Arterial Ischemic Stroke in Children

C.H. Topel
Vascular Neurology Fellow
Department of Neurology
Disclosures

- Trained in Austin?

I WENT TO SXSW ONCE

I HATED IT
Objectives

- Discuss Epidemiology and demographics of pediatric ischemic stroke
- Identify common presentations
- Identify common causes and risk factors
- Establish junior neuroradiologist status!
- Discuss available treatments
Ischemic Stroke Epidemiology

- Overall....
- 795,000 strokes in the USA.
- 5th leading cause of death
- Leading cause of morbidity
- Increasing age leading risk factor (sorry!)
  - ¾ of all strokes occur age > 65
Pediatric Epidemiology

- Kids have stroke?!?
- 1.2 to 8 cases in 100,000 per year
  - Annual incidence (1 to 18 years): ~ 3/100,000 per year
  - Likely underestimated
  - Estimations are quite variable depending on the specific community studied

- Unfortunately, rate continues to increase
  - Awareness! (thanks for attending!)
  - Advances in neuro-imaging
  - Survival of children with previously considered “lethal” congenital heart conditions and leukemia
IS and HS occur at approximately the same rate

Boys are at a higher risk (60%)

Pediatric registry with 1187 arterial ischemic and CVT

Black children are at a higher risk

Not fully explained by the prevalence of SCD in this population
EPIDEMIOLOGY

10 Leading Causes of Death by Age Group, United States – 2008

<table>
<thead>
<tr>
<th>Rank</th>
<th>&lt;1</th>
<th>1-4</th>
<th>5-9</th>
<th>10-14</th>
<th>15-24</th>
<th>25-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Congenital Anomalies</td>
<td>5,638</td>
<td>Unintentional Injury</td>
<td>1,469</td>
<td>Unintentional Injury</td>
<td>925</td>
<td>Unintentional Injury</td>
<td>1,624</td>
<td>Unintentional Injury</td>
<td>14,039</td>
<td>Unintentional Injury</td>
</tr>
<tr>
<td>2</td>
<td>Short Gestation</td>
<td>2,754</td>
<td>Congenital Anomalies</td>
<td>521</td>
<td>Malignant Neoplasms</td>
<td>457</td>
<td>Malignant Neoplasms</td>
<td>433</td>
<td>Homicide</td>
<td>5,275</td>
<td>Suicide</td>
</tr>
<tr>
<td>3</td>
<td>SIDS</td>
<td>2,353</td>
<td>Homicide</td>
<td>421</td>
<td>Congenital Anomalies</td>
<td>170</td>
<td>Suicide</td>
<td>215</td>
<td>Suicide</td>
<td>4,260</td>
<td>Heart Disease</td>
</tr>
<tr>
<td>4</td>
<td>Maternal Pregnancy Comp.</td>
<td>1,760</td>
<td>Malignant Neoplasms</td>
<td>394</td>
<td>Homicide</td>
<td>113</td>
<td>Homicide</td>
<td>207</td>
<td>Malignant Neoplasms</td>
<td>1,683</td>
<td>Malignant Neoplasms</td>
</tr>
<tr>
<td>5</td>
<td>Unintentional Injury</td>
<td>1,315</td>
<td>Heart Disease</td>
<td>186</td>
<td>Heart Disease</td>
<td>97</td>
<td>Congenital Anomalies</td>
<td>161</td>
<td>Heart Disease</td>
<td>163</td>
<td>Heart Disease</td>
</tr>
<tr>
<td>6</td>
<td>Placenta Cord Membranes</td>
<td>1,080</td>
<td>Influenza &amp; Pneumonia</td>
<td>142</td>
<td>Benign Neoplasms</td>
<td>59</td>
<td>Heart Disease</td>
<td>132</td>
<td>Congenital Anomalies</td>
<td>467</td>
<td>Alzheimer’s Disease</td>
</tr>
<tr>
<td>7</td>
<td>Bacterial Sepsis</td>
<td>700</td>
<td>Septicemia</td>
<td>93</td>
<td>Chronic Low Respiratory Disease</td>
<td>55</td>
<td>Chronic Low Respiratory Disease</td>
<td>64</td>
<td>Influenza &amp; Pneumonia</td>
<td>206</td>
<td>Chronic Lower Respiratory Disease</td>
</tr>
<tr>
<td>8</td>
<td>Respiratory Distress</td>
<td>630</td>
<td>Cerebrovascular</td>
<td>63</td>
<td>Cerebrovascular</td>
<td>41</td>
<td>Cerebrovascular</td>
<td>56</td>
<td>Diabetes Mellitus</td>
<td>204</td>
<td>Congenital Anomalies</td>
</tr>
<tr>
<td>9</td>
<td>Circulatory System Disease</td>
<td>594</td>
<td>Chronic Low Respiratory Disease</td>
<td>54</td>
<td>Influenza &amp; Pneumonia</td>
<td>40</td>
<td>Influenza &amp; Pneumonia</td>
<td>49</td>
<td>Cerebrovascular</td>
<td>189</td>
<td>Cerebrovascular</td>
</tr>
</tbody>
</table>


Ranked Number 8 Among the top 10 causes of death in children
Clinical presentation?
Arterial Ischemic Stroke Risk Factors: The International Pediatric Stroke Study

Mark T. Mackay, MBBS,1 Max Wiznitzer, MD,2 Susan L. Benedict, MD,3
Katherine J. Lee, MSc, PhD,4 Gabrielle A. deVeber, MSc, MD,5
and Vijaya Ganesan, MD,6 on behalf of the International Pediatric Stroke Study Group

Objective: To describe presumptive risk factors (RFs) for childhood arterial ischemic stroke (AIS) and explore their relationship with presentation, age, geography, and infarct characteristics.

Methods: Children (29 days–18 years) were prospectively enrolled in the International Pediatric Stroke Study. Risk factors, defined conditions thought to be associated with childhood AIS, were divided into 10 categories. Chi-square tests were used to compare RFs prevalence across regions and age; logistic regression was used to determine whether RFs were associated with particular features at presentation or infarct characteristics.

Results: A total of 676 children were included. No identifiable RFs was present in 54 (9%). RFs in others included

2011
676 children prospectively enrolled
Arterial ischemic stroke
age 29 days-18 years
Clinical presentation?
So what does a strokes look like in a child?

- **Presenting Symptoms**
  - 82% focal neurological signs
    - More common in older children
    - Of those, 86% had hemiparesis
    - 45% had speech disturbance
    - 13% visual disturbance
  - 64% had diffuse signs
    - More common in neonate/younger
    - Most common was a reduced level of consciousness,
    - Second is headache
  - 31% had seizures at presentation.
Where do they have strokes?

Lesion distribution, $n=660^b$

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>445</td>
<td>67%</td>
</tr>
<tr>
<td>Posterior</td>
<td>143</td>
<td>22%</td>
</tr>
<tr>
<td>Both</td>
<td>72</td>
<td>11%</td>
</tr>
</tbody>
</table>

Number of infarcts, $n=618^b$

<table>
<thead>
<tr>
<th>Infarct Type</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>356</td>
<td>58%</td>
</tr>
<tr>
<td>Multiple</td>
<td>262</td>
<td>42%</td>
</tr>
</tbody>
</table>

Laterality, $n=641^b$

<table>
<thead>
<tr>
<th>Laterality</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral</td>
<td>477</td>
<td>74%</td>
</tr>
<tr>
<td>Bilateral</td>
<td>164</td>
<td>26%</td>
</tr>
</tbody>
</table>
What do they look like on CT?
What do they look like on MRI?
Which children get stroke?

- **Common risk factors / etiologies**
  - Cerebral arteriopathy (53%)
  - Congenital Heart disease (31%)
  - Chronic systemic conditions (19%)
  - SCD #1
  - Prothrombotic states (13%)
- And the not so common….metabolic causes
ETIOLOGY & RISK FACTORS

TABLE 1: Prevalence of Risk Factors and Details of Condition
ANN NEUROL 2011;69:130-140

<table>
<thead>
<tr>
<th>Risk Factor Category</th>
<th>Diagnoses Included</th>
<th>Frequency, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac disorders</td>
<td>Total</td>
<td>204/667 (31%)</td>
</tr>
<tr>
<td></td>
<td>Congenital heart disease</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>Acquired heart disease</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Isolated PFO</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>&lt;72 hours after cardiac surgery</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Previous cardiac surgery</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Cardiac catheterization</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>ECMO</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Left ventricular assist device</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Arrhythmia</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Other cardiac</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Factor Category</th>
<th>Diagnoses Included</th>
<th>Frequency, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arteriopathy</td>
<td>Total</td>
<td>277/525 (53%)</td>
</tr>
<tr>
<td></td>
<td>Focal cerebral arteriopathy</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Moyamoya</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Arterial dissection</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Vasculitis</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Sickle cell arteriopathy</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Post varicella arteriopathy</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Unspecified arteriopathy</td>
<td>9</td>
</tr>
</tbody>
</table>
**ETIOLOGY & RISK FACTORS**

**TABLE 1: Prevalence of Risk Factors and Details of Condition**

*ANN NEUROL 2011;69:130-140*

<table>
<thead>
<tr>
<th>Risk Factor Category*</th>
<th>Diagnoses Included</th>
<th>Frequency, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic systemic conditions</td>
<td>Total</td>
<td>126/674 (19%)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Sickle cell disease</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Indwelling catheter</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Trisomy 21</td>
<td>17</td>
</tr>
<tr>
<td>Other genetic disorders</td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>Hematological malignancy</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Iron deficiency</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Oral contraceptive pill</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Connective tissue disease</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Solid extracranial tumors</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>L-asparaginase</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Factor Category*</th>
<th>Diagnoses Included</th>
<th>Frequency, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prothrombotic states</td>
<td>Total</td>
<td>87/674 (13%)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Multiple</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>MTHFR</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Elevated Lp (a)</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Acquired thrombophilia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FVL</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Other genetic thrombophilia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Protein S deficiency</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>PT20210A</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Protein C deficiency</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Antithrombin III deficiency</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Hyperhomocysteinemia</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Not specified</td>
<td>4</td>
</tr>
</tbody>
</table>
Arteriopathy

- Arteriopathy 53%
  - Focal Cerebral Arteriopathy
  - Moyamoya
  - Dissection
  - Vasculitis
Focal Cerebral Arteriopathy

What is it?

- Focal stenosis of distal carotids or proximal Circle of Willis.
Focal Cerebral Arteriopathy

- Associated with recent Upper respiratory tract Infx
- Etiology not well understood
  - Multifactorial?
    - Inflammation (Secondary Vasculitis)?
    - Spasm?
    - Thromboembolic?
Arteriopathy

- **Moyamoya**
  - Hyperplasia (slow process, non-inflammatory) of intracerebral vessels causes narrowing.
  - 0.35 per 100,000
  - Collateralization
    - Sx appear when stenosis progresses and inadequate collateral supply
Arteriopathy

• Moyamoya
  o Differences in race and age
    ▪ Japanese
      o Bimodal distribution
      o First decade of life (AIS)
      o 30 – 40 years (ICH)
    ▪ North American
      o More common 3rd or 4th decade
      o TIA/ischemic
Arteriopathy

- Moyamoya
  - Puff of smoke
Arteriopathy

1 internal carotid artery – cervical segment
2 internal carotid artery – vertical petrous segment
3 internal carotid artery – horizontal petrous segment
4 presellar (Fischer C5) segment internal carotid artery
5 horizontal (Fischer C4) intracavernous internal carotid artery
6 ophthalmic artery
7 & 11 proximal and distal supraclinoid segment internal carotid artery
8 posterior communicating artery
9 anterior choroidal arteries
10 internal carotid artery bifurcation
11 A1 segment of anterior cerebral artery
12 recurrent artery of Heubner
13 proximal A2 segment anterior cerebral artery
14 callosomarginal branch of anterior cerebral artery
15 pericallosal branch of anterior cerebral artery
16 M1 segment of middle cerebral artery
17 lateral lenticulostriate arteries
18 bifurcation/trifurcation of middle cerebral artery
19 anterior temporal lobe branches of middle cerebral artery
20 orbitofrontal branch of middle cerebral artery
21 Sylvian point
22 opercular branches of middle cerebral artery
23 insular branches of middle cerebral artery
Arteriopathy

- Internal carotid artery – cervical segment
- Internal carotid artery – vertical petrous segment
- Internal carotid artery – horizontal petrous segment
- Basilar (Fischer C5) segment internal carotid artery
- Horizontal (Fischer C4) intracavernous internal carotid artery
- Ophthalmic artery
- 11 proximal and distal supraclinoid segment internal carotid artery
- Posterior communicating artery
- Anterior choroidal arteries
- Internal carotid artery bifurcation
- Segment of anterior cerebral artery
- Pericallosal artery of Heubner
- Proximal A2 segment anterior cerebral artery
- Allosumarginal branch of anterior cerebral artery
- Pericallosal branch of anterior cerebral artery
- Segment of middle cerebral artery
- Lenticulostriate arteries
- Trifurcation of middle cerebral artery
- Anterior temporal lobe branches of middle cerebral artery
- Orbital branch of middle cerebral artery
- Sylvian point
- Perforating branches of middle cerebral artery
- Sylvian (insular) branches of middle cerebral artery
Arteriopathy

- **Moyamoya**
  - Non-invasive imaging
Arteriopathy

- **Moyamoya**
  - Genetic
    - RNF213 gene 17q25.
    - ACTA2 gene 10q23.3
    - GUCY1A3 gene 4q32.
    - Down Syndrome
    - NF1
Moyamoya

8 year-old boy with Neurofibromatosis Type I

*Lancet Neurol* 2011; 10: 264–74
Myomoya

RICA of a 2.5 year old child with left hemiparesis and an R179H mutation in ACTA2(A)

*Lancet Neurol* 2011; 10: 264–74
Arteriopathy

- Dissection
  - Extracranial/traumatic
  - Intracranial/spontaneous
    - Ehlers Danlos, Marfan’s
Remember the importance to confirm history, trauma, or pre-existing connective tissue disorder.

Vertebral dissection with underlying connective tissue disorder.

Six-year-old boy presenting with headaches and vertigo with repeated episodes of vertigo 1 month later
Arteriopathy

- Vasculitis (primary vs. secondary)
  - Inflammation of the cerebral vessels
    - Primary
      - Takayasu arteritis
        - Inflammatory phase, systemic illness, malaise, fever, fatigue
        - Typically female
        - Unknown cause
        - Often anemia and elevated labs ESR, CRP
      - Kawasaki Disease
        - Age < 5
        - High fever x 5 days
        - Erythema of the lips or oral cavity
        - Rash on the trunk
        - Swelling or erythema of the hands or feet
        - Swollen lymph node in the neck of at least 15 mm
        - In adults, Polyarteritis nodosa, Wegener’s granulomatosis
Arteriopathy

- **Vasculitis**
  - Secondary
    - Collagen vascular disorders leading to immune complex deposition
      - SLE
    - Infectious
      - Bacterial meningitis, CNS TB
      - HIV
  - Post Varicella
    - characteristic findings include basal ganglia infarction
    - Transient cerebral angiopathy: unilateral focal or segmental stenosis
    - Average age of onset is 5 years
    - 3 – 4 months after chicken pox
HIV angiopathy

16-old boy with HIV presenting with sudden onset right-sided hemiplegia
Varicella angiopathy

MCA most commonly affected

Prognosis good

7 year-old girl, 3 months post varicella infection presenting with left hemiparesis.

Cardiac Disorders

- **Cardiac disorders 31%**
  - Occurs in *uncorrected* congenital heart disease
- **Complex right-to-left shunting**
- **Systolic ejection murmur**
  - ASD, VSD
  - Patent foramen ovale (up to 35% between ages 1 to 29)
  - Transposition of great vessels
  - Neonates with hypoxia
  - 20 : 100,000
  - Needs an ASD!
  - Blue Crying
  - Egg on a string

Transposition of great vessels
EGG ON STRING SIGN
Cardiac Disorders

Cardiomyopathy with reduced LVEF
Muscular dystrophy

- Duchenne’s, X-linked, 1 : 3,600 boys
- Cardiomyopathy common
  - 328 pts 1976 – 1987
  - Pre-clinical cardiac involvement 25% of patients under 6 years old
  - 59% between the ages of 6 and 10 years
  - Clinically evident after 10 years of age
Risk Factors

Cardiomyopathy with reduced LVEF
Friedreich’s ataxia
- reduced mito expression frataxin
- neurodegeneration in spinal cord,
- 1:50,000
- staggering, stumbling
- also at risk for afib
- Chagas’ disease (Southwestern US!)
Risk Factors

- These conditions are difficult to dx in an emergent setting.
- Remember, asking family/caretakers of past medical history is crucial!
Hematologic

- Blood disorders
  - Sickle Cell
  - Prothrombotic disorders
    - Hypercoagulable disorders to OCP use
Hematologic

- Sickle Cell Disease
  - Ischemic (54%) and hemorrhagic strokes
    - Age 2-9
  - Incidence of stroke without intervention 11% by age 20,
  - Increased with dehydration, high velocities on TCD, low Hb
  - 10% will have stroke
  - 20% silent strokes
  - Steno-occlusive arteriopathy
    - Intimal progressive stenosis
    - Abnormal interactions between WBC’s, RBC’s, platelets, and vascular endothelium
Hematologic

**Sickle Cell Disease**
- TCD screening test for stroke risk in children with SCD

<table>
<thead>
<tr>
<th>Result of TCD</th>
<th>CBFV (cm/sec)</th>
<th>Frequency of Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt; 170</td>
<td>Repeat Annually</td>
</tr>
<tr>
<td>Low Conditional</td>
<td>170 - 184</td>
<td>Repeat q 3 months</td>
</tr>
<tr>
<td>High Conditional</td>
<td>185 – 199</td>
<td>Repeat q 1 month</td>
</tr>
<tr>
<td>Abnormal</td>
<td>&gt; 200</td>
<td>Repeat q month</td>
</tr>
</tbody>
</table>

![Diagram of blood flow and sickle cells]
Sickle Cell Disease

- Stroke prevention in Sickle Cell Anemia (STOP) trials
  - Ages 2-16
  - Exchange transfusion: Keep HbS < 30% reduced stroke 90%
  - Termination of transfusion in high-risk patients is associated with return of high velocity parameters and stroke risk (STOP II Trial)
Risk Factors

- Prothrombotic states
  - Meta analysis 22 observational studies
  - Ischemic stroke associated with:
    - Protein C deficiency
    - APS
    - Factor V Leiden
    - Elevated homocysteine with MTHFR mutation
    - Oral Contraceptive with high estrogen content
Risk Factors

- **Metabolic causes**
  - MELAS
    - Mitochondrial encephalomyopathy with lactic acidosis and stroke-like episodes
    - Mutations in mitochondrial DNA
    - RECURRENT metabolic failure stroke, not arterial ischemic
    - Sx appear in childhood (age 2-15)
      - Myalgias, fatigue, seizures
      - Vision loss, hemiparesis, hemisensory loss
      - Progressive, sx additive, cognitive decline
Risk Factors

- **Metabolic causes**
  - Fabry’s Disease
    - Very rare cause of stroke in children
    - X-Linked
    - Deficiency of alpha-galactosidase A cause glycolipid accumulation within blood vessels
    - Ischemic strokes mainly in the posterior circulation
      - Pulvinar sign (also seen in CJD)
Specific Treatment therapies

- **Sickle Cell**
  - optimal hydration, correction of hypoxemia, and correction of systemic hypotension
  - Periodic transfusions to reduce the percentage of sickle hemoglobin in children 2 to 16 years of age with an abnormal TCD.

- **Moyamoya with progressive ischemic sx**
  - revascularization
  - Meta analysis 1156 pediatric pts treated direct/indirect, 86% had symptomatic benefit
Revascularization

- EDAS

A small oval craniotomy is performed underneath the course of the artery.
Specific therapies

- **Cardiac Disorders**
  - Correction of congenital anomaly
  - PFO closure may be more beneficial in children with stroke than adults
  - Children with cardiomyopathy and decreased LVEF may benefit from long term anticoagulation

- **Dissection**
  - 2008 pediatric guidelines rec 3-6 months anticoagulation

- **Primary CNS vasculitis**
  - IV Methyl-prednisone 1g daily for 3 days followed by oral prednisolone 60 mg/day, decreasing by 10 mg at weekly intervals to 10 mg/day if possible.

- **Fabry’s**
  - Alpha galactocidase replacement

- **Hypercoagulable states**
  - Check homocysteine levels
    - If high, give Folic Acid, Pyridoxine, Vitamin B12
  - Anticoagulation
So, what can we do?

- Prompt recognition and diagnosis are essential
  - ABC’s
  - PMHx history/risk factors
    - PLEASE get contact info from family members/caretakers
    - Trauma?
      - Intracranial hemorrhage or ischemia from dissection?
      - Seizure?
        - Todd’s paralysis?
    - Congenital risk factors?
  - Vital signs, EKG, identify obvious other causes for neuro changes
    - O2 sats (hypoxia, shunt, transposition)
So, what can we do?

- **Imaging**
  - MRI w/o with DWI preferred
    - Differential is often large, helps identify stroke and mimics
  - CT head to evaluate for hemorrhage if STAT MRI unavailable
  - CTA/MRA head and neck is helpful to evaluate for dissection, embolism, or arteriopathy (moyamoya)
    - Gad+? TOF?
    - Focal occlusion 2/2 embolism from vert dissection vs gradual stenosis from moyamoya.
  - CXR can help look for cardiomyopathy
So, what can we do?

- **Labs**
  - Glucose!
  - CBC, CMP
  - aPTT, PT, INR
  - Toxicology
  - Blood EtOH level

- **If suspicious for vasculitis:**
  - Conventional Angio
  - ESR, CRP, ANA, Varicella titres, HIV
So, what can we do?

- **Supportive measures**
  - HOB flat
  - Normoglycemia and normothermia
  - IV NS at maintenance rate
  - Permissive modest HTN
  - Supplemental O2 goal sats > 95%
  - Continuous cardiac monitoring
Can we use tPA?

- Not FDA approved <18.
- No prospective data available
  - TIPS closed to slow enrollment
- Very few observational reports
Use of alteplase in childhood arterial ischaemic stroke: a multicentre, observational, cohort study

*The International Pediatric Stroke Study*
*Lancet Neurol 2009; 8: 530–36*

687 children from around the world
Only 15 (2%) receive rt-PA: 9 IV and 6 IA
The median time to treatment 3.3 h (range 2.0–52.0 h) IV rt-PA
4.5 h (3.8–24.0 h) for IA rt-PA

The 9 patients in the IPSS cohort who received IV rt-PA were mostly younger, waited longer for treatment, and had worse outcomes.
Between 2000 and 2003, 1.6 percent of children presenting with AIS received thrombolytic therapy *(Janujua et al, 2007)*

A significant pre-hospital and in-hospital delay exists in diagnosis of AIS in children, sometimes up to 12 hours *(Leaker et al, 1996)*

Uncertainty in diagnosis: "stroke mimicker," such as (among others) Todd's paralysis or acute demyelinating encephalomyelitis (ADEM) are more common in children.

Presentation of stroke is different in children than adults.

Children seek attention much later than adults.
ACUTE REPERFUSION THERAPY

IV rt-PA – Why it doesn’t work as well?

Arterial AIS is much less common in children than in adults.

Etiologies and patho-physiological mechanisms of AIS in children are quite diverse and do not necessarily parallel those of adults.

(HTN, DM, tobacco, afib, carotid stenosis)

If the decision to administer IV rt-PA in a child with AIS is finalized, there exists no standard protocol for an appropriate dose or duration of infusion.
Fourteen-year-old girl with sudden onset of right hemiplegia and aphasia.
OUTCOMES

Mortality
3-11%

Persistent neurological deficit
Up to 66%

Recurrent event (long term)
10-20%
60% in SCD
Summary

- Childhood AIS is under-recognized.
- Risk factors are etiologies are different than those of adults.
- Mimics are common (21%)
  Seizure, headache, PRES, infection, metabolic
- Remember to get contact info for family member.
- Workup for acute intervention requires multiple imaging modalities.
- Treatments are more geared toward individual risk factors.
- Prospective trials?
- Guideline update?
"No one is useless in this world who lightens the burdens of another."

*Charles Dickens*
References

Thank you!