An Innovative Paradigm: Coordinating Anesthetic Care for Complex Pediatric Patients requiring Multiple Procedures

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Abstract

Background: The goal of the anesthesia coordination of care team is to optimize safety for children requiring multiple procedures under general anesthesia, by providing a single continuous anesthetic for imaging and surgical requests.

Methods: We developed an inter-professional team to create a pathway for providers to request multiple procedures with one anesthetic. Data collected includes patient and family satisfaction and a growing expertise of best practices for planning such coordinated care.

Results: The program began in December 2011, with over 300 cases completed to date. Through the development of this program, we have evolved our clinical expertise to provide optimal combinations and sequencing of procedures under one continuous anesthetic.

Conclusions: After a review of the literature, our team has not identified another care organization that consistently and prospectively plans for one continuous anesthetic for multiple procedures for children. Evidence supports this necessary planning, as there is a growing body of scientific research suggesting a possible risk of long term neurocognitive deficits related to anesthetic exposure at an early age. Certainly this approach is the right thing to do for patient safety, and it also is very appreciated by families.

Introduction and Background

Frequently, both a surgical procedure and an anesthetized radiological procedure are requested, but often they are not arranged to occur with one continuous anesthetic. Unfortunately, these procedures are planned by schedulers from multiple subspecialties, leading to uncoordinated care. Previously, hospital faculty and staff knew some patients were scheduled for more than one sedated procedure, such as an MRI and a minor surgery, often within the same month, but this was frequently discovered too late to coordinate the care. For patients, this means multiple trips to the hospital for two separate sedations and procedures or imaging. This results in two separate fasting periods, two separate intravascular access attempts, two intubations and two anesthetic exposures. To decrease risk for the patient, care can be coordinated to proactively plan for one continuous anesthetic that allows for all requested imaging and surgical procedures to be sequenced and completed in one visit.

Initiative Description

The goal of the coordination of care team is to optimize care for patients requiring multiple procedures under general anesthesia, often in multiple hospital locations, by providing a single continuous anesthetic for all requested procedures/imaging. In order to define the most efficient process for planning this care, we collaborated with pediatric surgical, medical, procedural, nursing, scheduling and admitting services in perioperative and radiology departments. The initial request is sent to the designated pediatric anesthesiologist who serves as a consultant to provide guidance and recommendation regarding procedural sequence, procedural room reservation and timing details. When arrangements for care are finalized, the coordination of care plan is saved to the patient's medical record.

Innovation

After a review of the literature, our team has not identified another care organization that consistently and prospectively plans for one continuous anesthetic for multiple procedures for children. Recommendations for planning and sequencing combinations include:

a. As a general rule, non-invasive procedure or imaging should be scheduled first, then the procedure or surgery should follow. For sequence guidelines and examples see Figure 1.

b. Some procedural combinations are not recommended, such as elective imaging that must be read prior to the procedure.
Figure 1: Template for Sequencing Coordination of Anesthetic Care.

For Example: MRI needs to be read and reviewed with the Interventional Radiology (IR) attending prior to performing joint injections, so taking the patient direct to IR leads to wasted time in the IR suite, and extra anesthesia time, so these must be purposefully planned to be separated. For additional examples see Figure 2.

<table>
<thead>
<tr>
<th>Types of Procedures/ Imaging</th>
<th>Clinical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental rehabilitation and adenoidectomy</td>
<td>nasal endotracheal tube required for dental procedure obstructs ability to excise adenoid tissue</td>
</tr>
<tr>
<td>T&amp;A and pH probe</td>
<td>the pH probe cannot be in place during immediate T&amp;A postop period due to risk of irritation and ensuing hemorrhage to newly cauterized tonsillar bed</td>
</tr>
<tr>
<td>Any invasive procedures with cardiac catheterization</td>
<td>combining EGD/colon or dental rehabilitation with a cardiac catheterization, presents increased risk for bacteremia</td>
</tr>
<tr>
<td>MRI</td>
<td>Any non-urgent imaging that is required to be read prior to the procedure</td>
</tr>
</tbody>
</table>

Figure 2: Procedural/Imaging Combinations that are Not Recommended.

Actual Results and Outcomes

Positive outcomes include both significant patient satisfaction with the approach and better understanding of best practice for sequencing and planning coordinated anesthetic care. Families of children requiring combined care procedures can now expect a well-executed hospital experience (see Figures 3 and 4), improving satisfaction. Confirmation of enhanced patient and family satisfaction are evidenced by responses to our patient satisfaction survey (IRB # 120682). Families shared with us their impressions of their experience with this program.

"I am extremely pleased with the communication level and the compassion shown in trying to coordinate these procedures. My child does not handle anesthesia well and it helped my peace of mind knowing that this was going to be a one-time anesthesia."

Parent described the coordination of care as "lifesaving" for her autistic child. "It decreased my child's aggression and anxiety."

"Improved my child's safety"

"With him being 2 years old we wanted to limit his exposure to anesthesia" 

"Appreciate the opportunity for multiple procedures in the same day since we live so far away"

"Initial communication from both clinics was a little confusing, but once the nurse (pre-operative clinic) became involved, everything became clear. Great experience overall!"

Figure 3: Prior State: One Patient, Two Anesthetics
In addition to improving satisfaction, we hypothesize that patient risk is likely reduced by well-planned care that minimizes the number of required preoperative fasting experiences, preoperative anxiety, intubations, venipunctures and multiple discrete anesthetics. This is especially important for medically complex children who are at high risk for complications. Furthermore, this program allows fewer separate hospital trips, resulting in cost savings to families who travel a significant distance for each visit, and reduces absences from school or work days.

The program began in December 2011. To date, we have completed over 300 cases. Development of this program did not add expense for the hospital. Instead, the program grew as a result of two committed colleagues, who invested in seeing this concept become a real and sustainable program. One of our pediatric anesthesiologists has acted as physician champion of this program, with partnership from one of our perioperative nurse practitioner leaders. Ultimately, communicating the intent of the program to colleagues throughout the institution has helped create increasing enthusiasm for the process supporting coordination of services. We are experiencing an increase in requests now that we have a well-defined care pathway. As the service continues to grow, we recognize that sustainability will only be achieved through further team work, and we are beginning to engage and train a dedicated perioperative advance practice nursing team to help plan and coordinate these requests in the future.

**Methods**

**IRB/Consent:**

The study was approved and evaluated by the IRB and determined to be non-research and consent therefore is not necessary.

RE: IRB# 120682 "Patient/Family Satisfaction with Coordination of Multiple Procedures Under Single Continuous Anesthetic." A designee of the Institutional Review Board reviewed the research study identified above. The designee determined the project does not qualify as "research" per 45 CFR §46.102(d). Family satisfaction is discussed...
via phone call and documented in a secure de-identified database, following their perioperative care.

To improve our process, we de-briefed with stakeholders and reviewed a number of early cases, and three key issues were identified. First, communication flow and a clear process was needed to support the team work. Second, an informatics access point for coordination and accountability for the plan was also necessary. Finally, identifying team leaders for aligning resources and scheduling was also essential for success. This was an iterative process, and required ongoing communication to achieve a well-coordinated team approach. Bringing key stakeholders together to debrief was the most efficient form of designing and re-designing our approach. Repeating this investigation at other care organizations would start with identifying a physician champion who can lead the process development. First steps would include engaging key personnel, including admitting, registration, surgical schedulers, and anesthesia, surgical and informatics leaders, to start the discussion on how best to accomplish this coordinated care in their individual institution’s setting.

**Discussion**

This coordination supports a culture of personalized care that children and families appreciate. Additionally this methodology streamlines the patient’s care experience, specifically including the opportunity to decrease repeated anesthetic exposure. As a growing body of scientific research suggests a possible risk of long term neurocognitive deficits related to anesthetic exposure at an early age, this work is clinically relevant. A 2013 article by Bong et al. in Anesthesia and Analgesia, describes an observational cohort study undertaken to determine whether children exposed to general anesthesia for minor surgery during infancy exhibited differences in academic achievement at age twelve years, compared with children who were never exposed to anesthesia or sedation. Findings include a 4.5 times greater odds of a formal diagnosis of a learning disability by age 12 years in children who had been exposed to general anesthesia. Although further research is needed to sort out this clinical question of causality, it seems prudent to proactively minimize the number of exposures to general anesthesia for infants and children. Also, social media is actively bombarding parents of young children with these concerns and thus parents and families are seeking opportunities to minimize repeated anesthetic exposure.

**Conclusions**

After a review of the literature, our team has not identified another care organization that consistently and prospectively plans for one continuous anesthetic for multiple procedures for children. Evidence supports this planning as necessary, due to potential neurological sequelae related to anesthetic exposure at an early age.

Our experiences thus far have guided our development of the template for sequencing coordination of anesthetic care (see figure 1 and 2). Evaluation of our program has included both patient satisfaction feedback and successful streamlining of the perioperative process (see figure 3 and 4). We are enthusiastic to further explore other potential positive effects of this approach, including cost savings for the perioperative service line. This is especially relevant as our health care industry is challenged to shift from a fee-for-service model to a value based health care purchasing model.

This paradigm is dedicated to patient centered care and emphasizes the ethic of making the patient the first priority, rather than scheduling at the convenience of the operating room or surgical schedule. Although identifying the best process for coordinating this care will be somewhat different at each organization due to scheduling and registration systems, we hope that this article shares a framework on how to begin and thus encourages other organizations to develop similar programs.

**References:**

A Multispecialty Pediatric Neurovascular Conference: A Model for Interdisciplinary Management of Complex Disease

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ABSTRACT

INTRODUCTION: In 2013, our institution established a multidisciplinary pediatric neurovascular conference for coordination of care. Here, we review our initial experience. METHODS: Clinical and demographic data were obtained from medical records for patients presented to the pediatric neurovascular conference from April 2013 to July 2014. Patient descriptive characteristics were described by mean and standard deviation for continuous measures and by number and percent for categorical measures. Patients were secondarily stratified by lesion/disease type, and descriptive statistics were used to measure demographic and clinical variables. RESULTS: The pediatric neurovascular conference met 26 times in the study period. Overall, 75 children were presented to the conference over a 15-month period. The mean age was 9.8 (standard deviation, 6.3) years. There were 42 (56%) male patients. These 75 children were presented a total of 112 times. There were 28 (37%) patients with history of stroke. Complex vascular lesions were the most frequently discussed entity; of 62 children (83%) with a diagnosed vascular lesion, brain arteriovenous malformation (29%), cavernous malformation (15%), and moyamoya (11%) were most common. Most discussions were for review of imaging (35%), treatment plan formulation (27%), the need for additional imaging (25%), or diagnosis (13%). Standardized care protocols for arteriovenous malformation and moyamoya were developed. CONCLUSION: A multidisciplinary conference among a diverse group of providers guides complex care decisions, helps standardize care protocols, promotes provider collaboration, and supports continuity of care in pediatric neurovascular disease.

Keywords: pediatric stroke, arteriovenous malformation, moyamoya, cavernous malformation, multidisciplinary

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when applicable, and on expert opinion. Many of these conditions are found in children with rare diseases that may predispose them to neurovascular abnormalities.1-9 (Table 1).

Given the paucity of guidelines for pediatric neurovascular disease management, in 2013, our institution established a multispecialty pediatric neurovascular conference (PNVC) to address complex cases that we believed would benefit from a coordinated, multidisciplinary approach to patient care. Our objective was to create a collaborative forum where providers could meet to discuss cases, review diagnoses and imaging, and develop joint management plans at no cost to the patient.

The PNVC is composed of attending physicians and nurse practitioners representing seven specialties: pediatric neurology, pediatric neurosurgery, neurointerventional (endovascular) surgery, anesthesiology, neuroradiology, radiation oncology, and pediatric critical care. The PNVC is held every 2 weeks, and trainees are invited to attend as well. Cases of known or suspected neurovascular lesions are submitted by participants for discussion.

Here, we review our initial experience and examine how the PNVC has helped foster multispecialty collaboration and coordinated care protocols for pediatric neurovascular disease management.

Methods

Study procedure

A record of patients presented to the PNVC was established in April 2013 and prospectively populated for quality assurance. After institutional review board approval, clinical records for these listed patients presented from April 2013 to July 2014 were retrospectively reviewed. Demographic variables (age, sex, and race/ethnicity) and clinical variables (presenting symptoms, stroke history, diagnosis, neuroimaging, and all interventions) were collected. PNVC records were reviewed to determine reason for referral to PNVC and clinical decisions after PNVC discussion.

A seven-item survey regarding usefulness of the PNVC was developed and administered to PNVC participants (all of whom are co-authors on this report) for quality improvement purposes. The survey was administered by the senior author, who did not complete a survey. Respondent specialty was collected. Items #1-6 were scored on a 5-point Likert scale, with choices ranging from “strongly agree” = 5 to “strongly disagree” = 1. Item #7 was a four-option multiple-choice question regarding what the respondent felt was the most useful aspect of PNVC.

Data analysis

Statistical analyses were computed using Microsoft Excel 2011 (Microsoft Corp, Bellevue, WA). Patient descriptive characteristics were described by mean and standard deviation for continuous measures and by number and percent for categorical measures. Patients were secondarily stratified by lesion/disease type, and descriptive statistics were used to measure demographic and clinical variables.

Results

Patient population

Overall, 75 children were presented to the PNVC over a 15-month period. The mean age was 9.8 (standard deviation, 6.3) years. There were 42 (56%) males. There were 53 (71%) caucasian, non-Hispanic/Latino; 14 (19%) African-American, non-Hispanic/Latino; and 8 (11%) caucasian, Hispanic/Latino patients. Headache (21 of 75, 28%), seizure (15 of 75, 20%), altered mental status/loss of consciousness (10 of 75, 13%), and focal weakness (9 of 75, 12%) were the most common presenting symptoms. Twenty-eight (37%) children had a history of stroke, 15 of 75 (20%) hemorrhagic and 13 of 75 (17%) ischemic. Of 62 children (83%) with a diagnosed vascular lesion, arteriovenous malformation (AVM); 18 of 62, 29%, cavernous malformation (9 of 62, 15%), and moyamoya (7 of 62, 11%) were most common (Table 2).

Initial PNVC discussions

The PNVC met 26 times in the study period. Seventy-five children were presented a total of 112 times. Initial discussions were primarily for review of imaging (26 of 75, 35%), treatment plan (20 of 75, 27%), need for additional imaging (19 of 75, 25%), or diagnosis (10 of 75, 13%; Table 3). Discussion of treatment plan was more common in AVM (10 of 18, 55%) and large vessel occlusion or dissection (3 of 6, 50%). Review of imaging was a common reason for moyamoya (6 of 7, 86%) and aneurysm (3 of 5, 60%) cases. For cases where there was a concern for vascular lesion on MRI (n = 4), concern for an infectious aneurysm (n = 3) or another unclassified vascular lesion (n = 9), need for additional vascular imaging was the primary question in 6 of 16 (38%) cases. Forty-two (56%) patients had a magnetic resonance imaging (MRI)/magnetic resonance angiography (MRA), and 10 (13%) patients had a computed tomography angiography after discussion at PNVC.

Interventions for 75 patients

Follow-up conventional angiography was performed in 18 of 75 (24%) cases, particularly for AVM (9 of 18, 50%) and aneurysm (3 of 5, 60%; Table 3). A diagnostic catheter
angiogram was performed in 13 individuals, and in the other 5 cases (all AVMs), embolization was performed. Considering all cases, a surgical operation was employed in 17 of 75 (23%); 12 of 75 (16%) underwent endovascular intervention; and 9 of 75 (12%) received stereotactic radiosurgery. Thirteen (72%) AVM patients had undergone treatment before presentation at conference; treatments were a combination of embolization in 7 patients, stereotactic radiosurgery in 4 patients, and resection in 5 patients. Five underwent treatment or retreatment after PNVC (a combination of embolization in 4 patients, resection 2 patients, and stereotactic radiosurgery 4 patients). Embolization was attempted in all individuals with vein of Galen malformation (n = 3). Three children underwent pial synangiosis after PNVC discussion (moyamoya in 2 patients, craniometaphyseal dysplasia with bilateral internal carotid occlusions and transient ischemic attack in 1 patient). One aneurysm was clipped, and three cavernous malformations were resected after PNVC discussion. All cases of developmental venous anomaly were managed conservatively.

**Post-PNVC repeat discussions for 26 patients**

Twenty-six patients (35%) were discussed more than once, a total of 36 repeated discussions. The most common reasons for rediscussion were imaging follow-up (17 of 36, 47%), need for additional imaging/timing of angiography (9 of 36, 25%), and treatment (8 of 36, 22%). Fourteen (39%) of the repeat discussions were for patients with AVMs (Table 3).

**Illustrative cases**

The following two cases represent the unique coordination of care offered by the PNVC, synthesizing expertise across disciplines to arrive at a joint management plan for complex cerebrovascular lesions.

**Case #1**

A 13-year-old girl presented with progressive myelopathy, with weakness and spasticity of both legs and her left arm. This progression was thought to be because of a persistent cervicomедullary AVM (previously coiled three times, with partial resection at age 11 years and treatments at three different medical institutions), causing vascular steal from the spinal cord. Discussions resulted in diagnostic cerebral angiography, which revealed a Spetzler-Martin grade 4 AVM, with reversed flow in the anterior spinal artery (Fig 1). Cervical spine MRI revealed a thin cervical cord with changes suggestive of chronic ongoing ischemia and prominent dural venous channels. The risk of surgical resection was thought to be

<table>
<thead>
<tr>
<th>Condition</th>
<th>N</th>
<th>Age, years</th>
<th>Sex</th>
<th>Number</th>
<th>Prior Stroke Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arteriovenous malformation</td>
<td>18</td>
<td>12.8 (4.7)</td>
<td>Male</td>
<td>14</td>
<td>Hemorrhage</td>
<td>8</td>
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<tr>
<td>Cavernous malformation</td>
<td>9</td>
<td>9.3 (6.8)</td>
<td>Male</td>
<td>4</td>
<td>Hemorrhage</td>
<td>2</td>
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<tr>
<td>Moyamoya</td>
<td>7</td>
<td>14.7 (4.5)</td>
<td>Male</td>
<td>3</td>
<td>AIS</td>
<td>2</td>
</tr>
<tr>
<td>Large artery occlusion or dissection</td>
<td>6</td>
<td>7.8 (7.3)</td>
<td>Male</td>
<td>2</td>
<td>AIS</td>
<td>5</td>
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<tr>
<td>Aneurysm</td>
<td>5</td>
<td>14 (8.4)</td>
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<td>2</td>
<td>Hemorrhage</td>
<td>1</td>
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<tr>
<td>Developmental venous anomaly</td>
<td>5</td>
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<td>Vein of Galen malformation</td>
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<td>2 (2.6)</td>
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<td>Other vascular lesion</td>
<td>9</td>
<td>5.9 (3.3)</td>
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<td>3</td>
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<tr>
<td>Concern for vascular lesion on MRI</td>
<td>4</td>
<td>12 (5.8)</td>
<td>Male</td>
<td>2</td>
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<td>-</td>
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<tr>
<td>Concern for infectious aneurysm</td>
<td>3</td>
<td>14.6 (5.3)</td>
<td>Male</td>
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<td>1</td>
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<tr>
<td>Stroke</td>
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<td>3 (3.1)</td>
<td>Male</td>
<td>3</td>
<td>AIS</td>
<td>3</td>
</tr>
</tbody>
</table>

Abbreviations:

- **AIS** = Arterial ischemic stroke
- **ICA** = Internal carotid artery
- **ICH** = Intracerebral hemorrhage
- **MRI** = Magnetic resonance imaging
- **NOS** = Not otherwise specified
- **PHACE** = Posterior fossa malformations, hemangioma, arterial lesions, cardiac abnormalities, and eye abnormalities
- **PNVC** = Pediatric neurovascular conference

*Age: mean (standard deviation).*

| Other vascular lesions: PHACE, sinus pericranii, congenitally absent ICAs, radiation vasculopathy, carotid occlusions from craniometaphyseal dysplasia, intracranial venous drainage abnormalities, and tumor encasing ICA. |
extraordinarily high, and stereotactic radiosurgery was recommended. Three dimensional angiography with possible repeat embolization is planned for radiosurgery targeting.

**Case #2**

A 15-year-old girl with a remote history of facial hemangioma presented with migraine. Brain MRI performed for worsening headaches revealed a 2-cm right-sided vascular anomaly within the perimesencephalic cistern. She was diagnosed with PHACE syndrome (posterior fossa malformations, hemangioma, arterial lesions, cardiac abnormalities, and eye abnormalities)\(^{10}\) based on hemangioma and arterial abnormalities. Brain MRI/MRA was obtained and reviewed at PNVC (Fig 2). This confirmed abnormal flow voids in the right perimesencephalic space and indicated a right internal carotid artery occlusion. Digital subtraction angiography was obtained, which demonstrated near-complete occlusion of the distal right internal carotid artery and proximal right middle cerebral artery, with moyamoya-like collaterals. In the absence of transient ischemic attack or other stroke symptoms, observation with hemodynamic MRI was recommended. Blood oxygenation level-
dependent MRI\textsuperscript{11,12} revealed a perfusion defect in the right posterior parietal region that did not improve with a vasodilatory stimulus, carbogen (95% oxygen, 5% carbon dioxide mixture) inhalation. Provided these findings of reduced cerebrovascular reactivity, the patient was felt at high risk for stroke. Surgical revascularization via pial synangiosis was recommended and was performed without complication.

Protocols

Standardized care protocols for AVM and moyamoya were developed from discussions among physicians from seven different specialties (Fig 3). For AVM, it was agreed that angiography for test of cure would be scheduled at 6 months after surgical resection or 3 years after radiosurgery. After the AVM is believed to be cured, surveillance MRI/MRA to check for recurrence is performed every 5 years thereafter. Moyamoya patients undergoing pial synangiosis are admitted the night before surgery and receive intravenous fluids while fasting to avoid dehydration presurgically.\textsuperscript{13} Postoperatively, to assess revascularization and for the presence of any new stroke, MRI and MRA of the brain are performed at 6 months; conventional angiography is performed at one year.
Respondent survey results

Eight PNVC participants completed the survey (Fig 4). Rated highest were both PNVC’s utility in informing a better understanding of patients’ cases (5.0 of 5.0) and facilitating better communication across specialties (5.0 of 5.0). Respondents from the pediatric intensive care unit and anesthesia reported, appropriately, that PNVC would not significantly change their management plan (3.0 of 5.0), whereas other specialties represented felt that it did (5.0 of 5.0). Respondents unanimously cited PNVC’s greatest utility as facilitation of a collaborative approach to patient care.

Discussion

The beneficial role tumor boards play in promoting multidisciplinary review of care for adults and children with cancer has been historically affirmed. Although we are aware of boards similar to the PNVC at other centers, none have yet been presented in the literature. However, the development of primary pediatric stroke centers has been described for the first time recently. The PNVC is an extension of the idea that children with neurovascular disease deserve coordinated, multispecialty care. Therefore, we have examined our initial experience with such a conference as an instrument for the coordination of complex neurovascular disease care.

The paucity of established guidelines for pediatric neurovascular conditions served as the impetus for instituting the PNVC at our center. Accordingly, issues discussed primarily concerned the best imaging and treatment plans for complex pediatric neurovascular cases. The most common reason that patients were presented was to review imaging; however, in reviewing images, the fundamental objective

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FIGURE 1.

Case #1: 13-year-old girl with cervicomedullary dural arteriovenous malformation (AVM). (A) Magnified digital subtraction angiography (DSA) vertebral artery injection, early arterial phase. There is significant supply from the anterior spinal artery, with reversed flow ascending to supply the lesion (black arrows). The anterior spinal artery is already visualized filling, without opacification of its normal origin at the distal vertebral artery (arrowhead). (B) DSA reveals that the AVM, at the site of prior embolization, is supplied by bilateral vertebral arteries and bilateral posterior inferior cerebellar arteries. There is rapid shunting through the right sigmoid sinus, a contralateral cerebellar vein, and the spinal venous plexus (white arrows). (C) DSA three dimensional reconstruction reveals a 3.5-cm Spetzler-Martin grade 4 AVM, with a diffuse nidus. (D) Sagittal T2-weighted magnetic resonance images of the cervical spine (D, E) redemonstrate the cervicomedullary AVM. (E) Also visible are prominent dural venous channels posteriorly (arrow).
was to determine how best to manage these patients. Ultimately, 41% of patients had an operative intervention of some kind at some point, and 24% had follow-up angiography.

The PNVC promoted the standardization of pediatric neurovascular disease management at our institution, most clearly demonstrated by the development of care protocols for AVM and moyamoya perioperative and postoperative management. Recognizing that most cases of AVM were presented to discuss treatment, we were prompted to develop a standardized care protocol for AVM, informed by guidance from multifaceted training backgrounds. No clear protocol emerged from less common diseases. The PNVC helped providers better understand their patients’ cases, and also informed providers’ medical decision-making process, while establishing a group consensus on a case-by-case basis. Providers were able to counsel patients and families that the PNVC had specifically discussed their case and that the chosen management plan was reached after considerable thought and deliberation by the group. This conference has held significant educational benefit for trainees as well. By making the decision-making process more transparent, the PNVC provided a platform to develop clinical reasoning skills, whereas exposing trainees to different specialties, and more specifically to the way different specialties interface with one another, to provide coordinated care.

We believe that a PNVC can be useful in helping providers better understand and address the complex cases that arise in patient management, and as the study’s survey results espouse, the PNVC holds particular power in its ability to foster collaboration across the specialties. However, there remain children with complex cerebrovascular conditions for whom there is no good treatment. It is difficult to assess from the manner in which discussions were recorded in the medical record whether PNVC conference discussion truly made a major change in clinical management for most patients. Group discussion seemed to bring up new ideas for evaluation and treatment in a few cases. More typically, the attending physician would have a range of evaluation or treatment options in mind, and the group discussion would help to confirm or solidify these plans.

**Limitations**

This study is limited in its single-center, nonblinded, retrospective nature. The corollary is that content of PNVC discussions in their entirety were not available for review,
and information used in this study was largely derived from retrospective chart review and PNVC records. We also acknowledge that survey participants co-authored this manuscript, which could bias qualitative findings regarding the utility of the PNVC. However, participants were not informed that these data would be used in this report at time of survey completion. The survey was intended as a means for feedback for quality improvement/quality assurance purposes.

**Conclusion**

A multidisciplinary conference held among a diverse group of providers is a powerful resource that helps

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**FIGURE 3.**

Protocols for arteriovenous malformation (AVM) and moyamoya developed by the pediatric neurovascular conference. (A) For AVM, it was agreed that angiography for test of cure would be scheduled for 6 months after resection or 3 years after radiosurgery. After this, an MRI/MRA to check for recurrence would occur every 5 years thereafter. (B) For moyamoya, patients undergoing pial synangiosis would be admitted the night before surgery and administered fluids while fasting. Postoperatively, there would be an MRI/MRA at 6 months and angiography at 1 year. (The color version of this figure is available in the online edition.)

**FIGURE 4.**

Results from survey of pediatric neurovascular conference (PNVC) respondents (n = 8). Scored on Likert scale from 1 to 5. “Strongly disagree” = 1, “Strongly agree” = 5. (The color version of this figure is available in the online edition.)
physicians better address complex cases, leads to the development of standardized care protocols, promotes faculty collaboration, and supports continuity of care in pediatric neurovascular disease management.

The authors would like to thank Melissa Gindville for invaluable help in organizing the pediatric neurovascular conference.

References


