Disclaimers: The Journal of Neurosurgery Publishing Group (JNSPG) acknowledges that the preceding abstracts are published as submitted and did not go through JNSPG’s peer-review or editing process.

**Abstract #1: Informed Consent in Fetal Surgery: Who is Being Consented and for What?**

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**Institutions:**
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All authors have no relevant disclosures.

**Introduction:** Informed consent is a pillar of modern bioethics and is supported by numerous ethical principles, including beneficence, respect for persons and personal autonomy. It is also now a legal requirement for most research and medical care. Its elements include that the patient understands the risks/benefits, that “relevant” information has been disclosed to the patient and that the patient has the ability to make a voluntary decision to proceed.

**Methods:** The advent of maternal-fetal medicine has presented unique challenges, starting with the notion of two patients. Furthermore, much of the care offered is at the leading edge of innovation. The impact on informed consent is broad, including uneven distribution of risks, tangible benefit for one patient only, fetal benefit being highest in lethal conditions, the fetus cannot consent and has poorly defined rights (up until delivery) and the father’s rights remain unclear.

**Results:** The process of fetal repair of myelomeningocele has passed through the stages of innovation/experiment, research and ultimately to “standard of care” in <25 years. As a non-lethal condition, the risk/benefit approach is much harder to define, particularly as the risks can evolve with the growth of the procedure. It is proposed that the development of the procedures must be based on the hope of reducing disability, with consent being based on the principles of autonomy and beneficence for the mother, but on the beneficence principle only for the baby.

**Conclusion:** An example of a less than ideal informed consent will be presented, and the historical lessons learned from the development of caesarian section will also be reviewed.
Abstract #2: The Impact of Voluntary Folate Fortification of Corn Masa Flour and Tortilla Products on Pregnanices Complicated by Neural Tube Defects

Roxanna Garcia MD, MPH, Syed I Khalid, MD, Kyle Thomson, BS, Brittany M Hunter, MD, Robin Bowman MD, Sandi Lam, MD, MBA

Introduction: In 1996 the United States Food and Drug Administration (FDA) mandated folic acid fortification for enriched cereal grains. This resulted in a reduction of neural tube defect (NTD) affected pregnancies. However, Hispanic women continued to be twice as likely to give birth to a child affected by NTD compared to non-Hispanic white women. Hypotheses explaining this difference mainly depend on cultural dietary intake of cereal grains. In 2016, the FDA approved voluntary folic acid fortification for corn masa flour products to focus on the Hispanic diet staple. This study investigates rates of NTDs in predominantly Hispanic zip codes before and after the voluntary fortification of corn masa flour with folic acid.

Methods: Normal pregnancies and those complicated by NTDs between 1/1/2016 and 12/31/2020 were identified using ICD-9 and ICD-10 codes in an all-payer claims database, with the post-fortification period beginning twelve months after the fortification recommendation. The causal impact of the FDA’s recommendation was assessed by means of a Bayesian structural time-series model.

Results: 2,584,366 total pregnancies were identified among females aged 15-50 years. Of these, 365,983 took place in predominantly Hispanic zip codes (>75% of households). Mean quarterly NTDs per 100,000 pregnancies did not significantly differ between predominantly Hispanic zip codes and predominantly non-Hispanic zip codes pre-FDA recommendation (184.5 vs. 175.6, p=0.387), nor post-recommendation (188.2 vs. 185.9, p=0.688). Rates of NTDs predicted to occur if no FDA recommendation had been made were compared to the actual rate post-recommendation. No significant difference was observed in predominantly Hispanic zip codes (p=0.245) or overall (p=.116).

Conclusions: Rates of neural tube defects were not significantly reduced in predominantly Hispanic zip codes following the 2016 FDA approval of voluntary folic acid fortification of corn masa flour. Further research and implementation of comprehensive approaches to advocacy, policy, and public health are necessary for decreasing rates of preventable congenital disease.

Figure 1. Neural tube defects per 100,000 live births per quarter before and after the voluntary folate supplementation of corn masa flour was recommended by the FDA.
Solid black: actual number of NTDs per 100,000 live births.

Blue dashed line: projected number of NTDs per 100,000 live births.

Shaded blue region: confidence interval for projection. Dashed grey line: border between before and after implementation periods.
Table 1. Structural time-series models of post-intervention period response per quarter

<table>
<thead>
<tr>
<th></th>
<th>Average (SD) [95% CI]</th>
<th>Cumulative (SD) [95% CI]</th>
<th>p-value</th>
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<tbody>
<tr>
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<tr>
<td>All Zip Codes</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Actual n</td>
<td>186</td>
<td>2793</td>
<td></td>
</tr>
<tr>
<td>Prediction n</td>
<td>181 (4.4) [172, 190]</td>
<td>2714 (66.2) [2580, 2845]</td>
<td></td>
</tr>
<tr>
<td>Absolute Effect n</td>
<td>5.3 (4.4) [-3.5, 14]</td>
<td>79.6 (66.2) [-51.8, 213]</td>
<td></td>
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<tr>
<td>Relative Effect n (%)</td>
<td>2.9% (2.4%) [-1.9%, 7.9%]</td>
<td>2.9% (2.4%) [-1.9%, 7.9%]</td>
<td>.116</td>
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<td></td>
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<tr>
<td>Zip Codes With &gt;75% Hispanic Population</td>
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<tr>
<td>Actual n</td>
<td>188</td>
<td>2823</td>
<td></td>
</tr>
<tr>
<td>Prediction n</td>
<td>202 (17) [166, 237]</td>
<td>3035 (260) [2495, 3555]</td>
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</tr>
<tr>
<td>Absolute Effect n</td>
<td>-14 (17) [-49, 22]</td>
<td>-213 (260) [-732, 327]</td>
<td></td>
</tr>
<tr>
<td>Relative Effect n (%)</td>
<td>-7% (8.6%) [-24%, 11%]</td>
<td>-7% (8.6%) [-24%, 11%]</td>
<td>.245</td>
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<tr>
<td>Zip Codes With &lt;75% Hispanic Population</td>
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<tr>
<td>Actual n</td>
<td>186</td>
<td>2788</td>
<td></td>
</tr>
<tr>
<td>Prediction n</td>
<td>178 (3.2) [171, 184]</td>
<td>2664 (47.4) [2570, 2759]</td>
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<tr>
<td>Absolute Effect n</td>
<td>8.3 (3.2) [1.9, 15]</td>
<td>123.9 (47.4) [29.0, 218]</td>
<td></td>
</tr>
<tr>
<td>Relative Effect n (%)</td>
<td>4.7% (1.8%) [1.1%, 8.2%]</td>
<td>4.7% (1.8%) [1.1%, 8.2%]</td>
<td>.006*</td>
</tr>
</tbody>
</table>

*Significant Values P <0.05
Table 2. Descriptive characteristics for patients with pregnancies complicated by neural tube defects before and after initiation of corn masa flour supplementation with folic acid in 2016 in all zip codes

<table>
<thead>
<tr>
<th>Age</th>
<th>Before NTD/Total Pregnancies n=3,509/794,491</th>
<th>After NTD/Total Pregnancies n=10,989/1,789,875</th>
<th>p-value</th>
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</thead>
<tbody>
<tr>
<td>15-19</td>
<td>198 (5.6) / 66,144 (8.3)</td>
<td>604 (5.5) / 171,937 (9.6)</td>
<td>0.129/&lt;.001*</td>
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<tr>
<td>20-24</td>
<td>782 (22.3) / 179,610 (22.6)</td>
<td>2541 (23.1) / 378,327 (21.1)</td>
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<tr>
<td>25-29</td>
<td>941 (26.8) / 204,455 (25.7)</td>
<td>2975 (27.1) / 432,085 (24.1)</td>
<td></td>
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<tr>
<td>30-34</td>
<td>954 (27.2) / 177,772 (22.4)</td>
<td>2745 (25) / 385,454 (21.5)</td>
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<tr>
<td>35-39</td>
<td>493 (14) / 107,084 (13.5)</td>
<td>1642 (14.9) / 253,734 (14.2)</td>
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<tr>
<td>40-44</td>
<td>141 (4) / 41,084 (5.2)</td>
<td>441 (4) / 112,162 (6.3)</td>
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<tr>
<td>45-50</td>
<td>4 (0) / 18,342 (2.3)</td>
<td>41 (0.4) / 56,176 (3.1)</td>
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<tr>
<td>NTD/100,000 Pregnancies</td>
<td>442</td>
<td>614</td>
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</table>

*Significant Values P <0.05
Table 3. Descriptive characteristics for patients with pregnancies complicated by neural tube defects in predominantly Hispanic zip codes versus predominantly non-Hispanic zip codes before initiation of corn masa flour supplementation with folic acid

<table>
<thead>
<tr>
<th>Age n (%)</th>
<th>Non-Hispanic zip codes</th>
<th>Hispanic zip code</th>
<th>p-value</th>
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<tbody>
<tr>
<td></td>
<td>NTD/Total Pregnancies</td>
<td>NTD/Total Pregnancies</td>
<td></td>
</tr>
<tr>
<td>15-19</td>
<td>174 (5.8) / 57,669 (8.4)</td>
<td>24 (4.8) / 8,475 (7.9)</td>
<td>0.159/ &lt;.001*</td>
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<tr>
<td></td>
<td>668 (22.2) / 156,818 (22.8)</td>
<td>114 (22.7) / 22,792 (21.3)</td>
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<tr>
<td>20-24</td>
<td>804 (26.7) / 177,512 (25.8)</td>
<td>137 (27.3) / 26,943 (25.2)</td>
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</tr>
<tr>
<td>25-29</td>
<td>836 (27.8) / 153,477 (22.3)</td>
<td>118 (23.5) / 24,255 (22.7)</td>
<td></td>
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<tr>
<td>30-34</td>
<td>409 (13.6) / 91,348 (13.3)</td>
<td>84 (16.7) / 15,736 (14.7)</td>
<td></td>
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<tr>
<td>35-39</td>
<td>116 (3.9) / 34,890 (5.1)</td>
<td>25 (5) / 6,194 (5.8)</td>
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<tr>
<td>40-44</td>
<td>0 (0) / 15,937 (2.3)</td>
<td>0 (0) / 2,405 (2.3)</td>
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<tr>
<td>NTD/100,000 Pregnancies</td>
<td>437</td>
<td>470</td>
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*Significant Values P <0.05
Table 4. Descriptive characteristics for patients with pregnancies complicated by neural tube defects in predominantly Hispanic zip codes versus predominantly non-Hispanic zip codes after initiation of corn masa flour supplementation with folic acid

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<th>p-value</th>
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<tbody>
<tr>
<td></td>
<td>NTD/Total Pregnancies</td>
<td>NTD/Total Pregnancies</td>
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<td></td>
<td>n=9,346/1,540,544</td>
<td>n=1,650/259,143</td>
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<tr>
<td>15-19</td>
<td>174 (5.8)/57,669 (8.4)</td>
<td>24 (4.8)/8,475 (7.9)</td>
<td>0.024*/&lt;.001*</td>
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<td>20-24</td>
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<tr>
<td>NTD/100,000 Pregnancies</td>
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<td>470</td>
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*Significant Values P <0.05
Abstract #4: Society of MYND: Mentorship of Young Neurosurgical Doctors: Results of a Pilot Project

Kimberly Hamilton, S. Hassan A. Akbari, Howard Weiner

All authors have no relevant disclosures.

**Introduction:** Pediatric neurosurgery has evolved significantly over the last several decades, with expansion of our field into smaller hospitals and more remote locations. More children can access neurosurgical care by fellowship trained pediatric providers, with less travel burden. We hypothesized that this increased distribution of surgeons has led to a higher number of small-volume practices, leaving newly trained providers with fewer opportunities for on-campus mentorship by senior partners.

**Objectives:** We aim to understand how the evolution of pediatric neurosurgery has affected junior faculty education. We strive to provide active, scheduled mentorship of pediatric neurosurgeons in their early years of practice.

**Methods:** Remote methods were utilized to establish a nationwide case conference twice monthly. Recently graduated pediatric neurosurgeons were contacted and offered participation. Surveys were deployed for understanding practice environments and establishing logistics of conferences. Data regarding ABPNS certification was obtained to understand volume of surgeons.

**Results:** Notable growth of the field has occurred since ABPNS certification began: 76 pediatric neurosurgeons in 1996, to 303 currently practicing board-certified pediatric neurosurgeons. Conferences have been held twice monthly since June 2022. Attendance has ranged from 5-16 participants, including 0-3 senior faculty support members. Topics of discussion have included acute inpatient care, nonurgent outpatient work up, surgical techniques, nuances of family discussions and counseling, strategies for navigating departmental changes, among others. Outlook data reveals expected attendance is routinely greater than actual attendance. Repetitive attendance is seen from junior faculty in practices of all sizes (1-7 partners); participation rates are lower among faculty residing in western time zones.

**Conclusions:** Junior faculty demonstrate interest in continued, active mentorship, available on a regular basis, which appears independent of local partner presence. Varied participation by time zone suggests re-evaluation of scheduling is warranted. Further avenues to fulfill ongoing educational needs of junior faculty will be investigated and pursued.
Abstract #5: Sociodemographic Barriers to Treatment for Elective Pediatric Neurosurgical Disease

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Objective: Review the impact of sociodemographic factors in the management of neurosurgical disease.

Methods: CM1-SM patients receiving surgery with ≥1 year of follow-up data were identified in the Park-Reeves Syringomyelia Research Consortium (PRSRC) database. Additionally, single-institution cohorts of CM1 and sagittal synostosis patients were identified. Presentation, treatment, and complications were analyzed by sociodemographic determinants. Greater advantage was defined as an Area Deprivation Index score of >5.

Results: In the PRSRC dataset, 76.8% were non-Hispanic white and 23.2% were non-white (NW). NW patients more frequently used Medicaid (p<0.001), were treated at low-volume centers (p<0.01), were older at diagnosis (p=0.002), presented more with lower cranial nerve and cerebellar signs, were older at surgery (p=0.001), and had longer OR times (p<0.001), longer hospital stays (p=0.037), and higher blood loss (p<0.001). Non-white patients had a longer duration of symptoms before reaching diagnosis (p=0.033). Among a single-institution cohort of patients with initially asymptomatic CM1, 40 underwent delayed decompression. These patients were more likely to be from urban areas (p=0.023) of greater advantage (p=0.025). Finally, among 50 patients undergoing sagittal synostosis repair, all non-white patients underwent open repair (p=0.018), were older at the age of neurosurgery consultation (p=0.001) and were from areas of greater disadvantage (p=0.013). Patients with higher levels of disadvantage
were older at initial visit (p=0.004), were more likely to have Medicaid (p<0.001), were more likely to be NW (p=0.007) and were more likely to undergo open repair (p=0.015).

**Conclusions:** Non-white CM1-SM patients tended towards delayed diagnosis, intervention, and treatment at low-volume centers. Initially asymptomatic patients undergoing delayed decompression were from more affluent areas, suggesting better follow-up care. Patients with greater disadvantage were more likely to have delayed diagnosis, thus requiring more invasive open sagittal synostosis repair. These findings point to sociodemographic disparities and the need for greater neurosurgical outreach and pediatrician education.
Abstract #6: Long-term Outcomes Among People with Lipomyelomeningocele (LMM): An Analysis from the National Spina Bifida Patient Registry (NSBPR)

Mark S. Dias, MD (Penn State Health Children’s Hospital), Ming Wang, PhD (Penn State College of Medicine), Menglu Liang, MS (Penn State College of Medicine), Yunting Yu, BS (Penn State College of Medicine), Elias Rizk, MD (Penn State Health Children’s Hospital), Tiebin (Kevin) Liu, Centers for Disease Control and Prevention, Jeffrey Blount, MD (Children’s Hospital of Alabama), Brandon Rocque, MD (Children’s Hospital of Alabama), Robin Bowman, MD (Lurie Children’s Hospital), Gregory Heuer, MD (Children’s Hospital of Philadelphia), Betsy Hopson (Children’s Hospital of Alabama), Jonathan Castillo, MD (Texas Children’s Hospital, Houston), Alex Van Speybroeck, MD (Children’s Hospital Los Angeles), Stacy Tanaka, MD (Vanderbilt University), Carlos Estrada, MD (Boston Children’s Hospital)
On behalf of the National Spina Bifida Patient Registry Group

Introduction: Previous studies of people with LMM have provided conflicting results regarding outcomes, particularly retethering rates (ranging from 2-47%). The NSBPR, a multi-institutional registry presently with more than 10,000 registrants, provides an opportunity to study long-term outcomes, and compare in particular the long-term retethering rates after early initial versus later repair among a large cohort.

Methods: Registrants with LMM enrolled between 2009-2019 were studied. Two groups were contrasted – those undergoing initial repair ≤ 6 months of age as a proxy for prophylactic repair (Group I; n = 547), and those undergoing repair > 6 months of age (Group II; n = 623). Clinical outcomes and rates of subsequent tethered cord release (TCR) were contrasted. Acute clinical deterioration following initial repair and subsequent TCR were studied.

Results: Of 1170 identified registrants, at the last visit 68.7% had sacral level function, 80.1% were community ambulators, 66.4% had bladder dysfunction, 55.8% were on a bowel regimen, and 51.8% had bowel continence. Subsequent TCR were performed in 24.9% with a greater rate among Group I (27.8%) compared with Group II (22.3%) (p = 0.036). Kaplan-Meier analysis confirmed that TCR also occurred earlier after initial repair in Group I (p < 0.001). Mean length of follow-up was significantly greater (p < 0.001) in Group II (16.1 yrs) than in Group I (12.24 yrs). However, there were no significant clinical differences between Groups I and II with respect to functional level, ambulation, use of braces or wheelchairs, or bladder/bowel function at last follow-up. Although there were no significant changes in neurological or urological function after initial repair, there was a significant post-operative decline in functional motor level after subsequent TCR when compared with pre-operative status (p < 0.001).

Conclusions: In this, the largest long-term study of people with LMM, long-term clinical outcomes are significantly worse than previously reported. Those who underwent early repair (≤ 6 months) had higher retethering rates than those who had delayed repair (> 6 months) with no significant differences in functional outcomes. TCR itself was associated with significant post-op deterioration in functional level.
Abstract #7:  Surgical Treatment of Spinal Disease in Achondroplasia – Results from CLARITY (The Achondroplasia Natural History Study)

Jeffrey Campbell, MD, Nickolas Nahm MD, Stuart Mackenzie MD, William G. Mackenzie MD; Adekemi Alade MD MPH; S. Shahrukh Hashmi MD MPH PhD; Jacqueline Hecht PhD; Julie Hoover-Fong MD PhD; Janet M. Legare MD; Mary Little BSN RNC-NIC; Chengxin Liu MPH; Peggy Modaff MS; Richard M. Pauli MD PhD; David F. Rodriguez-Buritica MD; Elena Serna; Cory J. Smid MS; Michael B. Bober MD PhD

Background: The purpose of this study was to describe the frequency and risk factors for spine surgery in patients with achondroplasia. CLARITY (The Achondroplasia Natural History Study) includes clinical data from achondroplasia patients receiving treatment at four skeletal dysplasia centers in the United States from 1957 to 2018.

Results: One thousand three hundred and seventy-four patients with achondroplasia were included in this study. 12.7% (n=175) of patients underwent spine surgery. The most common spinal procedure was decompression (152 patients underwent 271 laminectomy procedures). The mean age for all laminectomies was 25.5 ± 15.5 years with a median age of 20.6 (0.1-67.6). One hundred and six patients underwent 142 fusion procedures. The mean age for fusion was 21.0 ± 15.1 years with a median age of 15.6 (0.8-65.8). When the indication for a spinal decompression surgery was thoracolumbar kyphosis versus all other potential indications, the median age at surgery was 13.2 years vs. 22.7 years (p=0.026). Kaplan Meier analysis suggests surgery for spinal stenosis that that is roughly 10% per decade with 14.8% of patients having a laminectomy by age 20, 41% by age 40, 69.1% by age 60, and 93.4% by age 80. Risk factors making surgery more likely include patients with hydrocephalus requiring shunt placement having higher odds of undergoing spine surgery (OR 2.06, 95% CI 1.27-3.34) and patients having a cervicomedullary decompression also had higher odds of undergoing spine surgery (OR 1.85, 95% CI 1.30-2.63)

Conclusions: Need for spine surgery for spinal stenosis follows age in a linear fashion at roughly 10% per decade. Persistent thoracolumbar kyphosis is associated with surgery at an earlier age. Cervicomedullary decompression and symptomatic hydrocephalus are associated with an increased risk for spine surgery. The findings from CLARITY, the largest natural history study of achondroplasia, should aid clinicians in counseling patients and families about spine surgery.

Disclosures: This study was funded by a research grant from BioMarin Pharmaceutical Inc (San Rafael, California) and the Alan and Kathryn Greenberg Center for Skeletal Dysplasias at Johns Hopkins University.
Abstract #8: Fetoscopic, Three-Miniport Technique for Prenatal Myelomeningocele Repair: Technical Evolution and Outcomes in 60 Consecutive Cases

Charles B. Stevenson, MD; Mounira A. Habli, MD; Foong Y. Lim, MD; Jose L. Peiro, MD

All authors have no relevant disclosures.

Objective: In the decade since the Management of Myelomeningocele Study (MOMS) concluded, multiple groups have demonstrated the feasibility of fetoscopic myelomeningocele (MMC) repair, with potential reduction in rates of preterm birth, lower risk of uterine dehiscence, and the option of vaginal delivery when compared to open fetal repair. Here we describe our experience with a fully endoscopic technique providing a multi-layered closure for prenatal MMC repair utilized at our center over several years, reporting on the technical aspects, evolution, and clinical outcomes in 60 consecutive cases.

Methods: IRB-approved, retrospective study of all fetoscopic MMC repairs performed at our center from 11/2015 to 07/2022. Technical details of each procedure, as well as maternal and fetal clinical outcomes, were analyzed.

Results: In all cases, midline maternal limited laparotomy was performed under a combination of general and epidural anesthesia. The uterus was exposed and three fetoscopic ports (6/10/10 Fr) were placed under US-guidance and direct visualization via Seldinger technique. The neural placode was released utilizing bimanual technique. Duraplasty was performed with an allograft patch. The skin was closed primarily with running suture if feasible; an acellular dermal allograft patch was utilized in 15 cases (25%). No procedures required conversion to open hysterotomy. A watertight seal was achieved in all cases, with no evidence of CSF leak at birth. Cesarean-section was performed in 32 patients (53%) and vaginal delivery in 28 patients (47%). No infants demonstrated significant brainstem dysfunction. Fourteen (23%) required CSF diversion for progressive hydrocephalus.

Conclusion: A laparotomy-assisted, three-miniport fetoscopic approach using dural patches offers excellent access and magnification for watertight closure in prenatal myelomeningocele repair. Initial results demonstrate clinical outcomes comparable to those of open fetal repair reported in MOMS, while obviating the need for delivery via cesarean section in every case.
Abstract #9: Fourth Ventricle Roof Angle Validation in Pediatric Chiari I Malformation

Curtis Rozzelle MD, Brandon Rocque, MD, Tori Caudill, Anastasia Smith, MPH, Luke Anderson, Jana Badrani

Introduction: Bowing of the Fourth Ventricle, defined as a Fourth Ventricle Roof Angle (FVRA) > 65 degrees, was recently reported to predict brainstem dysfunction in a mixed series of adult and pediatric Chiari-I malformation (CM-I) patients at a single center. This novel finding has not been validated elsewhere.

Objectives: To validate FVRA >65 degrees as 1) a predictor of brainstem dysfunction in pediatric CM-I, 2) investigate other potential correlations: syringomyelia, scoliosis, other symptoms, or presence of a veil obstructing the fourth ventricular outlet, and 3) evaluate FVRA correlations with established radiographic markers.

Methods: FVRA measurements were made for all patients evaluated for CM-I between 11/2010 and 11/2017 and added to a previously populated institutional database. Univariable logistic regression was used to test for independent relationship of clinical variables with FVRA >65 degrees. FVRA was tested, as a numeric variable, for correlation relative to other measures of craniovertebral relationships, such as tonsil position, clivo-axial angle (CXA), basion dens interval (BDI), and presence of basilar invagination (BI).

Results: FVRA measurements were made for 388 pediatric CM-I patients (up to 21 years of age), of whom 128 had decompression surgery. FVRA >65 degrees did not correlate with lower cranial nerve dysfunction or central sleep apnea. It did correlate with surgical decompression (OR 2.78, CI 95% [1.73-4.51] p<0.001), syringomyelia (OR 2.59, CI 95% [1.55-4.34] p<0.001), or non-tussive headache/neck pain (OR 2.72, CI [1.37-5.41] p<.005). As a numeric variable, FVRA correlated with tonsil position, CXA, BDI, and presence of basilar invagination (BI).

Conclusions: Brainstem dysfunction did not correlate with FVRA >65 degrees in this series but syringomyelia, non-tussive occipital/cervical pain, and subsequent surgical decompression did. While FVRA also correlated with previously reported radiographic markers of CM-I severity, its potential clinical utility regarding brainstem dysfunction could not be validated.

Abstract #10: A Novel Arthrodesis Technique Results in Superior Occipitocervical Fusion Rates Over a 5-year Period

Brandi Pang, BS; Maryam Shahin, MD; Christina Sayama, MD, MPH

**Background:** The success of occipitocervical fusions (OCF) in children has been widely variable, with failure rates ranging 0 to 20%. We report our series in which we switched from using allograft to autograft in August 2016, and specifically changed the technique of arthrodesis in hopes to increase bony fusion rates. Our unique arthrodesis technique has not been described in the literature to our knowledge.

**Methods:** The authors report our retrospective series of 21 patients who underwent OCF at Doernbecher Children’s Hospital from January 2015 - May 2022. Cohort-1 included patients from January 2015 to July 2016 who underwent OCF with standard instrumentation and arthrodesis with allograft/BMP onlay only. Cohort-2 included patients from August 2016 - May 2022, in which rib autograft and the new technique of screwing down the ribs was used. Fusion was determined by post-operative CT scan at a minimum of 3 months post-operatively. 1 patient was excluded because of lack of CT evaluation at 3 or more months post-operatively. Other factors, such as patient age, sex, reason for surgery, medical comorbidities, type of biologics/graft(s) used, use of rigid external fixation, complications, and need for revision surgery were recorded.

**Results:** From Cohort-1, there were 7 patients who underwent OCF with 42.8% requiring revision surgery for complete/significant bony resorption. In Cohort-2, there were 17 patients who underwent OCF (including 3 revisions from Cohort-1) with standard instrumentation and rib autograft using the new arthrodesis technique. One patient was excluded due to no CT available. 16 patients (100%) achieved a solid bony fusion with this new technique. There was no difference in use of external rigid fixation post-operatively or reasons for surgery between the groups.

**Conclusion:** The use of rib autograft and novel arthrodesis technique to fixate ribs led to a positive effect on the overall fusion rate, with no further fusion failures in a 5+ year period.
Abstract #11: Unique Radiographic Features in Previously Asymptomatic Patients Presenting with Acute Neurologic Decline and Chiari Type 1 Malformation: A Case Series

Renee Reynolds, MD

Introduction: Chiari Type 1 Malformations can present in a myriad of ways including incidental findings, orthopedic abnormalities or neurologic symptoms. Acute presentations, with acute neurologic decline, are rare and there is little data regarding the radiographic features and outcomes in this patient population.

Methods: We present a case series of four, previously asymptomatic patients, who presented with severe acute neurologic decline following innocuous events. Unique radiographic similarities and outcomes are discussed.

Results: Four patients (3 female, 1 male) ages 10-14yo presented for emergency medical attention after experiencing severe neurologic symptoms following a relatively innocuous event. Two occurred following a sneeze while two others occurred after quickly sitting up from a supine position. All patients presented with acute onset of severe headache and right upper extremity motor and sensory loss. Two also experienced severe vomiting while another had debilitating vertigo. Each was identified as having a Chiari malformation and a large associated cervical syrinx. In all cases the syrinx was noted to have an eccentric irregular extension emanating from the rostral extent out through the foramen of Luschka. All patients were managed with urgent decompression. All had complete resolution of their symptoms over time.

Discussion: Although rare, Chiari malformation can present in an acute fashion with associated neurologic decline. Imaging in this small series suggests the possibility of an unstable syrinx with acute rupture and tissue dissection as a source in some cases. With appropriate and early surgical intervention outcomes appear to be favorable.
Abstract #12: Development and Validation of a Fast Spine Protocol for Use in Pediatric Patients

Albert Tu, MD

Objective: Conventional pediatric spine MRI protocols have multiple sequences resulting in long acquisition times. Sedation is consequently required. This study evaluates the diagnostic capability of a limited MRI spine protocol for selected common pediatric indications.

Methods: After REB approval, records of pediatric patients under 4 years of age who underwent a spine MRI at CHEO between 2017 and 2020 were reviewed. Two neuroradiologists blindly and retrospectively reviewed the T2 sagittal sequences from the craniocervical junction to sacrum and T1 axial sequence of the lumbar spine, to answer specific questions regarding cerebellar ectopia, syrinx, level of conus, filum <2mm, fatty filum, and spinal dysraphism. The results were independently compared to previously reported findings from the complete imaging series.

Results: 105 studies were evaluated in 54 male and 51 female patients (mean age of 19.2 months). The estimated combined scan time of the limited sequences was 9-18 minutes compared to 24-36 minutes for conventional protocols (delta = 20-30 minutes). The average percent agreement between full and limited sequences was >95% in all but identifying a filum <2mm, where the percent agreement was 87%. Using limited MR sequences had high sensitivity (>0.91) and specificity (>0.99) for the detection of cerebellar ectopia, syrinx, fatty filum, and spinal dysraphism.

Conclusion: This study demonstrates that selected spinal imaging sequences allows for consistent and accurate diagnosis of specific clinical conditions. A limited spine protocol reduces acquisition time, potentially avoiding sedation. Further work is needed to determine the utility of selected imaging for other clinical indications.
Abstract #13: The Role of Hydroxyringomyelia in the Surgical Treatment and Functional Outcomes in Pediatric Patients with Intramedullary Spinal Cord Tumors

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Introduction: Maximal-safe resection is recommended for intramedullary spinal cord tumors (IMSCTs). Syrinx is considered operatively favorable though impact on surgical and functional outcomes is unknown.

Methods: 74 IMSCT were treated at BCH between 1995-2022, 28 with syrinx (IMSCT+S) and 46 without (IMSCT). Tumor characteristics, symptoms, extent of resection, and functional outcomes are reported.

Results: Tumor characteristics: Comparing IMSCT vs. IMSCT+S, IMSCT+S were mostly thoracic (35vs.18% cervical, 9vs.18% cervicothoracic, 35vs.57% thoracic, 4 vs.4% thoracolumbar, 17vs.4% lumbar). No significant pathologic differences between IMSCT vs. IMSCT+S (30vs.29% pilocytics, 0 vs.7% pilomyxoids, 26vs.25% LGGs, 24vs.25% ependymomas, 11vs.11% HGGs, 4vs.0% gangliogliomas, 4vs.4% anaplastic astrocytomas.) Presenting Symptoms: Symptoms comparing IMSCT vs. IMSCT+S included comparable motor deficits (63 vs.57%), sensory deficits (37 vs.46%), and neuropathic pain (7 vs.10%), and higher rates of bowel (11 vs.29%) and bladder symptoms (11 vs.29%), and scoliosis (22% vs.43%) in IMSCT+S. Extent of resection (EOR): Neuro-monitoring was used in 61/74 tumors; only biopsy or STR occurred without monitoring. No significant difference in EOR between IMSCT vs.IMSCT+S: 17 vs.11% biopsy, 39 vs.50% STR, 20 vs.18% NTR, 24 vs.21% GTR. 36% had residual syrinx. There were no operative complications. Discharge status: Majority of patients discharged home- 72% of IMSCT vs.68% of IMSCT+S; remainder discharged to rehab. Functional Outcomes: No significant difference between groups with favorable outcomes at 6-months. 92% of patients were ambulatory with 87% of IMSCTs and 78% of IMSCT+S McCormack grade 1-2. Catheterization rate was 2% for IMSCT vs.7% for IMSCT+S. Rate of instrumented fusion was 28% for IMSCT vs. 32% for IMSCT+S.

Conclusions: The majority of IMSCT are low-grade tumors amenable to surgical debulking with neuro-monitoring and have a >30% chance of GTR or NTR. Presence of syrinx does not significantly impact extent of resection or functional outcomes. The majority of patients discharge home with functional recovery by 6-months post-operatively.
Complication Talk #1: The Story Starts with Leg Pain and Ends with Three Surgeries and a New Diagnosis

Eric M. Thompson, MD

The patient is a 16-year-old female who presented with debilitating back pain and left L5 radiculopathy. She had tried/failed PT, oral steroids, NSAIDS, gabapentin, epidural steroid injections. She was having difficulty ambulating and was taking dilaudid. MRI showed L4-5 broad based disc bulge and lateral recess stenosis.

She was taken for L4-5 laminectomies and bilateral L4-5 and L5-S1 foraminotomies. The disc was incised and explored but there were mobile fragments. She was discharged on post op day 3. At her 2 week post op visit, had nearly complete pain relief. Incision was flat and dry.

She presents 1 month later with positional headaches. MRI showed small epidural fluid collection at the surgical site. Myelogram showed a dural rent at L4-5. She was taken back to the OR and a lateral dural rent was found, repaired with Prolene, Duragen over this, and DuraSeal.

She was kept flat for 2 days, and discharged, with positional headaches resolved.

She presented 2 weeks later with CSF egress from the wound. Lumbar puncture showed an opening pressure of 23 cm H2O. Lumbar drain plus blood patch vs. lumbar drain and open repair were discussed. We proceeded with the latter. Intraoperatively, CSF was found to be emanating from the dura suture line. Sutures were clipped and a BioDesign pledget was placed intradurally and sutured with prolene. Duragen was placed over this, and the area covered with Tisseal.

Had lumbar drainage for 5 days and a blood patch was performed at the lumbar drain site at the time of removal. During this hospitalization, genetics was consulted. She was diagnosed with Ehlers-Danlos Syndrome.

She did well from her hospitalization with symptoms of CSF leak. However, she has re-developed back pain.
Complication Talk #3: A Challenging Loculated Cystic Lesion: What to Do When the first Two Operations Fail?

David I Sandberg, MD

A 15-month-old boy presented with seizures that consisted of staring spells lasting 30 seconds. These spells continued despite anticonvulsant therapy. MRI scan demonstrated a non-enhancing loculated cystic lesion involving the suprasellar cistern, right ambient cistern, and medial aspect of the right temporal lobe. A right frontotemporal craniotomy was performed, and a lesion was encountered that was presumed to be a benign neoplasm. All obvious abnormal tissue was removed, and final pathology was disputed between two institutions (neuroepithelial cyst versus low grade neuroglial neoplasm). Postoperative MRI showed near-total resection of the lesion, and seizures resolved postoperatively.

On routine surveillance MRI 3 months later, the lesion had completely recurred. Re-operation was performed, during which no obvious tumor was encountered. Cyst wall was removed where feasible, and pathology was neuroepithelial cyst. Postoperative MRI again showed near total resection of the lesion.

On repeat MRI 3 months later, the lesion again had recurred. At this point, the patient’s imaging studies were sent for additional opinions to several senior pediatric neurosurgeons at outside institutions. Discussion will center on treatment options at this point and the patient’s outcome.
Complication Talk #4: Beware the Craniosynostotic Ossified Bulging Fontanel

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Blood loss is always a concern during craniosynostosis surgery. In addition to the use of blood management protocols, preoperative imaging must be carefully examined for potential surgical pitfalls. The author reports the case of a child who presented at 3 years of age with bicoronal and sagittal craniosynostosis associated with Apert syndrome. Having been recently adopted from a low resource country, he had no prior surgical treatment. Although he did not display clinical signs or symptoms of increased intracranial pressure, it was noted that his turribrachycephaly was associated with an anterior fontanel that had ossified in a bulging position. Imaging showed notable copper beaten changes, patent venous sinuses, one hypoplastic transverse-sigmoid sinus (not out of the range of normal), and no signs of significant venous drainage of the brain via the scalp vessels. Given signs of craniocerebral disproportion, he first underwent uncomplicated posterior cranial vault distraction to maximize intracranial volume. Due to the severity of the anterior cranial deformity at his advanced age, he also underwent bifrontal craniotomy and bilateral fronto-orbital advancement at the time of distractor removal. Intraoperatively, the ossified bulging fontanel was extremely adherent to the dura. It appeared as if there was ingrowth of dura into the medullary spaces of the bone. With careful dissection in the epidural plane under direct vision, the bone was freed without entry into the cerebrospinal fluid or venous spaces. The dissection was, however, associated with significant (but not catastrophic) blood loss requiring allogeneic (in addition to autologous) transfusion. The child did well postoperatively without complication. Upon follow-up, he had ample intracranial volume and a pleasing head shape without cosmetic deformity. Retrospective reanalysis of preoperative imaging revealed an inner table pattern at the ossified bulging fontanel which may allow identification of this entity in the future.
Practice Management #1: The Virtual Huddle

Bradley Weprin, MD

Background: It takes more than technical prowess to produce successful outcomes in pediatric neurosurgery. Surgery is a team sport performed in a modern operating room (OR) that is a complex environment designed to manage many different procedures and occupied by an increasing number of stakeholders. Potential for adverse events and inefficiency flourish. Miscommunication and poor coordination among surgical teams are known causes of preventable medical harms waste, and stress. Processes designed to improve perioperative communication have been shown to reduce errors and complications and to improve quality. There is extensive evidence supporting the use of checklists, timeouts, and debriefs.

One such activity is the pre-operative huddle. This briefing includes the entire surgical team. It is an attempt to ensure that every member of the operative team has clarity regarding the specifics of the proposed surgical procedure and the respective patient. It provides a standard approach to assuring everyone on the team is familiar with the plan, can ask questions, is able to identify potential problems and set expectations. Huddles and briefings have been consistently producing superlative results.

Huddle success is dependent upon compliance. Stakeholders at Children’s Health have found the effort to be unreasonable and it has not been sustainable. Technology may help overcome this challenge. Our UTSW pediatric neurosurgical division implemented use of a tailored technological platform for pre-operative communication. It is web-based, virtual and asynchronous. We tested the effects on compliance, safety, and efficiency using this innovative virtual huddle.

Methods: The electronic medical record (EMR) was used to record stakeholder compliance, the timing of procedures, and the outcomes of procedures. A surgical outcomes questionnaire detailing interruptions, workflow, and surgeon satisfaction was completed for elective neurosurgical cases. Baseline/ pre-intervention measurements on interruptions, delays, and workflow were recorded. The virtual huddle was introduced to the Children’s Health OR neuro-team. After implementation and execution of this intervention, measurements were documented.

Results: Following pre-intervention/baseline observations and huddle-implemented observations of elective neurosurgical procedures at Children’s Health, data was assessed. There was no significant difference in preoperative risk score between the preintervention and intervention patient populations. There was no significant change in morbidity and mortality between the preintervention and intervention periods. There was a significant improvement in compliance of a pre-operative huddle from in-person to virtual huddle. On the user recorded worksheets, there was improvement in interruptions, workflow, and surgeon satisfaction.

Conclusions: Deployment of a pre-operative communication (huddle) intervention in the UTSW division of neurosurgery at Children’s Health through a web-based platform increased communication and participation between neurosurgical team members. It led to a reduction in last-minute surgical delays and interruptions and to improved workflow and surgeon’s satisfaction. We believe that this intervention can lower costs, provide better surgical care for patients, and improve experience for patients and surgery team stakeholders.
Practice Management #2: What can Neurosurgery Learn from the Commercial Fishing Industry?

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Disclosure: I am a clinical advisor and investor in “8 Chili” (www.8chili.com), a company developing mixed reality products.

The fear associated with being a pediatric neurosurgeon are those related to my patients’ lives I have put at risk. I have had many sleepless nights thinking about the 1-2 children each year for whom I made an honest mistake, or their disease just won. If we recognize the stressors that lead to these fears, we can create a supportive environment that fosters our own physical and mental well-being.

Commercial fishing is recognized as one of the world’s most dangerous occupations. In October 2019 and January 2021, I was fortunate to be a deckhand on the F/V Saga, a commercial crab fishing boat, profiled on the Discovery Channel’s Deadliest Catch. The communication, teamwork, and well-being lessons I learned on these expeditions were surprisingly translatable to neurosurgery. There are similar stressors and risks with being a commercial fishing worker and being a neurosurgeon as the slightest error or lapse in judgment may lead to devastating consequences and death. These crab fishing workers must meet their crab quota in a safe, timely manner while working in challenging weather on slippery decks with thousand-pound swinging crab pots, fearing the loss of their anticipated yearly income. Similarly, a neurosurgeon must make quick decisions while working in a stressful environment. Although both industries require attention to detail, challenging work conditions, and long hours, the most important difference between healthcare and commercial fishing workers is that healthcare workers put other people’s lives, limbs, and organs at risk, while commercial fishing workers put theirs at risk.

But, if we think like commercial fishing workers, like teammates entrusted with each other’s lives and well-being, and remain flexible and resilient, we will endure. We need to listen, learn, and heal with each other to achieve a healthier, peaceful, and purposeful life with optimum performance in mind, body, and spirit.
Practice Management #3: Building a Robust Pediatric NeuroSpine Program

David F. Bauer, MD

Abstract: We will discuss tools one can use to develop a robust pediatric NeuroSpine program. We will discuss programmatic goals, building bridges with ortho spine, value to the hospital, value to orthopedics, and value to our patients. I will discuss personal anecdotes from my own journey building a robust spine practice that includes treatment of all aspects of pediatric spine surgery including spine deformity, skeletal dysplasia, dysraphism, compressive syndromes, trauma, spinal column tumors, and spinal cord tumors. Quality improvement projects, call schedule implications, and US News reporting will be discussed.
Neurosurgery is a discipline which exists on the precipice of opportunity and catastrophe. Inevitably, and despite our best efforts, neurosurgeons will have bad outcomes. Bad outcomes can have an impact on the neurosurgeon which prevents adaptive psychological recovery. Denied psychological recovery leads to feelings of burnout, emotional exhaustion, depersonalization, self-doubt and imposter phenomenon. Affected individuals experience second victim syndrome, and this can lead to a restricted career, or even the end of a surgeon’s career.

Second victim syndrome needs to be openly discussed. It will inexorably affect every surgeon. The audience will benefit from a discussion about the immediate biopsychosocial impact on a surgeon and the coping techniques and support strategies that are available. Hot and cold debriefing as well as local second victim peer support programs are uncommon, so a national program led by the cognoscenti of pediatric neurosurgery is a very reasonable topic to further discuss.

Well-being is often conceived as a fluffy topic with diffused edges; perioperative bad outcomes embody acute surgeon unwellness. Neurosurgeons can all identify with this, and together we can rally around psychological recovery as a concrete example of prioritizing well-being in neurosurgery. Bad outcomes cannot be eliminated from neurosurgery; our responses as a discipline to those affected by bad outcomes can promote individual surgical maturity.
Practice Management #5: Evaluation of a Role for Virtual Neurosurgical Education for Medical Students Over 2 Years of a Global Pandemic

Michael L Martini, MD, PhD, Raj K. Shrivastava, MD, Christopher P. Kellner, MD and Peter F. Morgenstern, MD

No Disclosures to Report

**Background:** Sub-internships are critical experiences for medical students applying to neurosurgical residencies, facilitating education and networking with colleagues. During the coronavirus disease 2019 pandemic, in-person rotations were suspended for 2020 and reduced for 2021. In 2020, our department developed a neurosurgical course to address this need. The course was continued in 2021, enabling assessment of student perceptions as the pandemic progresses.

**Methods:** The virtual course consisted of weekly 1-hour seminars over a 3- to 4-month period. Prior to starting, participants were sent a comprehensive survey assessing their backgrounds, experiences, and confidences in core concepts across neurosurgical subdisciplines. Participants also completed post-course surveys assessing the course's value and their confidence in the same topics. Responses from students completing both pre-course and post-course surveys were included, analyzed in pairwise fashion, and compared across course years.

**Results:** Students shared similar baseline characteristics in terms of demographics, educational background, and exposure to neurosurgery prior to the course. In the 2020 and 2021 cohorts, quality ratings for presentations were favorable for all seminars, and participants reported significantly increased confidence in core topics across all neurosurgical disciplines after the course (2020: 3.36 ± 0.26, P < 0.0001; 2021: 3.56 ± 0.93, P = 0.005). Most participants felt the course would remain useful following the pandemic in both the 2020 (96.9%) and 2021 (100.0%) cohorts.

**Conclusions:** Survey results suggest that the course adds value for students seeking a basic didactic curriculum to supplement their education, and perhaps, an online curriculum for medical students would continue to be beneficial going forward as in-person rotations resume. The positive responses to this format also indicate that a coordinated offering from organized neurosurgery for students entering the field would be well received.
Abstract #16: Intra-Arterial Drug Delivery with Blood Brain Barrier Disruption in Children with High Grade Glioma and Diffuse Intrinsic Pontine Glioma: Phase I Trial Results and Next Steps

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Introduction: Improving pediatric high-grade glioma (HGG) survival requires better drugs and increased delivery. Our Phase I trial of super-selective IA cerebral infusion (SIACI) of bevacizumab and cetuximab treated pediatric patients with refractory HGG (DIPG and GBM) to determine safety and efficacy and is now expanding on initial results with a multi-center repeat dosing protocol.

Methods: In our initial cohort, SIACI was utilized to deliver mannitol (12.5cc of 20% mannitol) to disrupt the blood brain barrier (BBB) followed by bevacizumab (15 mg/kg) and cetuximab (200 mg/m²) to target VEGF and EGFR, respectively. Patients with brainstem tumors had a balloon inflated in the distal basilar artery during mannitol infusion.

Results: In our 13 initial patients (10 DIPG and 3 HGG) toxicities included Grade I epistaxis (2 patients) and Grade I rash (2 patients). There were no dose limiting toxicities. Six of 10 symptomatic patients exhibited subjective symptom improvement, and one patient treated twice showed symptom relief with both IA treatments and no relief with IV delivery. 92% showed decreased enhancement on day 1 post-treatment MRI. Of 10 patients with 1 month MRI, 5 had progressive disease and 5 had stable disease on flair, while contrast scans included 4 progressive disease, 2 stable disease, 2 partial response, and 1 complete response. Mean overall survival of DIPG patients was 519 days (17.3 months) with mean survival post treatment 214.8 days (7.2 months). We have now opened a second phase with two sites and repeat monthly dosing for patients with stable or improved disease.

Conclusions: SIACI of bevacizumab and cetuximab was well tolerated in our initial cohort of 13 children. Our results demonstrate safety of this method, and we will now treat an additional cohort with repeat monthly dosing. As molecular targets are clarified, novel means of bypassing the BBB become more critical.
Abstract #17: High Throughput Drug Screening, Animal Avatars, CSF sequencing and Routine Autopsy Supplement DNA, RNA and Methylation Profiling for Pediatric CNS Tumors

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Introduction. High grade, inoperable and multiply recurrent CNS tumors confer poor prognoses for the pediatric population. Next Generation Sequencing may address aspects of tumor heterogeneity that account for outcomes. As we iteratively refine our precision medicine program, we can offer exome or genome sequencing, RNA sequencing, methylation profiling, avatar generation and CSF liquid biopsy for our patients. These assays may also be complemented by high-throughput drug screening (HTDS) and animal studies. We have also integrated detailed molecular analysis at autopsy.

Methods. Resected tumor tissue, CSF and blood from a diverse pediatric neuro-oncology cohort was allocated for whole exome sequencing (WES), RNA sequencing, and methylation profiling. DNA methylation arrays or methyl capture (RRBS) was utilized to delineate the epigenetic landscape for discreet tumors. Tissue acquisition at autopsy as also included in select cases. HTDS was performed on cell lines derived from primary OR-acquired tumor tissue, utilizing a drug library of FDA approved compounds. Selected compounds were validated as single agents or in combination both in vitro and in vivo on xenografted mice.

Results. We stratified and defined clinically relevant alterations detected by WES, RNA-seq and methylation classifier data as diagnostic, prognostic and targetable. Roughly 35% of variants detected from deeper sequencing demonstrated clinical utility. Methylation classifier data enhanced molecular sub classification or re-classification of tumor cases. We detected tumor-derived mutations in nearly 50% of CSF samples from brain tumor patients and this was associated with disseminated disease. 15 pediatric patients underwent autopsies that allowed the analysis of disease, disease adjacent, and distant sites. HTDS has been used to define novel drug targets for multiple tumor types.

Conclusion. The increasing number of molecular analyses must be weighed against their clinical utility and cost. Routine deep sequencing warrants consideration as an addition to standard of care. CSF liquid biopsy may improve diagnosis and decision making. Gene outlier expression, fusions and methylation classifier data demonstrated clinically relevant variants in 35% of cases. Technology has allowed us to deliver clinically relevant information at a reasonable cost and speed and will encourage frequent utilization of n-of-1 trials such as animal avatars and HTDS.
Abstract #19: Sonodynamic Therapy Using Low Intensity Focused Ultrasound and ALA for Diffuse Intrinsic Pontine Glioma: Rationale, Technical Considerations, and Challenges

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Introduction: Diffuse intrinsic pontine glioma (DIPG) is a devastating pediatric brain tumor. Despite standard radiotherapy, prognosis remains poor. Aminolevulinic acid (ALA) sonodynamic therapy (SDT) is a non-invasive strategy that involves the sensitization of target tissues with a non-toxic chemical agent and subsequent exposure of the sensitized tissues to MR-guided focused ultrasound (MRgFUS). The authors detail the rationale and mechanism behind the use of ALA SDT for DIPG, review criteria for patient inclusion, and describe the first patient selected for this clinical trial.

Methods: Preclinical studies have shown that performing SDT through MRgFUS to activate protoporphyrin IX, a metabolite of ALA, can slow the growth of gliomas and extend survival in animal models. Children’s National Hospital is conducting a first-in-human study of ALA SDT for DIPG. 18 patients, age greater than 5, with newly diagnosed, radiographic typical DIPG will be enrolled in dose-escalating cohorts. The technical considerations and challenges encountered in the first patient who underwent this trial are discussed.

Results: The first-in-human Phase 0/1 study investigates the feasibility and safety of ALA SDT. Six hours prior to SDT, pediatric patients with DIPG are administered Sonala-001 (10 mg/kg), an IV formulation of 5-ALA. In a dose escalation arm, patients are assigned one of three ascending acoustic energy doses of MRgFUS (200J/400J/800J). Initial patients are treated in 2 sessions, covering one-half of the pons. Safety is then assessed for treatment of the entire pons. The first patient was treated with 28 sonications to the right side and 54 to the left side. Total duration ranged from 148 to 182 min. No clinical adverse events were encountered after treatments. Post-procedure MRIs demonstrated no complications, and the patient was discharged after 1-day.

Conclusion: The first-in-human experience with a new therapeutic modality for DIPG patients demonstrates that ALA SDT is safe at 200J. Future procedures will involve ascending drug and MRgFUS energy dose combinations with evaluations of pharmacokinetics and radiographic evidence of tumor physiological changes. The use of focused ultrasound signals an innovative approach for pediatric brain tumors that remain challenging to treat.
Abstract #21: Ventriculoperitoneal Shunt Valves Encounter Transient but Repetitive Changes in Position and CSF Pulsations that Lead to a State of Chronic Over Drainage: Benchtop Model

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Background: Using benchtop valve testing, we’ve previously shown that VP shunt overdrainage is not limited to the vertical position, but that pulse pressures that simulate rhythmic (e.g., cardiac) and provoked (e.g., Valsalva) physiological CSF pulsations increase outflow in both the horizontal and vertical positions.

Objective: The present study aims to closely analyze the temporal and physiological characteristics of these flow perturbations through a shunt valve.

Methods: The previously developed pseudo-ventricle (PV) benchtop valve testing platform comprises a rigid pseudo-ventricle, compliance chamber, pulse generator, and pressure sensors. The PV was used to measure flow rates through a differential pressure shunt valve over 15 minutes under the following simulated physiological conditions: orientation (horizontal/vertical), compliance (low/medium/high), and pulsation generator force (none/low/medium/high).

Results: Two phases of CSF drainage, a transient state and a steady state, were identified. The steady state is the ideal state of a shunt, i.e., what valves aim to achieve. The transient state is created with every change in gravity or pulse pressure, with much larger outflow rate and volume generated in the transient state compared to the steady state ($P < 0.0001$). In the transient state, gravity increases outflow by 353%-1167% depending on compliance ($P < 0.0007$), while pulse pressure increases outflow by 206%-660% depending on pulse amplitude and compliance ($P < 0.005$).

Conclusion: As long as shunt valves are subjected to gravity and pulse pressures, a steady state of CSF drainage may not be reached, leading to repetitive bursts of high CSF outflow. Existing commercial valves are not designed to control these conditions, likely leading to a chronic state of shunt overdrainage.

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All authors have no relevant disclosures.

Introduction: Pediatric neurosurgeons may reasonably be asked about risks associated with future pregnancies when a patient has a ventriculoperitoneal (VP) shunt. However, contemporary literature on the incidence of complications in pregnant patients with VP shunts remains limited.

Methods: A research repository was queried for patients with hydrocephalus who delivered at a large hospital system between 1988-2022. Patients with a billing code for a vaginal/cesarean delivery and mention of VP shunt in their medical record were retrospectively reviewed.

Results: Fifty-nine patients, characterizing 83 pregnancies delivering 86 infants, were included. The median age at delivery was 32-years. The most common etiology of hydrocephalus was congenital abnormalities (34.0%), followed by intracranial tumors (28.8%), other/idiopathic hydrocephalus (18.6%), trauma (6.8%), spontaneous (6.8%) and neonatal (3.4%) IVH, and post-infectious (1.7%). Over half (62.7%) of the patients were <21 years at shunt placement (median 19-years), and 18.6% reported ≥1 prior shunt revision. During pregnancy, no patients experienced a shunt malfunction. Symptoms concerning for shunt malfunction (e.g. papilledema/vision changes, headache, abdominal pain) occurred in 10 pregnancies; however, there was no radiographic or shunt-tap evidence suggestive of malfunction. Two women underwent postpartum shunt revisions but neither reported symptoms of malfunction during pregnancy.

Obstetrical complications included preterm delivery (20.5%), gestational diabetes (10.8%), postpartum hemorrhage (7.2%), hypertension (4.8%), and placenta previa (3.6%). Cesarean section was the most common delivery method (56.6%), 25.5% of which were performed due to shunt-related concerns. The peritoneal-end of the shunt was observed in 21.3% of cesarean deliveries. NICU admissions of the forthcoming infant were rare (7.0%), and nearly all infants (98.8%) born to mothers in this series survived.

Conclusion: We identified a low rate of shunt-related complications and favorable obstetric outcomes in our series. Such findings suggest reassuring information regarding the safety of VP shunts during pregnancy that may be helpful for patient counseling.

Riva-Cambrin J, Ben-Israel D, Kulkarni A, Whitehead W, Wellons J, Limbrick D, Kestle J for the HCRN

Introduction: The superior treatment of hydrocephalus in infants under the age of two years remains in equipoise between CSF shunting and ETV+CPC. Prior to a formal economic analysis between these treatments, specific healthcare utilization rates for each population must be determined.

Methods: This was a retrospective cohort conducted by the fourteen centers within the HCRN. The HCRN’s Core Data Project was used to identify the last 200 infants with at least three years of follow-up for each of the two treatment cohorts: CSF shunt versus ETV+CPC. Premature infants treated for hydrocephalus secondary to intraventricular hemorrhage were excluded. Outcomes of interest were number of CTs, MRs, ER visits, clinic visits, hospital admissions, and hospital days. Multivariate regression was used to compare the treatments for each utilization outcome adjusting for age, sex, race, comorbidities, and hydrocephalus etiology.

Results: After exclusions, 198 shunted and 174 infants treated with ETV+CPC were included. No difference in age, gender, or comorbidities were seen between the cohorts. ETV+CPC infants were more likely to be of white race (p<0.001), have a myelomeningocele or aqueductal stenosis etiology (p<0.001), and had a longer overall follow-up duration (p<0.001). Within the first three years after treatment, infants who underwent ETV+CPC underwent less CTs (median 0 versus 1, p<0.001), but were more likely to have MRs (median 4 versus 2, p=0.015) and clinic visits (median 7 versus 6, p<0.001). No differences in the number of hospital visits, hospital days, or ER visits were seen.

Conclusions: Infants treated with ETV+CPC are more likely to use health care resources such as MRs and clinic visits but less likely to have CTs within their first three years after treatment than those treated with shunts. Given that the two treatments may have selection bias in terms of etiology and race, future comparative effectiveness studies should require randomization.
Abstract #24: Surgical Outcomes of CSF Diversion for Post-Hemispherectomy/Hemispherotomy Hydrocephalus based on Shunt Characteristics: an HCRN Study

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Introduction: Following anatomic hemispherectomy (AH) or functional hemispherotomy (FH) for intractable epilepsy, post-AH/FH hydrocephalus requires careful planning for cerebrospinal fluid (CSF) diversion.

Objectives: This Hydrocephalus Clinical Research Network (HCRN) study investigated the impact of different CSF shunt characteristics on surgical outcomes for post-AH/FH hydrocephalus, including laterality of shunt placement, programmable nature of the shunt valve, and anterior or posterior shunt entry site.

Methods: This retrospective review utilizing the HCRN core data project (Hydrocephalus Registry) included pediatric patients (under age 18 years) undergoing CSF shunt insertion for management of post-AH/FH hydrocephalus with at least 6-month follow-up. Data regarding demographics, timing of CSF shunt insertion, CSF shunt characteristics, and surgical outcomes were recorded. Primary and secondary outcomes included time to CSF shunt failure and post-operative complications, respectively. Data were summarized using descriptive statistics and compared using univariable Cox regression models to estimate hazard ratios (HR) for CSF shunt failure and Fisher’s exact test for post-operative complications.

Results: Among 34 subjects (22 Male, 65%), 26/34 (76%) underwent previous FH while 31/34 (91%) underwent ipsilateral CSF shunt insertion. There were no significant differences between subjects undergoing CSF shunt insertion with non-programmable (20/34, 59%) and programmable valves (14/34, 41%). There was no significant difference in CSF shunt survival between non-programmable and programmable (HR 0.44 [0.12, 1.6]) valve insertion (Kaplan Meier Curve Log-rank test: 0.201), or between anterior and posterior (HR 2.73 [0.74, 10.1]) entry site (Kaplan Meier Curve Log-rank test: 0.118). Post-operative complications occurred in 3 subjects total (3/34, 9%) without significant difference between non-programmable (3/20, 15%) and programmable (0/14, 0%) valve types ($p = 0.25$).
Conclusions:
Among subjects undergoing CSF shunt insertion for post-AH/FH hydrocephalus, most underwent CSF shunt insertion ipsilateral to AH/FH and there was no significant difference in CSF shunt survival between programmable and non-programmable valves nor between anterior and posterior entry sites.
Abstract #27: Corpus Callosotomy for Pediatric Epilepsy: Outcomes After Open and LITT Approaches in 113 Patients

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Introduction: Corpus callosotomy (CC) is an effective palliative surgical intervention for children with atonic seizures and has evolved in recent years to include a minimally invasive option with the advent of Laser Interstitial Thermal Therapy (LITT).

Methods: This retrospective review included 113 patients <21 years old who underwent CC at St. Louis Children’s Hospital and Johns Hopkins All Children’s Hospital between July 1, 2003 and July 1, September 30th, 2022. Surgical outcomes and the comparative effectiveness of the approaches were assessed.

Results: Median age at seizure onset was 2 years [IQR 0.45, 4] and at first CC was 10.3 years [IQR 6.2, 14.9]. Most patients were male (67%, n=75) and Caucasian (88%, n=98). Open craniotomy for CC was the most common approach (n=95, 86%); although, LITT was increasingly used in recent years and was associated with shorter hospital length of stay (3 days [IQR 2, 4.75] versus 5 days [IQR 3, 8]; p<0.001). Complete callosotomy was the most common surgical disconnection (66%, n=73) followed by anterior two-thirds (34%, n=37) and posterior one-third (9%, n=10). Engel I, II, III, and IV outcomes at last follow-up were 19% (n=18/94), 22% (n=21/94), 39% (n=36/94), and 22% (n=18/94). Of the 75 patients with preoperative atonic seizures, 76% resolved postoperatively (n=54/74). Median follow-up duration was 6.4 years [IQR 3.1, 10.3]. The overall complication rate was 5% (n=6/110).

Conclusions: Most patients who undergo CC experience resolution or near resolution of their atonic seizures postoperatively with an acceptable complication rate. LITT was generally better tolerated by the patients with shorter hospitalization and similar seizure outcomes. The adoption of a minimally invasive approach to CC (LITT) warrants further investigation into long-term outcomes in a multi-center investigation.
Abstract #28: Corpus Callosotomy for Intractable Epilepsy: A Contemporary Series of Operative Factors and Overall Complication Rate

Stephanie Einhaus, MD

Introduction: Recently, laser interstitial thermal therapy has been adapted and recommended over the traditional operation for corpus callosotomy because it is less invasive. However, a modern series of traditional corpus callosotomy is lacking for comparison.

Objectives: Our study examines operative factors and complication rates for a sample of patients who underwent open craniotomy for corpus callosotomy to determine current benchmarks in safety and efficiency for this procedure.

Methods: We retrospectively reviewed institutional data on patients who underwent first time open callosotomy from 2005 to present. Demographic and clinical variables were collected and analyzed with a focus on operative factors and complication rates.

Results: 105 patients were included in the study with a mean age of 9.39 years (0.67-24.17 years). 58.1% of patients were male (61), and one surgeon performed a majority (76.20%, 80) of the operations with two other surgeons performing the remainder (21.9% and 1.90%, respectively). In total, 63 complete, 31 subtotal (anterior 70-99%), and 1 posterior (40%) callosotomies were performed. Blood loss was available for 102/105 patients with a mean of 96.67mL (10-500mL), and mean operative time was calculated as 226.76 minutes (45-504 minutes) from 76/105 patients by excluding those patients who underwent concurrent vagal nerve stimulator placement or revision. Operative complication rate was determined to be 6.67% and was comprised of 3 pseudomeningoceles, 3 superficial wound infections, and 1 delayed intraparenchymal hemorrhage. No venous infarcts were observed on postoperative MRI.

Conclusion: This largest single center series of open callosotomy patients describes important updated metrics to help evaluate new techniques being developed for the surgical treatment of atonic seizures in medically intractable epilepsy.

References


Abstract #29: Comparison of Long-term Survival of Pediatric Patients with Drug-resistant Epilepsy: Continued Medical Therapy, Vagus Nerve Stimulation, and Cranial Epilepsy Surgery

Lu Zhang PhD, Matt Hall PhD, Sandi Lam MD, MBA

Background and objective: Mortality of pediatric patients with drug-resistant epilepsy (DRE) is higher than the general population and adult patients. We aimed to compare the long-term survival rate associated with medical treatment only, vagus nerve stimulation (VNS) plus medications, and cranial epilepsy surgery plus medications in pediatric patients using a large national administrative database.

Methods: Patients 0-17 years diagnosed with DRE between 1/1/2004 and 12/31/2020 were identified from the Pediatric Health Information System Database. Patients treated with antiseizure medications (ASMs) only or ASMs plus VNS or ASMs plus cranial epilepsy surgery were included and were followed until the date of their last clinical encounter, in-hospital death, or December 31, 2020. The unconditional probability of survival was estimated by Kaplan-Meier survival analysis and the statistical significance of the difference was tested by the log-rank test. Cox proportional hazards model was performed to compare time to death in the follow-up period.

Results: 10,240 patients were treated with ASMs only, 5,019 patients with ASMs plus VNS, and 3,033 with ASMs plus cranial epilepsy surgery. The unconditional probability of surviving >10 years were 89.93% for medical therapy cohort (95%CI, 88.56%-91.30%), 93.38% for VNS cohort (95%CI, 91.81%-94.95%), and 98.29% for cranial surgery cohort (95%CI, 97.31%-99.27%). The difference in the estimate of survival probabilities was significant (p<.001). Compared with patients in the only medical therapy, the risks of overall death were reduced by 33% (HR=0.660; 95%CI, 0.506-0.863) and 83% (HR=0.168; 95%CI, 0.106-0.207) for VNS patients and the cranial epilepsy surgery patients, respectively.

Conclusion: Pediatric patients with refractory epilepsy who underwent cranial epilepsy surgery or VNS had higher survival rate than those who received only medical treatment. These findings point to opportunities for enhanced policies for access, and the need for care at comprehensive pediatric epilepsy centers which include surgical treatment options.
Abstract #30: Endoscopic Hemispherotomy and Corpus Callostomy: Outcomes, Technical Pearls and Pitfalls

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Background: Corpus callosotomy and hemispherotomy are conventionally performed via open craniotomy using a microscope in children with intractable epilepsy. However, parents/patients may be hesitant to consent to open procedures, particularly for procedures considered palliative. Less-invasive epilepsy surgeries may be more palatable for families/patients due to smaller incisions, lower postoperative pain, minimal brain retraction and blood loss. We developed endoscopic-assisted techniques for disconnective surgeries, hemispherotomy and corpus callosotomy. We optimized a minimally-invasive, two-handed, single-operator approach with a 3D-endoscope.

Methods: From 2014 to 2022, 19 patients underwent endoscopic-assisted corpus callosotomy and 15 patients underwent endoscopic-assisted vertical parasagittal hemispherotomy. Endoscopic-assisted disconnective procedures are performed with an endoscope with mounted suction (10Fr suction mounted on a 0-degree endoscope using a clamp) held in the operator’s left hand. For hemispherotomy, surgery was performed through a 3-cm mini-craniotomy. For corpus callosotomy, surgery can be performed through a frontal or parieto-occipital mini-craniotomy. The posterior interhemispheric endoscopic approach minimizes the need for interhemispheric fissure dissection, particularly in patients with a short cerebral falx. Endoscopic hemispherotomy involves anterior corpus callosotomy, anterior frontobasal disconnection, lateral disconnection, fornix disconnection, and posterior corpus callosotomy, with the order of the disconnection steps determined based on the nuances of the anatomy.

Results: We evaluated blood loss, technical feasibility, and completeness of disconnection using postoperative diffusion tensor imaging. No patient undergoing endoscopic-assisted corpus callosotomy had residual connections on postoperative DTI. Among patient undergoing endoscopic-assisted hemispherotomy, one patient required return to OR for residual connection noted on DTI and one patient required conversion from endoscopic to open hemispherotomy due to anatomic considerations, both with hemimegalencephaly. Patients who underwent hemispherotomy achieved seizure freedom. Patients who underwent corpus callosotomy had reduction or complete resolution of drop attacks.

Conclusions: Endoscopic-assisted hemispherotomy and corpus callosotomy are surgically feasible, associated with minimal blood loss, allow for excellent visualization and success in complete disconnection.

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Introduction: This project aims to characterize the current utilization of magnetic resonance-guided stereotactic laser ablation (SLA) for the treatment of intracranial pathologies in pediatric patients. Current efforts are focused on evaluating the effect of institutional case volumes and learning curves on practice patterns, patient selection, and patient outcomes.
Methods: A multi-institutional retrospective review was conducted. Patients aged 21 years or younger and who were treated with SLA for intracranial pathologies at participating centers between 2008-2018 were included in the study. Clinical, technical, and radiographic data was collected and analyzed.

Results: Seventeen centers were enrolled, and 297 patients were identified. The most common diagnoses were drug-resistant epilepsy and brain tumors. Follow-up time ranged from 3 months–71.2 months. Reported case volumes per center ranged from 2-74 cases (mean 17.5, median 12 cases). Seizure freedom (Engel I) was achieved in 50% of patients. Engel I/II/III/IV outcomes for low-, medium-, and high-volume centers was 52.6%/26.3%/15.8%/5.3%, 41.5%/34.1%/12.2%/12.2%, and 46.8%/18.9%/7.2%/27.0%, respectively. At latest follow-up, the volume of SLA-treated tumors had decreased in 80.6% patients. Analysis of early- vs late experience revealed no difference in patient ages or case duration, however an increased trend in treatment of malformations of cortical development and palliative epilepsy cases was observed.

A total of 184 acute complications were reported in 50 patients (16.8%) and included: wound infection (6), CSF leak (3), malpositioned catheters (18), intracranial hemorrhages (12), transient neurological deficits (80), permanent neurological deficits (24), symptomatic perilesional edema (27), hydrocephalus (12), and death (2). The incidence of complications for low-, medium-, and high-volume centers was 30.0%, 23.2%, and 11.9%, respectively.

Conclusions: Our results suggest that SLA is an effective and generally safe treatment option for pediatric patients, although not without risks. Improved outcomes and lower rates of complications are expected as the neurosurgical community gains more experience with this technology.

Relevant Disclosures:
Dr. Arocho-Quinones: No conflicts of interest. Nothing to disclose.
Dr. Tovar-Spinoza: consultant for Monteris Inc.
Dr. Perry: consultant for Encoded Therapeutics, Taysha, Biomarin, Eisai, Greenwich Biosciences, Marinus, and Stoke Therapeutics; and honoraria for advisory board/speaking from NobelPharma, Greenwich Biosciences, and Zogenix.
Dr. Barnett: consultant for Monteris Medical Inc.
Dr. Muh: consultant for Livanova PLC
Dr. Thompson: scientific advisor for Oncoheroes Biosciences
Abstract #32: Multimodal, Multidisciplinary Stereo-EEG Planning

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Disclosures: Mutchnick: none; Karakas: none
Barbery: Ms Barbery is a paid employee of Surgical Theater

Objectives: An ideal stereo-electroencephalography (sEEG) planning suite would allow: (a) precise merging of Phase I data; (b) easy abstraction and manipulation of the extended vascular tree to facilitate targeting; (c) concise planning discussions among team members; and (d) easy exportation of a final sEEG plan to the implantation platform of choice. Additionally, this planning suite would incorporate artificial intelligence (AI) to leverage deep knowledge about Phase I modalities into the implantation plan. Here, we present early data describing our sEEG planning approach.

Methods: Norton Children’s Hospital invested in the SuRgical Planning (SRP, Surgical Theater) system in 2019. SRP enables the import of volumetric, co-registered, Phase I data into a three-dimensional anatomically rigorous model, allowing for highly customized sEEG plans.

Results: Since 2019, we have built SRP models for 18 patients. Incorporated information included post-processed Medical Image Merge (MIM) PET data in 17; magnetoencephalography in 17; fMRI in 13; and transcranial magnetic stimulation in 6 cases. We recently finalized the pipeline for post-processed MIM SPECT data and are working to incorporate online freeware tools (eg Slicer, MRtrix, Freesurfer) into the workflow. Neurologists with deep training in seizure semiology and EEG data have been an essential part of the sEEG planning process. Vascular tree segmentation adequate for sEEG planning can be manually segmented, but no automated process for this yet exists. We can currently export finalized sEEG plans into WayPoint (STarFix, FHC) and the StealthStation (Autoguide, Medtronic).

Conclusions: The SRP system creates co-registered models of Phase I data, facilitating highly customized sEEG plans incorporating semiological and EEG data into the electro-clinico-anatomical hypothesis. While automated vascular tree abstraction is not yet possible, AI algorithms can produce this functionality if resources allow. A standardized platform for this type of planning would facilitate multi-center exploration of how best to interpret Phase I data.
Abstract #33: A Standardized Approach to MRI-guided Stereotactic Laser Corpus Callosotomy: Technical Description and Pediatric Case Series

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In the most severe cases of intractable epilepsy, surgical disconnection of the hemispheres (callosotomy) can provide patients with significant reduction in seizure burden, specifically for semiologies involving drop attacks. Classically, this disconnection involves an open craniotomy, with dissection between the hemispheres and partial or complete sectioning of the corpus callosum. Beyond the expected collateral syndromes created by isolating the hemispheres, callosotomy has morbidity associated with transgressing the scalp, skull, & dura, retracting a hemisphere, and manipulating vasculature. For this reason, MRI guided laser interstitial thermal therapy has recently been employed to perform corpus callosotomy in a minimally invasive way (stereotactic laser corpus callosotomy – SLCC).

We present and illustrate a standardized surgical framework for complete SLCC with four canonical trajectories targeting the genu, anterior body, posterior body, & splenium. An abbreviated 3 trajectory approach may be chosen from these for patients with favorable anatomy, and 2 trajectories are sufficient to complete disconnection in patients who have had a prior partial callosotomy.

Our experience with an initial 2-year case series of 9 pediatric patients (aged 3-23) with drop attack seizures is reviewed and comprehensively illustrated. Three patients required 4 trajectories for complete SLCC and four patients required 3 trajectories. Two patients underwent completion of prior partial callosotomy with 2 laser trajectories. There were no peri-operative nor post-operative complications, and no sustained neurologic deficits. One patient had delayed return to ambulation and was discharged 6 days post-operatively (POD6). Seven were discharged POD1 and one POD3. While follow-up (1-24 months) is limited by the short duration of the series, outcomes appear comparable to open callosotomy, with 6/9 patients free of drop attacks and 8/9 with improvement in all seizure types.
Abstract #35: Safety of Stereoelectroencephalography (SEEG) in Toddlers Under Two Years of Age: A Case Series

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Stereoelectroencephalography (SEEG) is now widely used for intracranial monitoring for intractable epilepsy in pediatric patients. However, there is debate as to whether this surgery can be safely offered to very young children due to skull thickness.

We present a series of four children under age two years who underwent SEEG at our institution between May 2021 and January 2022. The children ranged from 503 to 677 days old (1 year 4 months 16 days to 1 year 10 months 7 days; mean of 570.5 days) at the time of electrode placement. Three of the children had tuberous sclerosis; one had Lennox-Gastaut syndrome. There were an average of 15.75 electrodes per child (range 13-18). All were placed with ROSA navigation using skull fiducials. Post-placement CT scans were merged with pre-operative navigation plans. The distance from the planned entry and target points to the actual path of the electrode was measured for each electrode and the distance was agreed upon by two observers. The average distance from intended entry point to actual entry point at the skull was 0.63mm (range 0mm to 2.34mm) and average distance from intended target point to actual point of electrode at the target depth was 1.01mm (range 0mm to 3.91mm).

There were no intracranial hemorrhages, no infections, no cerebrospinal fluid leaks. Duration of SEEG was 3-7 days. All patients were monitored in the PICU and were given IV cefazolin while the electrodes were in place. They were brought to the operating room for electrode removal under anesthesia. All patients were discharged home within a few days of electrode removal then returned for laser ablation (3 patients) or temporal lobectomy (1 patient).

This case series suggests that SEEG can be safe and accurate in this patient population and should be considered when intracranial monitoring is needed in toddlers.

Disclosures:
Carrie R. Muh reports speaker fees from LivaNova and participation as an investigator in a clinical trial of Neuropace.
Jessica R. Dorillo reports no conflict of interest.
Cameron P. Beaudreault reports no conflicts of interest.
Patricia E. McGoldrick reports honoraria from Eisai, Neuropace, UCB, Sunovion, Greenwich Pharmaceuticals, and Mallinckrodt and participation as an investigator in clinical trials for Zogenix, GW Pharma, Neuropace, Neurelis, UCB, Eisai, Monosol.
Steven M. Wolf reports honoraria from Eisai, Neuropace, UCB, Sunovion, Greenwich Pharmaceuticals, Marinus and Mallinckrodt and participation as an investigator in clinical trials for Zogenix, GW Pharma, Neuropace, Neurelis, UCB, Eisai, Monosol.
Abstract #36: Near Infrared Spectroscopy Monitoring in Pediatric Abusive Head Trauma

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Introduction: Abusive head trauma (AHT) often presents as a severe form of pediatric traumatic brain injury (TBI). AHT commonly presents with seizures, which portends poor neurologic outcomes following trauma. Non-invasive Near Infrared Spectroscopy (NIRS) monitoring provides surrogate markers of cerebral oxygenation and may provide prognostic and diagnostic indications of seizure activity in AHT.

Methods: We retrospectively analyzed pediatric patients <18 years old who were admitted to a quaternary urban pediatric hospital from 2016-2021 with AHT who received concomitant NIRS and electroencephalogram (EEG) monitoring. We evaluated clinical presentation and hospital course, including imaging, EEG, and NIRS.

Results: Eight AHT patients who were monitored with both EEG and NIRS were identified. The average age of these patients was 13.9 months. Six of these patients experienced confirmed electroencephalogram seizures. On average, the NIRS values pre-seizure, peri-seizure, and post-seizure did not differ substantially. However, within individual patients, NIRS values were seen to rise in the hour preceding seizure activity as well as during periods of long seizure activity and status epilepticus.

Conclusion: The relationship between NIRS values and electrographic seizures in our series of pediatric AHT patients suggests NIRS detects increased cerebral oxygenation preceding seizure activity and during early seizure activity. Future studies with larger sample sizes may help elucidate the relationship between seizures and cerebral oxygenation in AHT.
Abstract #37: Exploring the Electrophysiological Basis of a Novel Mechanism for the Social Perception of Attention - The “Mind Beam” Hypothesis

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An important task in social cognition is understanding what another person is paying attention to in a given moment. Accurately perceiving the attention, intention, and beliefs of another person, so-called “theory of mind,” underpins fluent social functioning and high social-emotional intelligence. People with autism spectrum disorders (ASD) have a notable impairment of this ability. The “mind beam” hypothesis of social attention, which has been supported by non-invasive functional magnetic resonance imaging (fMRI) experiments, posits that the brain models the attention of others more richly than just as a vector indicating gaze direction, but rather as an implied motion, or “mind beam,” connecting agents to attended objects.

To identify the electrophysiological correlates of this hypothesized “mind beam,” patients with implanted stereoelectroencephalography (sEEG) and subdural grid electrodes performed a visual motion paradigm to determine whether they could discriminate activity patterns associated with the direction of low-level visual motion and significantly decode the gaze direction in images depicting a sighted face, but not a blindfolded face. A classifier trained on grid-wide high-gamma power associated with low-level visual motion streaming left versus right was able to significantly decode gaze direction in static images depicting a sighted face (56.7%-61.7% with p-values ranging from 0.010-0.070), but not in images with a blindfolded face (43.3%-50.0%, p-value 0.420-0.780).

The decoding is specific to electrodes present in the superior temporal gyrus and posterior hippocampus, the temporoparietal junction, and the anterior cingulate. Together, these results suggest that even though we are unaware of it, our brains encode others’ attention as an implied motion streaming from social agents to attended objects. These results offer a first step in understanding the fundamental principles of social cognition, which may have implications for understanding the social perceptual deficits in patients with autism.
Abstract #38: Dysregulation of Axon Guidance Factors Influence the Development Human Cerebral Cavernous Malformations: Discovery of a Novel Mutation and Regulatory Pathway of Ephrin B2/EphB4

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Introduction: The axon guidance factors, EphrinB2 and EphB4, are critical regulators of vascular development. Previous studies report utility of these markers in detecting the presence of cerebrovascular disease and involvement in endothelial-to-mesenchymal transition (EndMT) in cerebral cavernous malformations (CCMs). Here, we investigate EphrinB2 and EphB4 expression in CCMs and the effect of altering the EphrinB2/EphB4 ratio on endothelial cell function.

Methods: Human primary CCMs endothelial cell lines were compared to control endothelial cells for endothelial and mesenchymal markers, baseline ephrin expression, and evaluated with functional assays. Patient tissue was stained for EphrinB2 and EphB4 expression and subjected to whole-exome sequencing (WES). A newly identified mutation (c.-124G>C) from this research was subsequently introduced in control cells, then analyzed for alterations in EphrinB2/EphB4 binding and functional effects.

Results: Compared to normal endothelial cells, CCM cells exhibit increased EphrinB2/EphB4 ratios, increased expression of mesenchymal markers, decreased expression of endothelial markers and increased migration and markedly abnormal tube formation. A novel c.-124G>C mutation was identified in all CCM samples. Introducing that mutation into control cells significantly increased Ephrin B2/EphB4 binding, with corresponding altered cellular morphology, culminating in impaired tube formation and migration.

Conclusion: Cerebral cavernous malformation cells undergo EndMT and have increased migration and impaired tubule formation relative to non-CCM endothelial cells. These functional changes correlate directly with an increased EphrinB2/EphB4 ratio in CCM. We discovered a novel mutation in EphB4 in CCMs that increases EphrinB2-EphB4 binding and which exhibits a functional effect by altering endothelial cell morphology and impairing tube formation. Taken together, this work suggests that an increased binding of EphrinB2/EphB4 mediated by an underlying novel mutation that directly increases ligand-receptor affinity may play a critical role in cavernous malformation development. It also suggests the possibility of a novel potential therapeutic target through pharmacologic normalization of this EphrinB2/EphB4 ratio.
Abstract #39: Laboratory Studies of a Novel Diffusion Flow Zwitterion-Coated Ventricular Catheter That Prevents Proximal Shunt Catheter Obstruction

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Introduction: Most shunt failures in the pediatric population are result of occlusion of the ventricular catheter. This can be the fault of an over draining valve, debris occluding the catheter, and the growth of cells such as choroid, astrocytes, and inflammatory cells on the catheter and through the catheter holes. There are no commercially available shunt catheters that prevent this occlusion from occurring.

Methods: We have developed a shunt catheter to eliminate the bulk flow of CSF, and allowing only particles smaller than 6 microns to enter the catheter. The surface of a standard silicone catheter is altered by a zwitterionization treatment, using tridecafluoro-1,1,2,2-tetrahydrooctyl-trichlorosilane coating, and parylene layering. Parylene conformal coating is a thin film coating technology. Applied as vapor, the coating layer perfectly conforms to complex shapes of the shunt catheter holes and provides complete and even coverage. There catheters were cultured with various cells, and flow/pressure were assessed using our ventricular phantom.

Results: The coated catheters had their 500-1000 µ openings, along with 3 cm of the catheter tip, coated with the zwitterion, such that none had openings greater than 6 µ size. In modeled flow studies, human CSF flow was not impeded into or out of the catheter. No cellular ingrowth of cells occurred histologically onto or into the catheter lumen.

Conclusions: This is a novel ventricular catheter that does not allow CSF bulk flow, but rather only allows diffusion of the smallest molecule in the CSF (water) to diffuse through the catheter. Clinical applications are being developed.

We have developed a catheter that resists cellular attachment and tissue ingrowth onto the catheter and into the lumen.
Abstract #41: Automated Tubular Structure Segmentation Modeling: Methods and Potential Applications

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Background: Iatrogenic cranial nerve injury can result in devastating sequelae. Three-dimensional modeling allows patient-specific rehearsal, which may ameliorate risk, but current strategies poorly render small nerves, which are more susceptible to damage. Previous methods of neurovascular segmentation rely on image gradient analysis which has numerous downsides. Improved methods are needed to model these structures.

Methods: We developed segmentation method for tubular structures, by adapting traditional deformable surface models, which track density gradients on an image and are based on a 3-connected surface mesh. Our system uses a 2-connected paradigm using manual endpoints and detects structures between via a discrete deformable 3D contour. This consists of vertices linked by edges and is founded on a Newtonian expression for each vertex position and its derivatives, determined by an equilibrium between internal forces, which preserve continuity and statistical shape priors, and external forces that attract the contour to the centerline of detected tubes. This methodology was tested, then refined by incorporating a statistical shape model. Twenty nerves were used as a training set, and average and second order variation extracted using an energy minimization framework. Shape information is then used in a second-order computation, using an internal force that promotes compatibility with a shape prior.

Results: The paradigm was tested using synthetic and T2 MRI images. Nerve models were assessed for compactness, specificity, and generality. Accuracy was demonstrated using Mean Absolute Shape Distance of 0.19mm and Hausdorff Distance of 0.21mm. This is sub-voxel precision and indicates excellent model performance.

Discussion & Conclusion: This work developed a high-precision segmentation of cranial nerves from T2 MRI. A weakness is the requirement for human input of structure endpoints, though this could potentially be automated. Another is susceptibility to volume averaging artifacts. This technique could improve surgical planning, allowing precise multidimensional cranial nerve visualization, and can generalize to tubular structures elsewhere. Validation is needed on structures distorted by intracranial pathology. We are developing a virtual-reality simulation system based on this methodology with an industry partner.
Abstract #42: Structural and Functional Imaging Connectivity in Children with Hydrocephalus and Neonatal Brain Injury - From a Systematic Review to a Prospective Clinical Cohort

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The author has no relevant discloses to disclose

Hydrocephalus is one of the most commonly encountered conditions in pediatric neurosurgery, and posthemorrhagic hydrocephalus related to prematurity is its leading cause in North America. There are, however, other congenital etiologies leading to neonatal hydrocephalus and infant brain injury and as a group, refinement of imaging biomarkers for diagnosis and prognosis of hydrocephalus has been identified as a research priority. At the same time, there is no current consensus about the optimal timing of surgical intervention, nor has a clear threshold between ventriculomegaly and hydrocephalus been identified. Connectome-type imaging and, specifically, tractography and resting state fMRI techniques may detect changes that precede clinical deterioration and/or provide information beyond that offered by traditional anatomic MRIs. Several studies have described applications of connectome imaging in hydrocephalus. Our group performed a meta-analysis to report on the most promising applications of functional imaging as objective, non-invasive indicators of maturation and regional or general brain function that could inform treatment outcome and neurocognitive prognosis.

Our central hypothesis is that neurologic injury can be correlated to specific connectome imaging abnormalities. To test this, we are currently enrolling a prospective cohort of premature or term neonates with brain injury from intraventricular hemorrhage and/or hydrocephalus resulting from other etiologies to establish structural and functional MRI abnormalities. Imaging findings will be correlated with clinical and neurocognitive outcomes at diagnosis, 6 months, 1, 2 and 5 years after presentation. In patients requiring CSF diversion, changes in connectome type imaging before and after treatment will serve as parameters to guide decision on timing of therapy applicable in future trials.

Our 5-year prospective cohort study is underway to answer whether structural/functional connectivity can serve as an imaging biomarker to predict the severity of neurocognitive developmental outcome and better inform the timing of surgical intervention in this patient population.
Abstract #43: Ventral Dorsal Cervical Rhizotomy to Manage Upper Extremity Hypertonia

Melissa Lopresti, MD Hanna Kemeny, MD and Jeffrey S. Raskin, MS, MD

Hypertonia affecting the upper extremity causes severe muscle pain, joint deformity, and limits function in afflicted patients. Surgical strategies to address upper extremity hypertonia depend on the etiology and include intrathecal baclofen therapy (ITB) and deep brain stimulation (DBS). We have performed ventral dorsal cervical rhizotomy with the intent to decrease pathological hypertonia. Though not a gain of function procedure, patients retain voluntary movement while significantly decreasing hypertonia measured by modified Ashworth and Barry-Albright Dystonia Scores. Surgical technique and outcomes of a short case series is presented as well as opportunity to discuss future collaboration and improvement is surgical technique.
Abstract #44: Laparoscopic Repositioning of Peritoneal Catheter for Treatment of Sterile Abdominal Cerebrospinal Fluid Pseudocysts

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Background: Abdominal cerebrospinal fluid (CSF) pseudocysts are an uncommon though challenging complication of ventriculoperitoneal shunts. Pseudocysts consist of a loculated intraperitoneal compartment lined by inflammatory tissue that does not adequately absorb CSF and can be actively infected or sterile at diagnosis. Treatments range from full shunt explant to distal tubing externalization, to movement of the distal tubing to another peritoneal location or body cavity.

Objective: To study the efficacy of primary laparoscopic repositioning of the distal shunt catheter tip for treatment of sterile abdominal CSF pseudocysts relative to other strategies.

Methods: All patients treated for abdominal CSF pseudocysts at Children’s Health from 1991-2021 were retrospectively reviewed. Patient history and pseudocyst characteristics were analyzed, with a primary outcome of pseudocyst recurrence at 1 year.

Results: Of 92 first time pseudocysts, 71 were reimplanted into the peritoneal space. Proximal shunt tap or pseudocyst cultures were positive in 25%. All were treated with antibiotics. Four initial treatment approaches were used depending on culture status, clinical scenario, and surgeon preference: shunt explant/external ventricular drain (EVD) placement, distal tubing externalization, laparoscopic repositioning, and other methods such as pseudocyst drainage or open repositioning. One year survival for the explant/EVD approach followed by peritoneal reimplant was 93%. Thirty-five first time pseudocysts were treated with laparoscopic repositioning, with no recurrence at one year of 55% and 79% for those with high and low systemic inflammatory markers respectively (p=0.034); undetected infection was present in 2 of 35 of these patients, and both had pseudocyst recurrence. Hospital stay was shorter for laparoscopic repositioning (6.4 days) than for explant/EVD (22.2 days), p<0.0001.

Conclusion: Sterile pseudocysts with low systemic inflammatory markers can be effectively treated with laparoscopic repositioning, resulting in a shorter hospitalization and modestly higher recurrence rate than shunt explant.
Abstract #45: Is Routine, Early Imaging after Endoscopic Third Ventriculostomy Necessary?

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We investigated the results of early postoperative imaging after endoscopic third ventriculostomy (ETV) in adults and children. Fifty-eight patients with diverse pathology were included (aged 10 days to 81 years). Nearly one third (32.8%) of patients required further treatment within one year and were thus considered treatment failures. Changes in pre- and postoperative imaging were analyzed including: change in amount of CSF observed in the subarachnoid space, change in maximal diameter of the third ventricle (TV), change in bowing of the TV floor, and presence of postoperative flow void at the ventriculostomy site. No individual radiological parameter was predictive of ETV outcome at 30 days, six months, or one year postoperatively either in univariate or multivariate analysis. Any postoperative change on MRI significantly correlated with decreased odds of ETV failure at long-term follow-up.

An obstructive etiology significantly predicted success at one-year post-ETV in our data. Interestingly, we did not find a similar relationship between age and outcome. However, an age of >10 years was associated with success at one-year post-ETV in the obstructive hydrocephalus sub-group.

We found that immediate postoperative imaging did not alter clinical management, or meaningfully predict clinical outcome, therefore discontinuation of this practice can be considered.
Abstract #46: Neurosurgical -omics: Artificial Intelligence from Prototype to Practice

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Introduction: The “-omics revolution” of the early 21st century generated scientific breakthroughs using new quantitative methods and large datasets. Subsequent advances in artificial intelligence tools could then use large datasets to generate discoveries in protein folding and structure prediction. In contrast, neither datasets nor quantitative methods have been developed from the neurosurgical operating room, hampering artificial intelligence applications. We describe early efforts to develop the raw data, quantitative methods, and analytical pipeline for the application of artificial intelligence tools in the neurosurgical operating room.

Methods: Video datasets were generated from two cadaveric simulation courses (SOCAL, carotid artery injury repair and SOSPINE, minimally invasive spinal durotomy repair).Datasets, including manual instrument annotations and outcomes labels, are available online at www.surgicalvideo.io/datasets/. A third dataset of endoscopic third ventriculostomies was obtained (not yet available). Deep neural networks were trained to detect instruments and extract automated performance metrics. Additional experiments included prediction of blood loss and surgeon skill, and comparison of a deep neural network to expert predictions, as well as advances in object detection networks.

Results: The datasets include 185 surgeons performing 389 surgical events, 47,141 frames and 139,682 annotations. The first object detection network, YoloV3, had mean average precision of 0.911 for detection of large metallic instruments but poor detection of cottonoid and muscle patch (0.251, 0.097 respectively). Upgrades to Yolov4 improved performance, but identification of needle and durotomy remained poor (<0.1). In the carotid injury dataset, compared to experts (70%, 350 mL), the deep neural network had greater accuracy (85%) and lower error in blood loss prediction (295 mL).

Conclusion: We demonstrate the feasibility of surgical video dataset creation and publication. For specific tasks (instrument detection, performance assessment), deep neural networks can achieve human expert performance. Surgical video datasets are vital to create for clinically relevant artificial intelligence applications.

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Abstract #47: Categorizing the Venous Anatomy of Craniopagus Twins

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Introduction: Craniopagus deformity is a rare congenital anomaly occurring in 1/1,700,000 live births and represents 2-6% of all types of conjoined twins. Historically, successful separation without neurological deficit has been rare, particularly for complete, vertically joined twins. Staging procedures, as well as a greater focus on the shared venous anatomy have become vital for undertaking safe separations in the modern era. The aim of this report is to create a novel classification system for the venous anatomy of these twins and determine implications upon clinical outcomes.

Methodology: Cases from Dr. James Goodrich’s collection from among nearly 20 sets of craniopagus twins were compiled and 3D renderings of their surface as well as venous anatomy were created. Each set was classified according to the O’Connell classification and a review of their anatomy was undertaken.

Results: Data from 16 sets of twins were rendered and reviewed. Two were O’Connell type I, 4 were type II, and 10 were type III twins. Two patterns of venous anatomy emerged, with twins demonstrating less axial rotation sharing a common circumferential sinus with branches from both twins feeding inward. Twins with greater rotation demonstrated a helical pattern with both sagittal sinuses joined centrally, rather than circumferentially.

Discussion: This is the largest analysis of craniopagus twins known to the authors and will allow for their improved classification in the future, which may have substantial implications for safe surgical separations. As the axial rotation approaches 90 degrees, the organization around a circumferential sinus slowly transitions into a continuous helical sinus stretching from one twin to the other. This configuration may be less amenable to surgical separation. Current work is being undertaken to correlate historical outcomes to our developing venous classification, in order to understand how it can be used to guide decision-making for these twins in the future.
Abstract #48: Pediatric Intracranial Infections During the COVID-19 Pandemic

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Background: Central nervous system (CNS) infections in pediatric patients extending from upper airway infections (URI) are rare and life-threatening. During the late COVID-19 pandemic, our institution hospitalized several pediatric patients with sinusitis and/or orbital cellulitis with neurosurgical intracranial infections concerning for increased rate of intracranial infections. This study reports our institutional experience with intracranial infections during the recent stages of the COVID-19 pandemic.

Methods: A retrospective review of patients presenting with intracranial infection from November 2021-September 2022 was conducted and compared to earlier incidence of surgical intracranial infections.

Results: Eight neurosurgical patients with intracranial infections were identified over the eight-month period. In comparison, only one patient was identified during the period of November 2018-October 2021. Median age of patients in the COVID era was 9 (5-18) years old, 75% male. Seven (88%) of patients were up to date with childhood vaccines, however, only 25% (n=2) were confirmed to be vaccinated for COVID-19. The most common presenting symptoms were headache (88%), fever (75%) and cough (50%). Patients were managed operatively with neurosurgery (n=5, 63%), otolaryngology (n=7, 88%) and ophthalmology (n=1, 13%). Cultures grew streptococcus (n=6, 75%), staphylococcus (n=3, 38%) or other (n=4, 50%). One patient (13%) was COVID positive. The majority of patients were concurrently medically managed with ceftriaxone (n=7, 88%) and metronidazole (n=5, 63%). One patient demonstrated infectious recurrence requiring re-operation.

Conclusions: Pediatric intracranial infections are rare. In the recent COVID-19 era, our institution has treated strikingly more patient with URI-related intracranial infections than prior to the pandemic. Further investigation needs to be conducted to better quantify this experience and to understand the physiological impacts of the virus’ effects on the immune capabilities of the upper airway.
Abstract #50: Spring Assisted Cranioplasty: The Lumps No One Talks About

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Introduction: Spring assisted cranioplasty (SAC) is one of the two most common options for the minimally invasive treatment of craniosynostosis. The second option is helmet-assisted cranioplasty, with a variety of pros and cons for each option. While the long-term outcomes and aesthetic results for both procedures appear to be similar, the SAC approach creates an initial cranial morphology that can be alarming to parents and providers.

Methods: The six initial patients treated with SAC at our institution were included in this review. Preoperative and post-operative photos and cephalic index measurements were reviewed.

Results: Average age at surgery was 4.3 months. Average cephalic index preoperatively was 69%, which improved to 78% prior to spring removal, and subsequently to 80% at last follow up. Each patient experienced a “lumpy” phase in the initial 3-6 months after spring placement (Figures 1 and 2), which slowly improved over the subsequent follow up. Final contours appear to be similar to patients treated with helmets.

Discussion: The physiology behind this transient lumpy phase is well-known. However, this initial phase is not reported in the literature. During the process of spring cranioplasty, the parietal bones are expanded transversely due to the force of the springs. Since the coronal and lambdoid sutures are patent and adherent to the dura, there is no discernable movement of the frontal or occipital bones in the early period of treatment. With time, the frontal and occipital bones remodel in response to parietal forces. Practitioners who are new to this procedure, and families of patients who choose SAC should be aware of this phase to avoid concern and unnecessary imaging.

Figures 1 and 2: Representative patients with prominent lumps seen over the vertex and posterior parietal regions.
Abstract #51: Optic Disc Edema in Syndromic and Non-syndromic Craniosynostosis

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Authors have no relevant disclosures.

Objective: Children with syndromic multi-sutural craniosynostosis are known to be at risk for optic disc edema secondary to elevated intracranial pressure (papilledema). Papilledema in children with single suture craniosynostosis is typically associated with late presentation or presence of other risk factors. We sought to identify the incidence and risk factors for papilledema in our craniosynostosis patient population.

Methods: This is a single center retrospective chart review of patients with craniosynostosis treated at Stanford University, Lucille Packard Children’s Hospital from January 2011 to September 2022. Patients were identified by ICD-9 and -10 codes for craniosynostosis and papilledema as well as CPT codes and ICD-9 and -10 procedure codes for craniosynostosis surgery and diagnoses were verified by detailed chart review.

Results: Of the 375 patients who underwent surgery for craniosynostosis repair, we identified 24 patients (10F, 14M), with ophthalmologist confirmed papilledema attributed to elevated intracranial pressure (7%). 16 of these patients had multi-sutural craniosynostosis, including 2 who initially presented with single suture craniosynostosis with subsequent progression to multi-sutural: 10 of these were syndromic, 6 had no known craniosynostosis syndrome. Association with hydrocephalus was noted in 6 patients – 3 of whom also had an acquired Chiari I malformation. Papilledema was present prior to initial craniosynostosis surgery in 15 of 24 patients, while 9 patients developed papilledema at a later timepoint. Most patients with preoperative papilledema had one or more risk factor: craniosynostosis syndrome, multi-sutural craniosynostosis, or late initial craniosynostosis diagnosis/late initial surgery. However, 3 patients with isolated single suture craniosynostosis (one metopic, 2 unicoronal) were noted to have early papilledema which resolved postoperatively.

Conclusions: Papilledema in craniosynostosis is usually associated with multi-sutural craniosynostosis, craniosynostosis syndrome, or delayed treatment. However, it can rarely be observed prior to surgery in the first year of life in children with single suture craniosynostosis without other risk factors.
Abstract #52: Remote Assessment of Surgically Actionable Craniosynostosis Using Caregiver Provided Photographs

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Objective: Assessment of head shape is a common reason for referrals to pediatric neurosurgery clinics. To streamline patient assessments, we hypothesized that craniofacial practitioners can accurately screen for surgically actionable craniosynostosis by evaluating standardized caregiver provided photographs.

Methods: Parents of children referred to our neurosurgery clinic for assessment of head shape submitted a series of standardized photographs, which were blindly evaluated by 7 independent raters (3 neurosurgeons, 2 plastic surgeons, a pediatrician, and an OT). Each rater documented their diagnosis (presence or absence of potentially surgically actionable craniosynostosis) and their level of confidence in said diagnosis. All children were subsequently evaluated in person by an experienced pediatric neurosurgeon, and this diagnosis was used as the gold standard.

Results: Of 74 children evaluated, 24 (32.4%) had craniosynostosis diagnosed during an in-person assessment. Agreement amongst all raters was substantial (Fleiss-kappa 0.76). Individual raters' diagnostic performance based on photographic evaluation (sensitivity range 0.86-1.0; specificity range 0.77-0.90) compared favourably with the performance of the “majority rule” photographic diagnosis of all 7 raters combined [sensitivity=1.0 (0.88, 1.0); specificity=0.88 (0.76, 0.95)]. No patient with surgically actionable craniosynostosis was deemed as having a normal head shape based on the photographs provided.

Conclusion: Based on the evaluation of standardized photographs, experienced craniofacial practitioners can accurately identify infants with craniosynostosis who may require surgical intervention. Individual trained raters appear to perform as well as group consensus. Photographic pre-screening may be useful for discriminating between craniosynostosis and plagiocephaly, the two most common etiologies of an abnormal head shape.

Disclosures: None of the authors have any disclosures relevant to this study.
Abstract #53: Plasma Extracellular Vesicles as Carriers of Tumor-derived miRNAs in CNS Tumors

Vladimir Khristov, Ganesh Shenoy, Nataliya Smith, James Connor, Elias Rizk

Introduction: Central nervous system (CNS) tumors cause significant cancer-related mortality in children, being the deadliest among other pediatric cancers. Precise diagnosis is usually based on a one-time tissue biopsy, while disease progression is monitored through MRI. Current methods lack detailed molecular information and have difficulty distinguishing between disease progression and remission in select cases. There is a significant, dire, unmet gap in clinical practice for minimally-invasive diagnostic tools to enable a timely understanding of disease progression and treatment response. This significant clinical need is being addressed in this project by studying extracellular vesicles (EVs). EVs are 50-1000 nm lipid bilayer particles that circulate in patient biofluids and are known to carry genetic and proteomic cargo from their cells of origin, including cancer cells.

Objectives: To investigate the reproducibility of EV isolation from blood and examine the correlation of pathologic miRNAs in matched bulk tumor and plasma samples.

Methods: 6 matched frozen tumor and plasma samples from patients with anaplastic astrocytoma. EVs were isolated from plasma in triplicate using PEG precipitation, assayed by nanoparticle tracking analysis (NTA) and probed for CD81 and TSG101. miRNA was isolated from matched samples converted to cDNA, and expression levels of miR-21 and -222 were determined with qPCR.

Results: EV isolation using PEG precipitation proved reliable as assayed by EV proteomic markers and NTA. miR-21 displayed a negative correlation between tumor tissue and plasma EV levels. miR-222 displayed a strong positive correlation between tumor tissue and plasma EV.

Conclusion: PEG precipitation is a simple and reproducible technique to isolate EVs from patient plasma. Plasma EV miR-222 could be a useful biomarker representative of the CNS tumor levels. Further studies are needed to establish the clinical utility of this finding, especially focusing on fluctuations of this biomarker over the course of treatment.
Abstract #55: Recent Biological Insights and their Translation Towards Clinical Trials for Childhood Craniopharyngioma


Adamantinomatous Craniopharyngioma (ACP) is a highly debilitating tumor, which traditionally has been managed through a combination of surgical methods and radiation. Despite improvements in these modalities, outcomes for children with this tumor are often poor. Through the efforts of multiple groups, actionable biological insights have been achieved in the last decade.

ACP is histologically heterogeneous, with cell populations that include epithelial, immune and glial. The patterns and mechanisms of communication between these populations, and how these translate into pathological behavior are incompletely understood. Pathways of interest include canonical WNT signaling, cellular senescence, MAPK/ERK signaling, pro-inflammatory signaling and others. Using current and emerging data from our group and collaborators, we will detail basic biological insights derived from mapping spatial transcriptomics (scRNA-seq and snRNA-seq) onto tumor architecture (Visium, 10X genomics) regarding single cell biology, with a focus on the epithelial cell components of ACP and their functional relationships. This will be connected to emerging preclinical models of ACP, including 2D and 3D culture as well as organoid models. Means of advancing these models towards preclinical animal testing and informing future clinical trials will also be discussed.

Currently, 3 multicenter international clinical trials are preparing to begin patient recruitment. These include trials of the IL-6 inhibitor, Tocilizumab and the MEK inhibitor, Binimetinib through the COllaborative Network for NEuro-oncology Clinical Trials (CONNECT) Consortium. The third trial, through the Pacific Pediatric Neuro-Oncology Consortium (PNOC), will examine the use of the PD-1 Inhibitor Nivolumab and pan-RAF inhibitor, Day101 (Tovorafenib). The design and tissue analysis plans for each of these trials will be discussed.

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Abstract #56: Length of Stay and Readmission with Elective Tumor Resection in Children

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No Disclosures

Introduction: Length of stay (LOS) and readmission (RA) are now readily accepted measures of quality within neurosurgery and medicine in general. We reviewed our experience with elective craniotomies for tumor resection to determine factors associated with these 2 outcomes.

Methods: All procedures performed from January 1, 2010 through December 31, 2019 were included. Demographic, clinical and procedural variables for each elective craniotomy for tumor resection were collected. Patients > 21 years old were excluded. LOS was defined as the interval from the date of index surgery to the date of discharge; an extended LOS (eLOS) was defined as > 7 days. RA was defined as the first 90-days after discharge. Bivariate and multivariable analyses were conducted using generalized estimating equations with and exchangeable correlation to account for patients with multiple hospitalizations. The final multivariable model was obtained using a backward model selection process.

Results: 998 patients underwent a total of 1,130 elective craniotomies for tumor resection during the study period. The median age at the time of surgery was 9.5 yrs and the most common age group was > 10 yrs. Most tumors were located supratentorial (64%). A postoperative event or complication occurred in 38% of cases. On multivariable analysis, an eLOS as associated with age < 5 yrs (OR=1.9, p=0.009), posterior fossa tumor resection (OR=2.1, p=0.001), tumor grade (OR=0.22, p=0.021), tumor type (craniopharyngioma and ependymoma), and presence of at least one postoperative complication (OR=14, p<0.0001). RA was associated with LOS as a continuous variable (OR=1.0334) and tumor grade (high grade vs low grade, OR=1.7732).

Conclusion: LOS and RA are important measures of delivery of healthcare. Not surprisingly, eLOS is strongly associated with any postoperative event or complication. RA, surprisingly, had only mild association with LOS and tumor grade.
Abstract #57: Surgical Management of Large and Giant Craniopharyngiomas in Children

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Introduction: Despite benign histology, pediatric craniopharyngiomas are challenging to manage and associated with hypopituitarism, hypothalamic dysfunction, and cognitive/behavioral changes. This is particularly true for larger craniopharyngiomas.

Objective: We present our institutional approach with the nuances of selecting a surgical approach, goal of GTR, minimizing radiation, and techniques to preserve hypothalamic function in patients with large and giant craniopharyngiomas.

Methods: Retrospective institutional study of craniopharyngioma patients age ≤ 18 years between 2002-2021. Tumor size was defined as large (>2 cm) or giant (>5 cm).

Results: 38 pediatric craniopharyngioma patients met inclusion criteria (14 giant, 24 large). Mean age was 8.7 years and 42% were female. Patients presented with headache (62%), vision changes (59%), nausea/vomiting (43%), and pituitary dysfunction (14%). All histology was adamantinomatous, 34% of tumors extended into the third ventricle, and 50% of patients had hydrocephalus.

For large tumors, surgical approach was 46% transsphenoidal and 54% transcranial (e.g. orbitozygomatic craniotomy). For giant tumors, approach was 21% transsphenoidal and 79% transcranial. Gross-total or near-total resection was achieved in 97.4% of patients.

Median follow-up was 62 months. Complication rate was 18%, including a 5% rate of cerebrospinal fluid leak. Panhypopituitarism occurred in 84%. Forty-six percent were overweight or obese preoperatively; 54% were obese postoperatively. Forty-two percent of patients experienced progression (recurrence or growth of residual), and 32% underwent reoperation. Five-year progression-free survival was 61%, 12% received adjuvant radiation, and only 16% of patients required shunt placement. One patient had asymptomatic recurrence 108 months after GTR, detected on surveillance MRI.

Conclusion: Preservation of hypothalamic function is key amongst the goals in craniopharyngioma treatment. The hypothalamus is exquisitely radiosensitive in children. Therefore, we favor maximal surgical resection involving careful dissection and variable suction to respect the tumor-hypothalamus interface. GTR may also reduce the need for shunt placement. Long-term surveillance is necessary to detect recurrence.

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Abstract #58: Human Stem Cell Models to Tackle Brain Cancer

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With the explosion of knowledge on the genetic landscape of brain tumors, it is probably now more important than ever to invest in humanized pre-clinical models. To make progress in drug development, we need to understand the functional consequences of gene mutations and their downstream growth-promoting pathways within the cell in a human context.

Pre-clinical models also provide innovative insight into brain cancer at the cellular and organ level. For example, the stem cell hierarchy within tumors, the role of differentiation failure, the cellular origins, differences between quiescent and proliferating cells, the role of the microenvironment in promoting tumorigenesis and the mechanisms of brain tumor metastasis. These broader perspectives are fundamental to understanding how brain tumors operate, and how best to tackle them. Especially for more relentless tumors such as GBM or medulloblastoma, we may only start to see improvement in overall survival if these different dimensions are addressed simultaneously. With recent advances in stem cell technology, there has been an expansion of human stem cell models of brain tumors, including fresh approaches to engineering brain tumors using pluripotent and neural stem cells, both in organoid cultures and following xenotransplantation in mice.

In this talk, the current approaches to modelling brain cancer will be presented with a specific focus on human stem cells and the biological questions that are being addressed using these state-of-the-art tools. The development of personalized models of cancer predisposition such as Gorlin syndrome will also be discussed, providing proof of concept that tumorigenesis can be predicted in predisposed individuals using patient-derived stem cells. These approaches complement the exploding field of cancer genomics, as well as the functional studies in genetically engineered mouse models to unravel fundamental questions in tumor biology.

Author has no relevant disclosures.
Abstract #60: Durability of CSF Diversion for Persistent Hydrocephalus Following Posterior Fossa Tumor Resection: Endoscopic Third Ventriculostomy vs. Ventriculoperitoneal Shunting


Background: Persistent hydrocephalus following resection of a posterior fossa brain tumor (PFBT) remains one of the most common causes of pediatric hydrocephalus. Ventriculoperitoneal shunt (VPS) and endoscopic third ventriculostomy (ETV) are both established means of CSF diversion for a variety of hydrocephalus etiologies, with the latter offering the advantage of a life free of shunt dependency. However, the data supporting ETV for PFBT-associated hydrocephalus is limited. Specifically, little is known regarding the survival duration of ETV in this patient population. The purpose of this study was to compare the time-to-failure (TTF) between first time ETV and VPS in patients who undergo treatment for persistent hydrocephalus following surgical resection of a PFBT at participating Hydrocephalus Clinical Research Network (HCRN) centers.

Methods: This was a retrospective analysis of pediatric patients who underwent CSF diversion following resection of a posterior fossa brain tumor at participating HCRN sites from May 2008 - January 2021. The primary outcomes were treatment failure and time-to-failure for ETV or VPS. Secondary outcomes included surgical complications, as well as subsequent operations, admissions, and imaging studies obtained related to hydrocephalus workup and management.

For the group comparison between ETV and VPS, the Wilcoxon rank sum test was used for the comparison of continuous variables and Fisher’s exact tests for categorical variables. Survival curves were calculated from the Kaplan-Meier method for each group and compared using the log-rank test. Multivariable regression was used to evaluate if treatment type was an independent predictor for outcome after adjusting for relevant variables. Multivariable analyses were performed using Cox regression for time-to-failure and modified Poisson regression for 6-, 12-, and 24-month outcomes. Results were presented using hazard ratios (Cox model) or relative risk (modified Poisson model) alongside associated 95% confidence intervals (CIs).

Results: Across the 13 participating HCRN sites, 241 patients met study criteria and underwent CSF diversion for persistent hydrocephalus following resection of a PFBT. 183 patients received VPS and 58 underwent ETV. Age at treatment (5.6 vs 5.5 years, p=0.80), tumor size (4.4 vs 4.6cm, p=0.314), relative posterior fossa location (p=0.514), ETV success score (p=0.783), and perioperative EVD insertion (81% vs 71%, p=0.10) were similar between VPS and ETV cohorts. The VPS group, relative to the ETV group, had a greater proportion of patients with high-grade tumors (59% vs 31%, p<.001), and a smaller fronto-occipital horn ratio (41 vs 48, p<.001). There was no difference in overall treatment failure between VPS and ETV (33.9% vs 31.0%, p=0.751). The mean time-to-failure was shorter for ETV (0.45 years) than for VPS (1.30 years), p=0.001, and on the multivariable Cox Model was not influenced by age (p=0.76), perioperative EVD (p=0.52), or tumor histology (p=0.06). The modified Poisson regression demonstrated no difference in relative risk of treatment failure between VPS and ETV at 6-, 12-, and 24-months following index procedure (p=0.258, 0.87, 0.705). Major complications were similar between both groups. Minor CSF leak (10.3% vs. 1.1%, p=0.003) and pseudomeningocele (12.1% vs 3.3%, p=0.02) were more common in the ETV compared to the VPS group. The mean number of hospital readmissions and number of CSF-diverting procedures after index CSF-diversion were similar between both cohorts (p=0.185 & p=0.671), however the mean number of subsequent CT and MR scans performed following index CSF-diversion was higher following VPS (17 ±10.8) than ETV (14 ±9.4), p=0.025.
Conclusions: In patients with persistent hydrocephalus following posterior fossa brain tumor resection, VPS and ETV offer similar treatment success. ETV failure occurs earlier than shunt failure, however cumulative failure rate is equivalent by 6-months and maintained beyond 6 years. Patient age, perioperative EVD insertion, tumor histology & grade, and extent of resection are not associated with treatment failure. Prospective clinical trial design may be considered to better elucidate which procedure offers optimal long-term outcome.
Abstract #61: Use of Tranexamic Acid in Brain Tumor Surgery

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Hemorrhagic complications are a significant risk in pediatric brain tumor surgery. Pharmacologic adjuncts to improve hemostasis including tranexamic acid (TXA) have been used in settings including craniosynostosis and scoliosis surgeries with demonstrable benefit, although there is an associated risk profile, specifically regarding thrombotic complications and seizures. There is limited data on use of systemic hemostatic adjuncts in pediatric brain tumor surgery.

A single-center, single-surgeon series of 100 consecutive cases including all open craniotomies for brain tumor or cavernoma resection over 65 months is retrospectively analyzed. Stereotactic biopsy, endoscopic-only, and combined brain/spinal cord tumor operations were excluded, as well as extradural-only tumors and a single case whereaminocaproic acid was administered. The decision regarding whether to use a hemostatic adjunct was made primarily by the anesthesiology team, in consultation with the surgeon, at the time of surgery. Intraoperative estimated blood loss (EBL), blood product transfusion, postoperative thrombotic complications (including deep venous thrombosis, dural sinus thrombosis, and pulmonary embolism), and incidence of postoperative seizures were compared between the 24 patients who did and 76 who did not receive TXA perioperatively.

No patients experienced any documented thrombotic complications. Estimated blood loss was similar between the 2 cohorts, including normalizing for operative time (EBL/minute) or patient weight (EBL/kg). Analysis of seizure risk was confounded by multiple factors including variable seizure activity prior to surgery, inconsistent exposure to antiepileptic drugs prior to and during surgery, and anatomic distribution of lesions. However, seizure risk did not appear substantially elevated in the TXA cohort.

This case series represents a small and very heterogeneous patient population, but the data suggests that a larger, multi-institutional prospective study may be safe to consider.