Childhood Stroke: unique features and new advances

AHA Webinar

June 24th, 2016

Timothy J. Bernard, MD, MSCS
- Director, Pediatric Stroke Program
- Associate Professor of Pediatrics, Neurology and Child Neurology
  University of Colorado School of Medicine
Disclosures

Funding:

American Stroke Association/Bugher Foundation

- ASA/Bugher Foundation Stroke Collaborative Research Center  AHA14BFSC17680001 (PI: Traystman)
- Project 1: Childhood Acute Ischemic Stroke (AIS) Neuropsychological and Quality of Life Outcomes: lesion-specific plasticity in the developing brain. AHA-14BFSC17540000 (PI: Bernard)
- Collaborative Project: ASA/Bugher Foundation Stroke Research Center Collaborative Project AHA-14BFSC17540000 (PI: Bernard/Wright/Dobkin)

American Heart Association Pre-doctoral Fellowship

- Preservation of hippocampal volume and white matter in children with arterial ischemic stroke. AHA15PRE25550151 (PI: Ritchey; Mentor: Bernard/Stence)

Conflicts of interest: None
Goals

• To understand the unique features of childhood stroke presentation

• To review recent advances in the understanding of childhood stroke, and the capacity for recovery:
  1. Time is brain, lessons learned from our adult colleagues
  2. Treating the whole child
Goals

• To understand the unique features of childhood stroke presentation

• To review recent advances in the understanding of childhood stroke, and the capacity for recovery:
  1. Time is brain, lessons learned from our adult colleagues
  2. Treating the whole child
Acute Stroke: Definitions

Childhood AIS: (29 days - 18 years)
- Age 29 days-18 years
- Acute onset neurological deficit
- Neuroradiological imaging (MRI or CT) findings of brain infarction conforming to an arterial distribution concordant with the neurological presentation
Acute Ischemic Stroke: Epidemiology

• 1.2 per 100,000 children per year will have an arterial ischemic stroke (Colorado: >20 cases/year)

• Male Predominance (59%)

• Median Age: 5.7 Years

• 20% Cardiac Disease, 7% Dissection, 6% Sickle Cell Disease, 67% Other/Idiopathic

• Adverse outcomes
  • Neurological deficit or seizures in 70-75%
  • Death in up to 10%

Goals

- To understand the unique features of childhood stroke presentation
- To review recent advances in the understanding of childhood stroke, and the capacity for recovery:
  1. Time is brain, lessons learned from our adult colleagues
  2. Treating the whole child
Goals

• To understand the unique features of childhood stroke presentation

• To review recent advances in the understanding of childhood stroke, and the capacity for recovery:
  1. Time is brain, lessons learned from our adult colleagues
  2. Treating the whole child
Acute Ischemic Stroke: presenting symptoms

- Most common presenting stroke symptoms (n=47):
  - arm weakness (63%)
  - face weakness (62%)
  - leg weakness (57%)
  - speech disturbance (46%)
  - headache (46%)

- Most common stroke signs:
  - arm weakness (61%)
  - face weakness (70%)
  - leg weakness (57%)
  - dysarthria (34%)

- 78% of children have at least one positive symptom on FAST:

(Yock-Corrales et al., 2011)
Acute Stroke: diagnosis

Differential diagnosis of a focal neurological deficit in a child:

• Seizure and Todd’s paralysis
• Bleed
• Encephalitis
• Concussion
• Complicated Migraine
• Stroke
Acute Stroke: time to diagnosis

• Median time to diagnosis: 24 hours
• Stroke is suspected in initial presentation only 25%-50% of the time

• We need to do better!
Acute Stroke: mimickers

143 CHOP Stroke Consults

- Mimicker: not benign 13%
- Mimicker: Benign 8%
- Stroke Syndrome: TIA, Stroke, CSVT or ICH 79%

(Shellhass et al. 2005)
Acute Stroke: mimickers

Mimickers: benign (11)
- Migraine
- Psychogenic
- Musculoskeletal abnormalities
- Delirium
- Periodic hypertensive episodes

Mimickers: not benign (19)
- Neonatal seizure
- Metabolic stroke
- Epilepsy (new diagnosis)
- Postictal paralysis
- ADEM
- Tumor
- Cerebellitis
- Drug toxicity
- Idiopathic intracranial hypertension
- Subdural empyema
- AVM
- Moyamoya
- Intracranial abscess

(Shellhass et al. 2005)
CHCO: Case #1

• 2004
• A 17-year-old boy is taken to a rural Emergency Department after awakening from a 3-hour nap with right-sided moderate hemiparesis: arm>leg and aphasia. He has a headache and photophobia. CT head is negative.
• Vascular imaging is not done. MRI is not done.
• He is admitted overnight for observation for presumed complicated migraine. No one discusses the possibility of stroke or tPA with the family. No one considers stroke mimickers such as ADEM, encephalitis or seizure. No further evaluation is undertaken.
2004

The next morning his weakness has progressed to complete hemiparesis and he is transferred to Children’s Hospital Colorado. He is diagnosed with a left MCA stroke.

Mom’s first question to me: Is there anything else that could have been done?
Rationale for rapid diagnosis of stroke

In children with stroke:

1. Adopting adult stroke strategies for systematic diagnosis, evaluation, and management are likely to lead to a similar improvement in outcomes in childhood stroke.
   - Fluids
   - Glucose Management
   - Surveillance of Recurrence

2. Utilizing systematic approaches to diagnosis will also lead to improved patient/parent communication through:
   - decreased anxiety and frustration about delays in diagnosis
   - allowing for upfront discussion about management:
     - “I am not recommending tPA because…”
     - “Although the head CT is negative, stroke could still be a possibility.”

(Adams, 2007; Sapsonik, 2009; Langhorn et al, 2007)
Colorado Stroke Team
2007-present

• Stroke Team: Available 24/7
• Expertise/Interest in Childhood Stroke
• Stroke alert procedure
• MRI availability 24/7
• Stroke alert ordersets in ED/ICU

Sharon Poisson  Brad Miller  Jennifer Simpson  William Jones  Kelly Knupp  Jennifer Armstrong
A 10-year-old girl is taken to a rural Emergency Department after awakening from a 5-hour nap with right-sided moderate hemiparesis: arm>leg and mild aphasia. She is taken to an outside ED where they suspect stroke and transfer her to Children’s Hospital Colorado. At CHCO, MRI/MRA confirms stroke and distal M1 narrowing at 8 hours. She is given aspirin, started on IVF. Mom is told that she may worsen overnight due to her M1 narrowing. The family is also educated about the reasons she is not a candidate for tPA.
2014

- The next day her weakness progresses to complete hemiplegia just after standing up to go to the bathroom. Laying her supine improves her symptoms. The family is appreciative of our care and attention, even though she has waxing and waning care over the next 24-48 hours.

- **Outcome is improved by:**
  1. understanding the situation
  2. partnering with family around treatment
Development of acute stroke readiness: lessons from the TIPS Trial

TIPS - Thrombolysis in Pediatric Stroke

• 5-year multicenter international safety and dose-finding study of intravenous tPA in children with acute arterial ischemic stroke
• First ever prospective treatment trial in childhood stroke
• Inclusion:
  • Age 2-18
  • Confirmed Arterial Ischemic Stroke
  • 0 - 4.5 hours from symptom onset
  • PedNIHSS >6
• Exclusion: parallels adult criteria
• In December 2013, the TIPS trial was closed secondary to low recruitment.

(Amlie-Lefond 2011)
Development of acute stroke readiness: Lessons from the TIPS Trial

Before the TIPS trial:

• 17 participating centers asked, “How prepared are you to care for a child with stroke?”

• On a Likert scale from 1-10 (1 being “not ready at all”; 10 being “completely ready) the average center reported 6.2 prior to the trial.

(Bernard et al., Stroke, 2014)
Development of site readiness for acute stroke in Thrombolysis in Pediatric Stroke (TIPS) sites from 2003 to 2013.

(Bernard et al., Stroke, 2014)
Development of acute stroke readiness:
Lessons from the TIPS Trial

After the TIPS trial:

• 17 participating centers asked, “How prepared are you to care for a child with stroke?”

• On a Likert scale from 1-10 (1 being “not ready at all”; 10 being “completely ready) the average center reported 8.6 prior to the trial.

(Bernard et al., Stroke, 2014)
Summary

1. Children with stroke have similar symptoms to adults: FAST
2. Systems for childhood stroke are likely to lead to improved outcomes in childhood stroke - beyond tPA
3. Stroke alert systems will be site-specific and likely vary by site size/resources
4. Stroke alert systems increase preparedness for childhood stroke
Goals

• To understand the unique features of childhood stroke presentation

• To review recent advances in the understanding of childhood stroke, and the capacity for recovery:
  1. Time is brain, lessons learned from our adult colleagues
  2. Treating the whole child
Mixed Methods Survey of Childhood Stroke Survivors and Their Parents

All participants (50 adults, 10 children) reported primary themes of fear, anxiety, and frustration, including themes of:

1. **Recovery**: current and future disabilities, regaining milestones
2. **Recurrence**: worsening disabilities and impact to future QOL
3. **Resources**: limited resources to aid in recovery including financial, emotional, and medical
4. **Decision-Making**: within the family, community and medical team
5. **Normalcy**: regaining or adapting to normal activities for self and family as well as within the community and medical environments.

Importance of Stroke Support Group

• All participants reported the importance of the support group; of significance to parents and grandparents was the reassurance and knowledge offered from families with similar experiences.

• Adolescent participants preferred a separate support meeting from their parents with a focus on technology use for information sharing such as Facebook, texting, and email use, etc.
Multidisciplinary Approach to Childhood Stroke

Children’s Hospital Colorado Stroke Clinic

– Neurology
– Hematology
– Rehabilitation
– Neurosurgery
– Rheumatology
– Pharmacy
– Stroke Support Group
– Social Worker
– Research

Colorado Pediatric Stroke Parent Support Group

• Our mission is to provide support, education, and advocacy for families impacted by the range of outcomes of all types of pediatric strokes.
• Affiliated with the International Alliance for Pediatric Stroke (IAPS)
• Director: Amanda Kenny
• Facilitators: Amanda Kenny & Audra Leblanc
• Funding:
  – Local Denver grant (Professional Miracles Foundation)
  – Internal funding from Children’s Hospital Colorado
Support is emotionally beneficial!
Goals

• To understand the unique features of childhood stroke presentation

• To review recent advances in the understanding of childhood stroke, and the capacity for recovery:
  1. Time is brain, lessons learned from our adult colleagues
  2. Treating the whole child
Young Adult Ischemic Stroke

Sharon Poisson, MD MAS
Assistant Professor of Neurology
Director, Young Adult Stroke Program
University of Colorado, Denver
Disclosures

• Funding
  – Stroke Prevention/Intervention Research Program (NINDS U54): Project 2 - Racial Disparities in Ischemic Stroke and Atherosclerotic Risk Factors in the Young (Fullerton H) U54 NS081760 02S1 (Sidney S)

• Conflicts of interest: None
Young Adult Ischemic Stroke

- Epidemiology of young adult stroke
- Importance of stroke in young adults
- Specific risk factors and causes
- Diagnostic workup, treatment and secondary prevention
- What next?
What is “Youth”??

- Definition of “Young Adult”
  - Young \( \leq \) My age + 10
- Definition varies across studies
  - Lower limit varies from 15-20
  - Upper limit varies from 40-50
  - Often whatever is convenient in a particular study
Ischemic Stroke

21%-80% of all strokes in young adults
Compared with ~85% of overall stroke
Stroke is For Seniors, right?

• Ischemic Stroke Incidence
  – All Adults: ranges from 88-149/100,000 (depending on race/ethnicity)
  – “Young” Adults: 3-11/100,000
  – Children: 1.2-2.4/100,000
Trends in Stroke Hospitalization by Age Group

Trends in Stroke Hospitalizations – Young Adults

Males 35-44

Females 35-44

Males 15-34

Females 15-34
Percent Decline in Mortality 1989-2009

Poisson, SN et al. Neurology, December 2014
Importance

• Significant cost to individuals and to society
  – Years of productive life lost
  – Lifetime cost of stroke in a young adult estimated about $500,000

• Unique problems in this age group:
  – Young families
  – Bread-winners for family
  – Change in way young people view themselves
Who are Young Adults with Stroke?

– Just kids in adult clothing?

– Or young “seniors”?
Epidemiology of Ischemic Stroke in Young Adults

• Similar rates of ischemic stroke among men and women in this age group
  – Women more common in ages <35
  – Men more common in ages ≥35

• Racial/ethnic differences mirror those in overall adult population
  – 2-fold higher among African-Americans
## Risk Factors for Stroke

<table>
<thead>
<tr>
<th>Childhood Stroke</th>
<th>Adult Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Abnormalities</td>
<td>Age</td>
</tr>
<tr>
<td>Sickle Cell Disease</td>
<td>Atherosclerosis</td>
</tr>
<tr>
<td>Idiopathic/Other</td>
<td>Hypertension</td>
</tr>
<tr>
<td>Thrombophilia (30-50%)</td>
<td>Diabetes</td>
</tr>
<tr>
<td>Arteriopathy (50-80%)</td>
<td>Hyperlipidemia</td>
</tr>
<tr>
<td>Genetic Syndromes</td>
<td>Atrial Fibrillation</td>
</tr>
<tr>
<td>Metabolic Syndromes</td>
<td>Smoking</td>
</tr>
<tr>
<td>Collagen Vascular Disease</td>
<td>Obesity</td>
</tr>
<tr>
<td>Infection</td>
<td></td>
</tr>
<tr>
<td>Migraine</td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td></td>
</tr>
</tbody>
</table>

**Young Adults??**
Etiology of Stroke In Young Adults

• Data is LIMITED!
• Helsinki Young Stroke Registry
  – 1008 patients (ages 15-49)
  – Typical stroke risk factors:
    • 60% dyslipidemia, 39% HTN
  – Most common causes:
    • Cardioembolism (20%)
    • Dissection (15%)
  – Cryptogenic strokes (33%)
• Other series - similar results

Putaala J, et al. Stroke; 2009
<table>
<thead>
<tr>
<th>Arterial Disease</th>
<th>Cardioembolism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherosclerotic Disease/Lipohyalinosis</td>
<td>Atrial Fibrillation/Flutter</td>
</tr>
<tr>
<td>Nonatherosclerotic Vasculopathy</td>
<td>Infectious Endocarditis</td>
</tr>
<tr>
<td>Dissection</td>
<td>Nonbacterial Thrombotic Endocarditis</td>
</tr>
<tr>
<td>Focal Cerebral Arteriopathy</td>
<td>Patent Foramen Ovale/ ASA</td>
</tr>
<tr>
<td>Moyamoya Disease/Syndrome</td>
<td>Congenital Heart Disease</td>
</tr>
<tr>
<td>Sickle Cell Disease</td>
<td>Acquired Structural Heart Disease</td>
</tr>
<tr>
<td>Reversible Cerebral Vasoconstriction Syndrome</td>
<td></td>
</tr>
<tr>
<td>Genetic arteriopathies – CADASIL, Fabry Disease, MELAS</td>
<td>Genetic Thrombophilias (Factor V Leiden, Prothrombin G20210A, Protein C/S def)</td>
</tr>
<tr>
<td>Infectious arteriopathies</td>
<td>Acquired thrombophilias</td>
</tr>
<tr>
<td>Inflammatory arteriopathies</td>
<td>Primary hematologic disorders</td>
</tr>
<tr>
<td>Migraine</td>
<td></td>
</tr>
</tbody>
</table>

**Hematologic**

**Cryptogenic**
Atherosclerotic Risk Factors

• Evidence that atherosclerosis develops early in life and is related to the number of typical risk factors

• Prevalence of atherosclerotic risk factors may be increasing over time in children and young adults
  • Hypertension
  • DM
  • Obesity
  • Hyperlipidemia
Arterial Dissection

- Tear in wall of blood vessel, usually in cervical artery
- Mechanisms: thromboembolic, hypoperfusion
- About half are related to a known trauma, and other half are spontaneous
PFO

- 25% of population
- In patients with cryptogenic stroke, OR for PFO:
  - Overall = 2.1
  - Younger population = 5.1.
- Not clear that risk of recurrent stroke is higher in those with PFO.
- Evidence for closure is increasing in very specific groups – FDA panel recommended approval of Amplatzer device (5/2016)
Primary End-Point Events in the Intention-to-Treat and As-Treated Cohorts.

Significant Reduction in Recurrent Cryptogenic Stroke

54% Relative Risk Reduction in ITT Population

Event-free Probability

<table>
<thead>
<tr>
<th>Time to Event (Years)</th>
<th>AMPLATZER™ PFO Occluder (N=499; # cryptogenic strokes = 10)</th>
<th>Medical Management (N=481, # cryptogenic strokes = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Device not in place</td>
<td></td>
</tr>
<tr>
<td>0.85</td>
<td>HR: 0.460</td>
<td></td>
</tr>
<tr>
<td>0.90</td>
<td>Log-rank p-value: 0.042</td>
<td></td>
</tr>
</tbody>
</table>

# at Risk (KM Estimates)

<table>
<thead>
<tr>
<th>AMPLATZER</th>
<th>499 (0%)</th>
<th>463 (1.2%)</th>
<th>369 (1.5%)</th>
<th>212 (2.5%)</th>
<th>86 (2.5%)</th>
<th>20 (2.5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM</td>
<td>481 (0%)</td>
<td>394 (2.7%)</td>
<td>307 (4.1%)</td>
<td>168 (4.1%)</td>
<td>71 (5.2%)</td>
<td>10 (10.8%)</td>
</tr>
</tbody>
</table>
Substance Abuse and Young Adult Stroke

• Many substances have been associated with stroke risk
  – Tobacco use (OR ~4)
  – Heavy EtOH use
  – Cocaine (OR 13.9)
  – Amphetamines (higher risk of hemorrhage)
  – ? Marijuana (rare case reports)
## Trends in Substance Abuse Preceding Stroke Among Young Adults

<table>
<thead>
<tr>
<th></th>
<th>Strokes Only</th>
<th>1993–1994 (n=297)</th>
<th>1999 (n=376)</th>
<th>2005 (n=501)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Smoking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current*</td>
<td>129 (42%)</td>
<td>187 (47%)</td>
<td>245 (52%)</td>
<td></td>
</tr>
<tr>
<td>Past</td>
<td>24 (7%)</td>
<td>29 (7%)</td>
<td>61 (14%)</td>
<td></td>
</tr>
<tr>
<td>†Never</td>
<td>144 (51%)</td>
<td>160 (46%)</td>
<td>195 (35%)</td>
<td></td>
</tr>
<tr>
<td><strong>Heavy alcohol use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>28 (8%)</td>
<td>48 (12%)</td>
<td>52 (15%)</td>
<td></td>
</tr>
<tr>
<td><strong>Illicit drug use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>13 (3.8%)</td>
<td>39 (9.8%)</td>
<td>96 (19.8%)</td>
<td></td>
</tr>
</tbody>
</table>

- Data presented as raw n (weighted %).
- *Current if present within the last 3 mo.
- †Change over time, *P*=0.01.
- ‡Change over time, *P*<0.001.
Diagnostic Evaluation

• No good evidence-based algorithms exist for evaluating young adult stroke
  – Poorly understood
  – Very broad range of uncommon etiologies
• Best to use a tiered approach
From: Ischemic Stroke and Transient Ischemic Attack in Young Adults: Risk Factors, Diagnostic Yield, Neuroimaging, and Thrombolysis


Figure. Diagnostic tests in young adults with ischemic stroke. The lighter bars show the percentage of patients who underwent a certain test and the black bars show the percentage of tests showing a positive result relative to stroke etiology (ie, diagnostic yield). CSF indicates cerebrospinal fluid; CT, computed tomography; MRI, magnetic resonance imaging. See “Methods” section for individual tests included under each panel.
Diagnostic Evaluation

• Proposed algorithm
  – Typical adult evaluation:
    • Head CT and/or MRI (consider MRI given radiation risk in younger patients)
    • Noninvasive vascular imaging
    • Evaluate vascular risk factors: Lipid panel, Hemoglobin A1c, Blood pressure monitoring
    • Cardiac monitoring
    • Echocardiogram
  – Other routine studies to consider:
    • Toxicology screen
    • Inflammatory labs – ESR, CRP
    • Pregnancy test (if applicable)
Diagnostic Evaluation

• Other studies to consider based on history OR if etiology remains unclear:
  – Conventional angiogram
  – CSF evaluation (for infection, inflammation)
  – Rheumatologic panel (ANA, RF, ANCA, etc)
  – Hypercoagulable panel
  – Genetic tests (CADASIL)
  – Infectious studies (HIV, Lyme, VZV, HSV, etc)
  – LE dopplers, pelvic CT/MRV (if PFO present)
Acute Treatment

• Similar to treatment of older adults
• IV tPA is safe and effective in young adults
  – SITS-ISTR Registry of patients treated with IV tPA
    • 11.7% between ages 18-50
    • Lower risk of sICH in young compared with older adults (0.6% vs 1.9%, p=0.02)
    • Functional independence higher in young adults (72.1% vs 54.5%, p<0.001)
  – Only single center studies available looking at endovascular intervention specifically in young adults
Considerations in Acute Treatment

- Young patients with large strokes (especially MCA) should be considered for early decompression
  - Improves mortality and may improve functional outcomes

Secondary Prevention

• Little data specific to Young Adults
  – Under-represented in large trials
• Treat known modifiable risk factors!
  – Hypertension
  – Hyperlipidemia
  – Diabetes
  – Tobacco use
• Antiplatelet medication – accepted as standard of care
Use of Statins

• Clear data in overall adult stroke that high dose statin treatment lowers risk of recurrent stroke, cardiovascular events or vascular death
• Nonrandomized study evaluated young adults with stroke of undetermined etiology
• Best use of statins in young adult stroke remains unclear

Risk for composite vascular endpoint of any stroke, myocardial infarction, revascularization, other arterial event, or vascular death according to group of statin use.

Putaala J et al. Neurology 2011;77:426-430
Young Adult Stroke - Outcomes

- 7-fold higher mortality over 10 years
- Annual risk of recurrent stroke = 1-3%
- Cumulative risk of recurrence over life = 20%
- Functional Outcomes (based on case series):
  - “Independence” (mRS≤2) in 78-94%
  - Ability to return to work in ~50%
  - Depression/fatigue in 30-50%
  - Hard to quantify all of the impacts on functional outcomes of families

Rutten-Jacobs et al; Ann Neurol 2013
Aarnio K et al, Stroke 2014
J Neurol 2004; 251: 1507-1514
Outcomes in Young Adult Stroke

• Prospective cohort study (FUTURE) – Ages 18-50 with first-ever stroke
  – 5.8% 5-year mortality
  – 12.4% 10-year mortality
  – 26.8% 20-year mortality

• Causes of death:
  – 29% Cardiac
  – 15% Ischemic Stroke
  – Infections, malignancy
Action Needed!

• Important to recognize that young adults can have strokes
  – Poor education about risk and signs of stroke leads to delayed diagnosis and delayed treatment
  – Every 30 minutes treatment is delayed leads to a 10% decrease in functional outcome at 90 days

• Young people should be screened for stroke risk factors, such as high blood pressure, diabetes, high cholesterol

• Better support systems for young adults with stroke and their families
Research Needed

• Need a better understanding of the causes of stroke in young people
  – Atherosclerotic risk factors
  – Genetic or acquired abnormalities in blood vessels
  – Increased clotting factors

• Who is at high risk?
  – Can we screen high risk populations better

• How should treatment and prevention in young adults differ from in older adults?
Take Home Points

• Stroke can happen in young adults, and is becoming more common over time
• Causes of stroke in young adults overlaps with those in children and older adults
• Stroke in young adults has large impacts on individuals and families as well as on society
• More research and education are needed to improve our recognition, prevention and treatment of strokes in young adults
Thank You

University of Colorado | Anschutz Medical Campus
ASA/Bugher Foundation Stroke Collaborative Research Center

Richard Traystman
David Mirsky
Richard Boada
David Weitzenkamp
Andra Dingman
Paco Herson
Emily Maxwell
Sharon Poisson
Nick Stence
KC Clevenger
Amanda Kenny
Krista Rodgers
Zak Ritchey
Wendy Macklin
Jennifer Armstrong

Partners
Marilyn Manco-Johnson
Neil Goldenberg
Michael Rivkin
Michael Dowling
Warren Lo
Becky Ichord
Gabrielle deVeber
Mona Jacobson
Adam Kirton
Neil Friedman

Pediatric Acute Stroke Team

Sharon Poisson
Brad Miller
Jennifer Simpson
William Jones
Kelly Knupp