologist. These sketches of the histology accompanied...
50. FOURTH VENTRICLE ASTROCYTOMAS IN CHILDHOOD

Tadanori Tomita, M.D., David G. McLone, M.D., (Chicago, IL), Masaharu Yasue, M.D. (Tokyo, Japan)

Fourteen children with solid astrocytomas occupying the fourth ventricle are presented. They represent 33% of 42 patients with astrocytic tumors of the cerebellum/fourth ventricle treated since 1981. Histology showed benign astrocytoma in 11, glioblastoma in 2 and gemistocytic astrocytoma in one. These tumors were often invasive to the floor (7 cases) or the wall (4 cases) of the fourth ventricle. At initial posterior fossa craniotomy, only 5 patients had visible complete resection, whereas 8 patients had radical subtotal resection leaving a sheath of tumor next to the brain stem. One patient had a partial resection, but total resection was done at the second craniotomy. During the follow-up period, 2 patients with glioblastoma died due to recurrence despite postoperative radiation therapy (RT), and another patient with gemistocytic astrocytoma died of E. coli sepsis 10 days after surgery. All other 11 patients are alive, and did not have postoperative RT. However, three patients needed further surgical resection of recurrent tumor. Two of them received RT subsequently. Remaining 9 patients did not have recurrence without RT over 1 to 8 years follow-up. Neurological complications of surgical resection are as follows: transient cerebellar mutism in 2 after the first surgery, and facial-abducens palsy in 2 and transient MLF sign in 1 after radical tumor resection at the second surgery. In conclusion, fourth ventricle astrocytomas...
51. CHOROID PLEXUS TUMORS: TRENDS IN DIAGNOSIS AND MANAGEMENT

Curtis A. Dickman, M.D., Harold L. Rekate, M.D., Stephen Coons, M.D., Peter C. Johnson, M.D. (Phoenix, AZ)

Thirteen patients with primary choroid plexus tumors (CPT) were treated surgically at our institution during the past 20 years. There were 10 papillomas (CPP), 2 carcinomas (CPC), and 1 atypical papilloma (ACPP). Nine children (mean age, 3 years) and 4 adults (mean age, 35.5 years) presented with tumors of the cerebellopontine angle (n = 1), fourth ventricle (n = 5), or lateral ventricle (n = 7). Twelve patients presented with signs and symptoms of hydrocephalus, but only 2 required permanent shunts.

Ninety-two percent follow-up was obtained (mean 34.5 months). Three deaths occurred: one in a CPC with a postoperative hemorrhage and two in CPPs with recurrences of subtotally resected lesions. All patients treated with total tumor resection including tumors with atypical or malignant features, have survived without tumor recurrence. The operative microscope and improvement in anesthetic and monitoring techniques have facilitated total tumor resection and have reduced our perioperative mortality to zero.

Enhanced MR imaging assists in planning an operative approach and is the procedure of choice for detecting residual tumor postoperatively and for monitoring for tumor recurrence. The angiographic delineation of the vascular supply to these tumors retains usefulness for operative planning.
in diagnosis remains the hallmark of diagnosis and differentiation of CPC from CPP. Cytomorphological studies may aid in distinguishing CPC from CPP when the histological features are not helpful in differentiating benign from malignant.

52. INFRATENTORIAL EPENDYMOMAS IN CHILDHOOD: PROGNOSTIC FACTORS AND TREATMENT

Gregory B. Nazar, M.D., (Louisville, KY), Harold J. Hoffman, M.D., Laurence E. Becker, M.D., Derek Jenkins, M.D. (Toronto, ON, Canada)

The prognostic factors and survival data for 35 children with surgically treated childhood infratentorial (IT) ependymomas at the Hospital for Sick Children in Toronto during the years 1970-1987, were analyzed. Tumor histology was reviewed individually and grouped into three categories (I-III) for survival analysis. An overall 5 year survival of 44.6% was obtained after the exclusion of peri-operative mortality. Factors which were associated with an improved five year survival were total tumor removal, non-invasive tumors, category I histology, age greater than 6 years, and absent physical signs of parenchymal invasion or lower cranial nerve involvement. Five year survivals were worse when associated with category III histology, brain stem or cranial nerve signs, age less than 2 years, tumor invasion and/or cranial nerve involvement, and subtotal tumor removal. Clinical evidence of spinal metastases was found to be uncommon (3.1%). Surgical excision followed by radiation therapy was the primary mode of treatment for these tumors. Controversies regarding tumor histological classification, the volume of radiotherapy to be delivered and the use of adjuvant chemotherapy are discussed.
54. PEDIATRIC PITUITARY TUMORS

Souheil F. Haddad, M.D., Arnold H. Menezes, M.D., John C. VanGilder, M.D. (Iowa City, IA)

A retrospective review of all pediatric pituitary tumors with symptom onset before the age of 16 years was done from 1979 to 1989 to help define their pathological distribution, clinical presentation, treatment and prognosis.

Fourteen patients were encountered; ten had prolactinomas and four had ACTH secreting adenomas. The mean age at onset of symptoms was 12.75 years ranging from 6.5 to 16 years. There were a total of 12 girls and 2 boys.

The four patients with ACTH secreting adenomas were all females who presented with cushinoid features. The mean age at onset of symptoms was 10.5 years. The adenomas were all sellar and were resected transphenoidally with complete resolution of their endocrinological and clinical abnormalities.

There were 8 girls and 2 boys with prolactinomas. The mean age at onset of symptoms was 13.6 years. All the females presented with either primary or secondary amenorrhea; the tumors had extended outside the sella in four cases.

Initially transphenoid resection was performed, 3 patients remain recurrence free 1 to 6 years post operatively, 2 had symptom recurrence accompanied with moderate elevation of prolactin levels (up to 46) but without obvious tumor recurrence, one necessitated repeat...
The two boys presented with massive extension, requiring an average of three procedures and radiation therapy for tumor resection of a recurrence and two were lost. A nine-year follow-up revealed a recurrence free 9 years after diagnosis and a stable residual tumor 4 years later.

55. MANAGEMENT OF CHIASMAL/HYPOthalAMIC GLIOMAS OF INFANCY AND CHILDHOOD WITH CHEMOTHERAPY ALONE: PRELIMINARY EXPERIENCE WITH NITROSouREA-BASED REGIMENS

Joseph A. Petronio, M.D., (Philadelphia, PA), Michael S.B. Edwards, M.D., Michael Prados, M.D., (San Francisco, CA), Victor A. Levin, M.D. (Houston, TX)

Between March 1983 and February 1989, nineteen infants or children with newly diagnosed or progressive chiasmal/hypothalamic gliomas were treated at the University of California, San Francisco with chemotherapy alone. Patients ranged in age from 0.28 to 15.58 years (median, 3.91) at the start of therapy. Twelve patients were treated immediately following diagnosis because of progressive symptoms, while an additional seven received chemotherapy following either radiographic progression or clinical deterioration. Histologic diagnosis was available in 12 patients: 7/12 (58%) tumors were classified as juvenile pilocytic astrocytomas, 2/12 (17%) as astrocytomas, 2/12 (17%) as highly anaplastic astrocytomas, and 1/12 (8%) as a subependymal giant cell astrocytoma. The incidence of associated neurofibromatosis was 4/19 (21%). While two initial patients were treated with non-nitrosourea-based regimens, the remaining seventeen patients received nitrosourea-based therapy; fifteen were treated with a five-drug regimen utilizing 6-thioguanine, procarbazine, dibromodulcitol, CCNU [1-(2-chloroethyl)-3-cyclohexyl-1-nitrosourea], and vincristine. For 18 evaluable patients initially managed with chemotherapy alone, the response or
56. IMMUNOTOXINS AND PEDIATRIC BRAIN TUMORS

Karen M. Muraszko, M.D., Charles Riedel, M.D., Virginia Johnson, M.D., Walter Hall, M.D., Stuart Walbridge, M.D., Richard Youle, M.D., Edward Oilfield, M.D. (Bethesda, MD)

Immunotoxins are a new class of chemotherapeutic reagent, which are composed of a monoclonal antibody covalently attached to a peptide toxin. The monoclonal antibody targets the conjugate to the surface of tumor cells bearing the appropriate antigen, following which the toxin penetrates the cell membrane and inactivates protein synthesis.

Ricin is a powerful protein toxin that is purified from the castor bean. Using recombinant DNA technology, the pure A chain subunit of this toxin can be produced. Recombinant ricin A chain (rRA) possesses the full ribosome inactivating ability of the native toxin, but lacks the B chain mediated binding and internalization activity of the intact ricin. Diptheria toxin is produced by a bacteria and also acts to shut down protein synthesis within a cell. A new, genetically engineered toxin called CRM 107 is identical to Diptheria toxin except for two amino acid changes in its B chain. This mutant only lacks the binding activity of the native diptheria toxin.

Transferrin receptors (TfR) are expressed on proliferating cells, most notably hematopoietic cells and tumor cells. We have found TfR to be markedly elevated on medulloblastoma derived cell lines and medulloblastoma surgical specimens (4.8 x
57. DNA CONTENT AS A PROGNOSTIC FACTOR IN MEDULLOBLASTOMAS

Deborah E. Schofield, M.D., J. Russell Geyer, M.D., Mitchel S. Berger, M.D. (Seattle, WA)

DNA content (ploidy) was determined on nineteen medulloblastomas diagnosed at Children's Hospital and Medical Center between 1974 and 1985. Tumor ploidy was then compared to clinical outcome (disease free survival), as were age, sex, extent of resection, and chemotherapy. All children but one received radiotherapy. Of these factors, extent of resection and tumor DNA content seem to be of prognostic value with respect to these tumors.

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58. CSF SHUNTS AND EXTRANEURAL METASTASES FROM PRIMARY CNS TUMORS: AN ANALYSIS

Brenda Baumeister, M.D., M.S. Berger, M.D., Paul M. Kanev, M.D. (Seattle, WA)

Children with brain tumors and CSF shunts have been described as having an increased risk of extraneural metastases. The utility of filters in preventing this problem has been questioned. We retrospectively analyzed our brain tumor patients, with or without shunts, to determine if shunt related metastases is a concern, and, if so, what factors are associated with this occurrence.

From 1968 to 1988, the charts of 415 pediatric patients with benign or malignant primary brain tumors were reviewed. Ages ranged from the neonatal period to 18 years. One hundred and fifty-two of 415 patients (37%) had a shunt placed (pre-op -- 45, post-op -- 94). Confirmation of extraneural metastases was based on clinical and diagnostic examinations. Factors analyzed were: a) SHUNT: type (VA, VP, etc.), valve, location, filter, revisions; b) EXTENT OF RESECTION; c) PATHOLOGY; d) TYPE OF THERAPY.

Eight of 415 patients developed extraneural metastases during life. All eight patients had a medulloblastoma (cerebellar PNET). Five of eight (Group A) patients did not have a shunt (mean time, primary diagnosis to metastases, 15 months). Two children had a total resection. The predominant location of metastases (Group A) was: Bone (2); cervical lymph nodes (1); lung/bone (1); retroperitoneal pelvic mass (1). One of these patients had a simultaneous CNS recurrence. Three of eight (Group B)
59. USE OF POLYMERS TO LOCALLY RELEASE CARBOPLATIN AND INHIBIT THE GROWTH OF WALKER 256 CARCINOSARCOMA

Alessandro Olivi, M.D., Michael L. Pinn, B.S., Matthew G. Ewens, B.S., Daniel W. Chan, Ph.D., Henry Brem, M.D. (Baltimore, MD)

We have developed a polymer controlled-release system capable of treating experimental brain tumors by interstitial chemotherapy. Currently lipid soluble drugs (Nitrosoureas) are being tested clinically.

In order to determine if water soluble drugs remain effective when incorporated into polymers for local administration, we tested Carboplatin, a Cisplatin analog, against the Walker 256 carcinosarcoma which is capable of growing in a solid mass in the rat flank and has been used as a model for meningeal carcinomatosis.

Carboplatin (7mg) was incorporated into ethylene-vinyl acetate copolymer cylinders (14mg). In vitro kinetic studies demonstrated that approximately 12% of the drug is released over the first 10 days.

Walker 256 carcinosarcoma was implanted in the flank of 32 Sprague-Dawley rats. Four days later the animals were divided into 4 treatment groups: Group 1 received an intraperitoneal (IP) injection of Carboplatin (30mg/Kg), implantation of empty polymer adjacent to the tumor and in the contralateral flank; Group 2 received Carboplatin-loaded polymer adjacent to the tumor, empty polymer contralaterally and IP saline. Group 3 had empty polymer at the tumor site, Carboplatin-loaded polymer
AND INHIBIT THE GROWTH OF CARCINOSARCOMA

saline. Group 4 (Controls) had water acid and IP saline.

Group 1 (IBI) and Group 2 (local carboplatin) showed a significant tumor growth (t < 0.05 and p = 0.05 respectively) when compared to controls.

Group 2 retained its antitumor activity when loaded into a controlled release polymer.

A controlled release of Carboplatin at the tumor site might reduce the systemic toxicity associated with systemic delivery.

This may add to the armamentarium useful in the treatment of pediatric brain tumors.

GROWTH HORMONE FAILURE FOLLOWING RADIATION THERAPY OF PRIMARY BRAIN TUMORS

Paul M. Kaney, M.D., Mitchel S. Berger, M.D., John Lefebvre, M.D., Richard S. Mauseth, M.D. (Seattle, WA)

Many children have developed endocrine failure following radiation therapy for brain tumors. Growth hormone replacement therapy has become readily available since the development of genetically engineered hormone. We have reviewed the medical records of patients at Children's Hospital and Medical Center to assess the development of endocrinopathy following treatment and the success of hormone replacement.

81 children with brain tumors were cared for in 1986-1987, the first two years after synthetic hormone became available. Pathology was confirmed at craniotomy or biopsy in 71 patients. Presumptive diagnosis was made by MRI in 10 children with optic pathway or brainstem tumors. 60 children received radiation therapy: craniospinal - 25 patients, and focal infratentorial - 10 patients. No postoperative therapy followed complete tumor resection in 11 children. Chemotherapy was the only treatment used in 6 children. The families of 4 children refused all treatment including surgery. 48 children who received radiation therapy were alive at the time of review and represent the study populations. Endocrine evaluation was initiated when growth was less than 4 cm/year in children less than 4 years of age or when height fell to a lower growth percentile. Work-up included x-rays for bone age, T4, TSH and somatotropin-C levels. Growth hormone provocative studies followed 1-dopa and clonidine stimulation.
Intracranial primitive neuroectodermal tumors (PNET) are one of a series of tumors that occur predominantly in the pediatric population. Other tumors in this group include neuroblastoma, retinoblastoma, rhabdomyosarcoma, osteosarcoma, Wilm's tumor, and hepatoblastoma. Specific rearrangements or deletions resulting in a reduction from the heterozygous state to homozygosity have been identified on various chromosomes for all of these tumors but intracranial PNET. Hoping to identify similar genomic changes in patients with PNET, comparisons were made between tumor DNA and somatic DNA in a series of patients using the technique of Southern blotting. The DNA was examined for changes in restriction fragment length polymorphisms (RFLP) with a minimum of two DNA probes in regions of interest. The regions examined include chromosome 1p (neuroblastoma), 11p (Wilm's tumor, hepatoblastoma, rhabdomyosarcoma), and 13q (retinoblastoma, osteosarcoma). In addition, chromosome 10, which has been implicated in glioblastoma multiforme, and chromosomes 6q and 17p, which have been implicated in medulloblastoma on the basis of cytogenetic data, were also examined. A reduction to homozygosity has been identified on chromosome 17p in three of nine informative patients. In addition, two of eight informative patients showed a reduction to homozygosity on chromosome 6q. No more than one patient showed a reduction at any of the other loci examined. Thus, a tumor suppressor gene important in the oncogenesis of medulloblastoma may be located on chromosome 6q and/or 17p. Currently, work is in progress to determine the significance of the reduction to homozygosity seen in these patients.
62. GROWTH FACTOR RECEPTORS ON PEDIATRIC BRAIN TUMORS
(Cont')

receptor levels. TFN receptors were undetectable on normal brain and ependymoma tumor specimens. Two medulloblastomas expressed significant levels of TFN receptors. By performing a comparative analysis between the counts obtained from the tumor samples and a primitive neuroectodermal tumor-derived tissue-culture cell line (TE-671), we were able to estimate the number of receptor sites per cell for each tumor sample. The number of EGF receptors/cell for ependymomas were estimated to range from 1000-6000 receptors/cell. The number of TFN receptors/cell for medulloblastomas were estimated to be 1400 receptors/cell and 8200 receptors/cell.

The demonstration of EGF receptors on ependymoma and TFN receptors on medulloblastoma suggests that these tumors may be susceptible to immunotoxin therapy. Ependymoma and medulloblastoma, both known to spread via cerebrospinal fluid pathways, may be treatable by the intrathecal administration of one or more toxin-antibody conjugates.
assay. There was no significant potentiation of BCNU-sensitivity or BCNU-induced DNA-interstrand crosslinking in UW228, the cell line with the lower \( \text{O}^6 \)-AT level. These results are in agreement with our previous observation with human malignant astrocytomas and demonstrate that elevated \( \text{O}^6 \)-AT can be a significant basis for CENU-resistance of human medulloblastomas.

Supported by NIH, NCI, Grant CA46410, and NIH, NINDS Grant
position and orientation of the retractor displayed on the workstation. The tumour is excised by use of the CO2 laser attached to the operating microscope.

Radical excision of a deep seated pilocytic astrocytoma has been performed in one case using this system.
Section on
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*Alphabetical by name
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