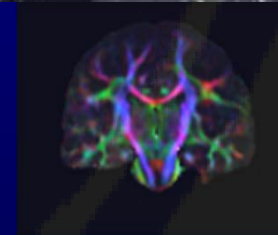
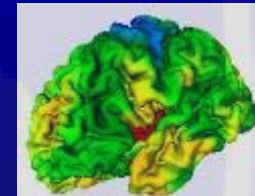


Arterial Ischemic Stroke in Children

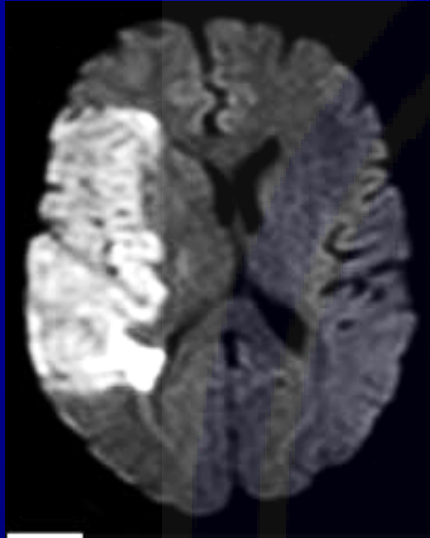
Michael J. Rivkin, M.D.
Stroke and Cerebrovascular Center
Department of Neurology
Boston Children's Hospital
Boston, Massachusetts



Disclosures

- Nothing to disclose

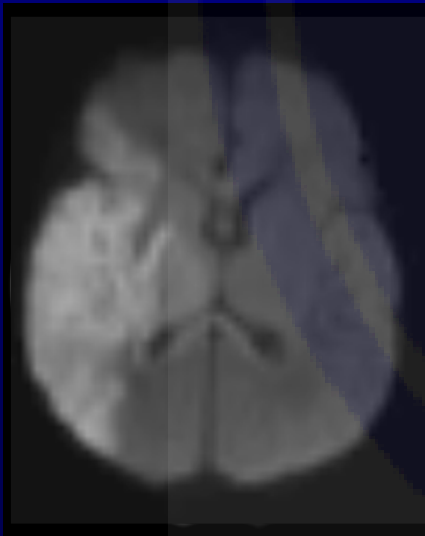




sudden onset; left
hemiparesis; lethargic

→ Male, 62 years old;
Smoker; high cholesterol

Diffusion Weighted Image (DWI)



focal left sided seizures
repeatedly, he was lethargic
and seizures were difficult to
stop, left hemiparesis present

→ Male, 1 day old,
full term

Diffusion Weighted Image (DWI)



Arterial Ischemic Stroke

Etiology in Adults

- Cardioembolism
 - Atrial fibrillation
 - Venous thrombosis
- Atherosclerotic disease
 - Intravascular thrombosis
 - Venous thromboembolus
- Small vessel disease
 - Hypertension
 - Diabetes



Arterial Ischemic Stroke in Children

Goals for today's talk:

1. Present the characteristics of arterial ischemic stroke (AIS) in children, both neonates and older children
2. Consider the etiologies of AIS in these children
3. Present some of the clinical features found in children with AIS
4. Medical treatment of stroke in children



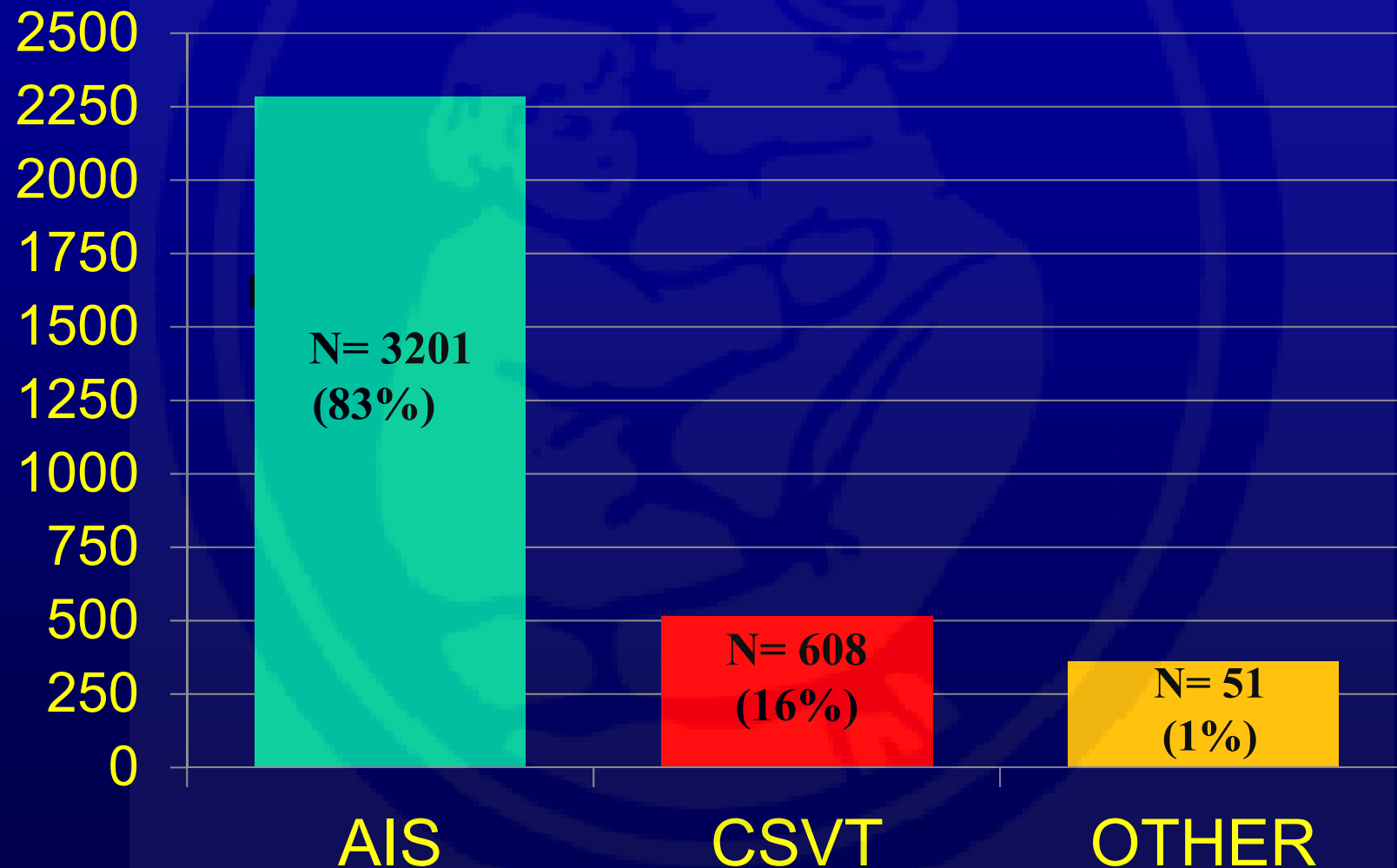
Mechanisms of Arterial Ischemic Stroke

A. Embolic

B. Thrombotic

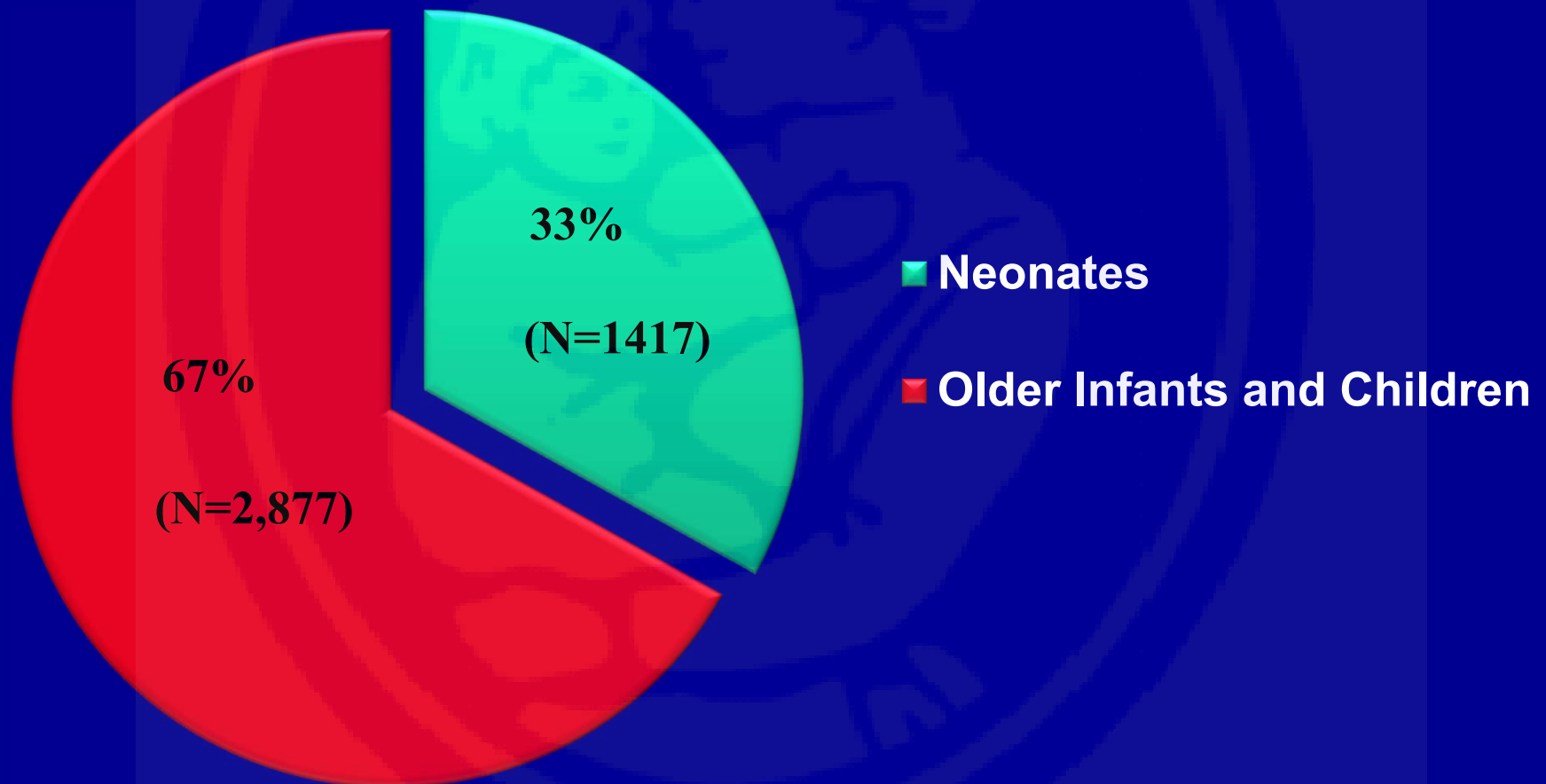
C. Hemorrhagic (but not traumatic)

IPSS Patients – Ischemic Stroke Subtype (N=4294 , IPSS Database lock #2, 2014)



IPSS Patients – Age at Stroke

(N=4294, IPSS Database lock #2, 2014)



Stroke: What is the scope of the problem?

Stroke in Children: Comparative Frequency

- Acute Disseminated Encephalomyelitis:
~0.4/100,000
- Inflammatory Bowel Disease in children:
~2/100,000
- Brain tumor in children: ~3/100,000
- *Arterial Ischemic Stroke: 13/100,000*



Cerebrovascular Disorders Rank Among the 10 Most Common Causes of Death in Children

**10 Leading Causes of Death, United States
1999 - 2018, All Races, Both Sexes**

Rank	Age Groups											All Ages
	<1	1-4	5-9	10-14	15-19	20-24	25-34	35-44	45-54	55-64	65+	
1	Congenital Anomalies 104,965	Unintentional Injury 29,879	Unintentional Injury 18,952	Unintentional Injury 22,356	Unintentional Injury 106,695	Unintentional Injury 167,933	Unintentional Injury 319,766	Unintentional Injury 339,816	Malignant Neoplasms 944,269	Malignant Neoplasms 2,094,171	Heart Disease 10,437,108	Heart Disease 12,878,021
2	Short Gestation 87,301	Congenital Anomalies 9,861	Malignant Neoplasms 9,328	Malignant Neoplasms 9,403	Homicide 37,205	Homicide 62,335	Suicide 117,280	Malignant Neoplasms 263,958	Heart Disease 719,387	Heart Disease 1,385,857	Malignant Neoplasms 8,006,823	Malignant Neoplasms 11,442,918
3	SIDS 40,218	Homicide 7,460	Congenital Anomalies 3,766	Suicide 6,365	Suicide 35,370	Suicide 57,959	Homicide 92,321	Heart Disease 233,827	Unintentional Injury 377,525	Chronic Low Respiratory Disease 284,084	Cerebrovascular 2,479,726	Cerebrovascular 2,874,333
4	Maternal Pregnancy Comp. 31,578	Malignant Neoplasms 7,435	Homicide 2,662	Homicide 3,794	Malignant Neoplasms 13,241	Malignant Neoplasms 18,802	Malignant Neoplasms 73,945	Suicide 135,013	Liver Disease 160,008	Unintentional Injury 278,344	Chronic Low Respiratory Disease 2,360,151	Chronic Low Respiratory Disease 2,754,413
5	Unintentional Injury 22,409	Heart Disease 3,255	Heart Disease 1,773	Congenital Anomalies 3,547	Heart Disease 6,910	Heart Disease 13,401	Heart Disease 65,531	HIV 61,991	Suicide 153,243	Diabetes Mellitus 237,737	Alzheimer's Disease 1,599,601	Unintentional Injury 2,514,947
6	Placenta Cord Membranes 20,091	Influenza & Pneumonia 2,293	Chronic Low Respiratory Disease 1,142	Heart Disease 2,676	Congenital Anomalies 4,249	Congenital Anomalies 4,336	HIV 22,952	Homicide 60,668	Cerebrovascular 116,258	Cerebrovascular 217,035	Diabetes Mellitus 1,074,664	Alzheimer's Disease 1,616,835
7	Respiratory Distress 13,761	Septicemia 1,474	Influenza & Pneumonia 1,063	Chronic Low Respiratory Disease 1,457	Chronic Low Respiratory Disease 1,443	Diabetes Mellitus 2,638	Diabetes Mellitus 13,357	Liver Disease 56,068	Diabetes Mellitus 114,868	Liver Disease 187,176	Influenza & Pneumonia 994,661	Diabetes Mellitus 1,484,889
8	Bacterial Sepsis 13,466	Perinatal Period 1,141	Benign Neoplasms 853	Influenza & Pneumonia 1,141	Influenza & Pneumonia 1,410	Influenza & Pneumonia 2,565	Cerebrovascular 11,125	Cerebrovascular 41,413	Chronic Low Respiratory Disease 80,392	Suicide 112,293	Unintentional Injury 830,320	Influenza & Pneumonia 1,153,761
9	Circulatory System Disease 10,840	Chronic Low Respiratory Disease 1,036	Cerebrovascular 755	Cerebrovascular 943	Cerebrovascular 1,340	HIV 2,476	Liver Disease 10,828	Diabetes Mellitus 39,798	HIV 65,729	Nephritis 90,140	Nephritis 754,444	Nephritis 909,999
10	Neonatal Hemorrhage 9,877	Benign Neoplasms 1,018	Septicemia 705	Benign Neoplasms 753	Diabetes Mellitus 1,031	Complicated Pregnancy 2,395	Congenital Anomalies 8,629	Influenza & Pneumonia 18,384	Septicemia 45,766	Septicemia 89,937	Septicemia 547,233	Suicide 745,360

Produced By: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System



Stroke and Cerebrovascular Center, Department of Neurology, Boston Children's Hospital



Stroke in Children: Epidemiology

Children > 1 month old

frequency of occurrence greater than originally thought → 13/100,000

Males > Females

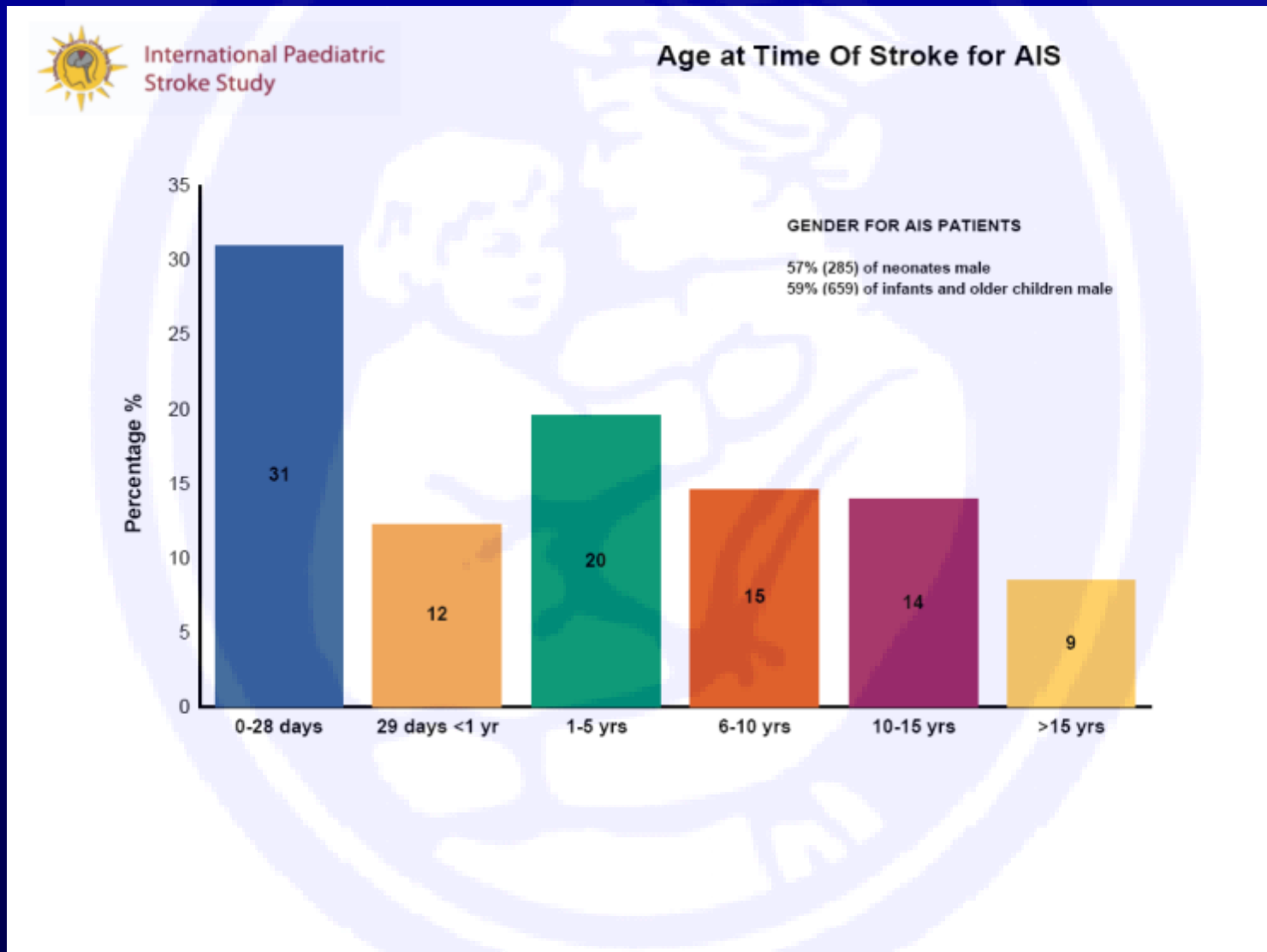
Blacks > Whites

83% as arterial ischemic stroke (AIS)

16% as cerebral sino-venous thrombosis (CSV) and hemorrhage



IPSS Database Demographics



Arterial Ischemic Stroke

Etiologies in Children

Idiopathic Stroke

Cardiac disease

- Congenital heart disease*
- Infectious endocarditis*
- Valvular disease*
- Cardiomyopathy*
- Arrhythmia*

Hematologic disorders

- Sickle cell disease*
- Inherited prothrombotic & lipid abns.*
- Antiphospholipid antibodies*
- Lymphoproliferative disorders*

Arteriopathy

- Moyamoya*
- Focal arteriopathy of childhood*
- Post-varicella arteriopathy*
- Fibromuscular Dysplasia*
- Takayasu arteritis*
- Vasculitis*

Trauma

- Blunt trauma to posterior pharynx*
- Cervical spine dislocation/rotation*
- Cervicocephalic artery dissection*

Infection

- Meningitis*
- Viral, bacterial, mycotic infections*

Drug/toxin exposure

- Cocaine*
- Sympathomimetics*
- Oral contraceptives*

Surgical interventions

- Cardiac catheterization*
- Catheter cerebral angiography*
- ECMO*

Metabolic disorders

- Hyperhomocysteinemia*
- Mitochondrial disorders*
- Congenital disorders of glycosylation*



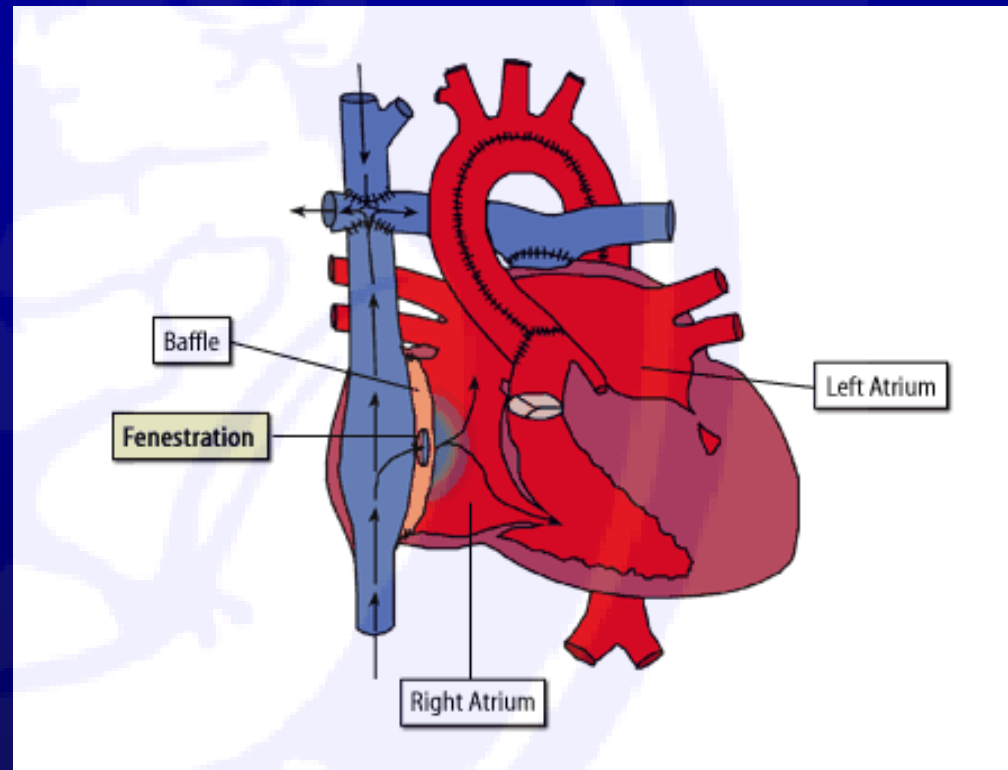
Arterial Ischemic Stroke

Congenital Heart Disease

Turbulent intracardiac flow
arrhythmia
cardiomyopathy

Nidus for embolus formation
prosthetic valves
synthetic materials

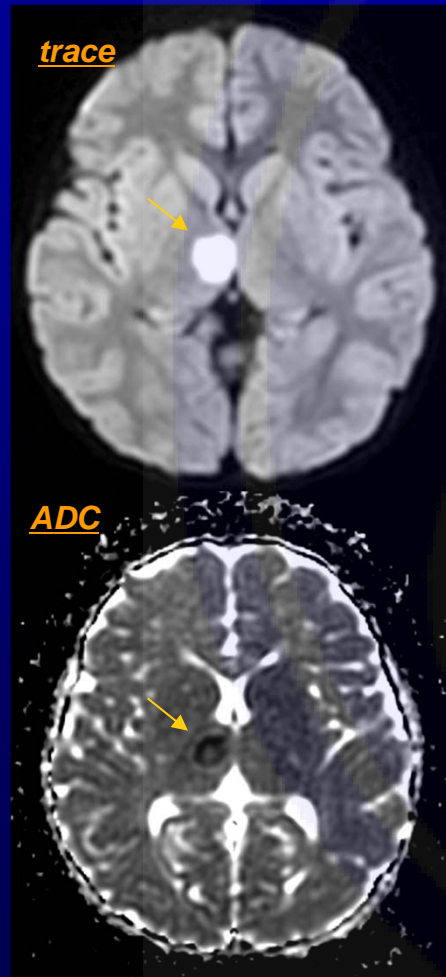
Right-to-left shunt
congenital lesions
congenital lesion repair



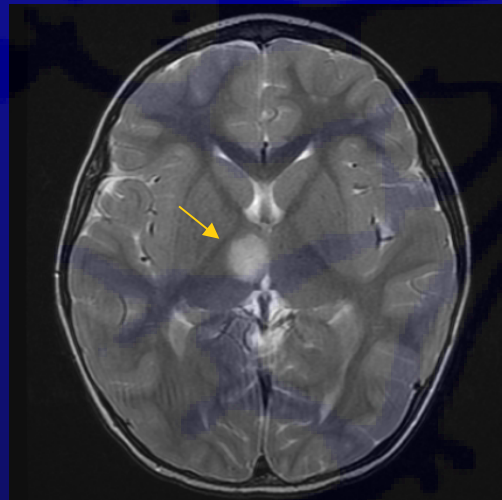
Rate of thromboembolic complication 3-19%



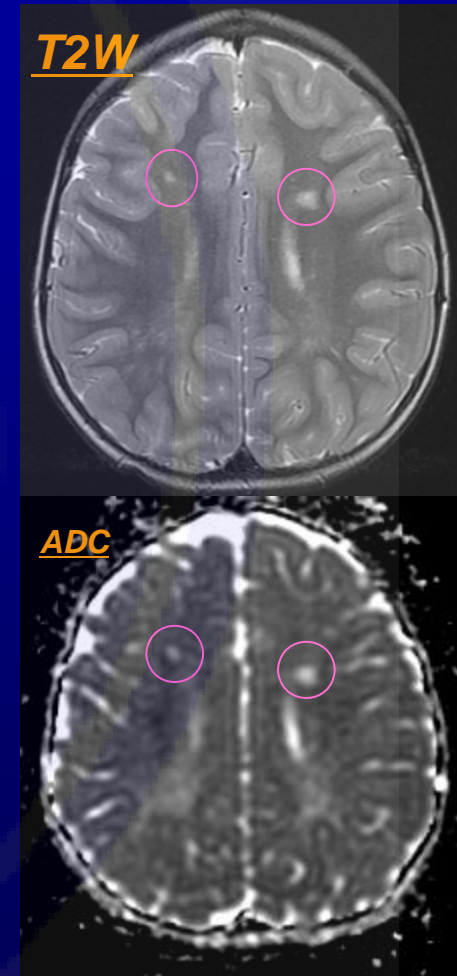
New Thalamic Infarct in a Patient with Fenestrated Fontan



DWI



T2W



Congenital Heart Disease and Stroke

- Cardiac catheterization
 - 0.38-0.5% rate of neurologic complication
 - » 57% hemorrhagic or ischemic stroke

Liu et al Pediatric Neurology 1991

- Extracorporeal Membrane Oxygenation (ECMO)
 - ≤ 14 days 13% Hemorrhagic or ischemic stroke
 - > 14 days 24-59% Hemorrhagic or ischemic stroke

Merrill et al, JTCVS 2013; Gupta et al, Ann Thor Surg, 2012

- Ventricular Assist Device (VAD)
 - 21% ischemic stroke
 - 2% hemorrhagic stroke

Almond et al, Circulation, 2013



Arterial Ischemic Stroke

Cerebral Arteriopathy

1. Cervicocephalic arterial dissection
2. Postvaricella arteriopathy
3. Focal cerebral arteriopathy of childhood
4. Moyamoya disease
5. Sickle cell arteriopathy
6. Primary or secondary arteritis of CNS



Arterial Ischemic Stroke

Cervicocephalic Arterial Dissection

- More common in males; mean age 10 yrs old
- Anterior circulation(60%)>posterior circulation(40%)
- ~35% spontaneous;20% assoc. w/ activity;
~45% assoc. with trauma
- Traumatic association:43% present within minutes-hrs;
57% present days-weeks
- Presenting signs:**hemiparesis** (97% AC; 57% PC)
headache (54% AC; 53% PC)
seizure (21% AC; 9% PC)
neck pain uncommon

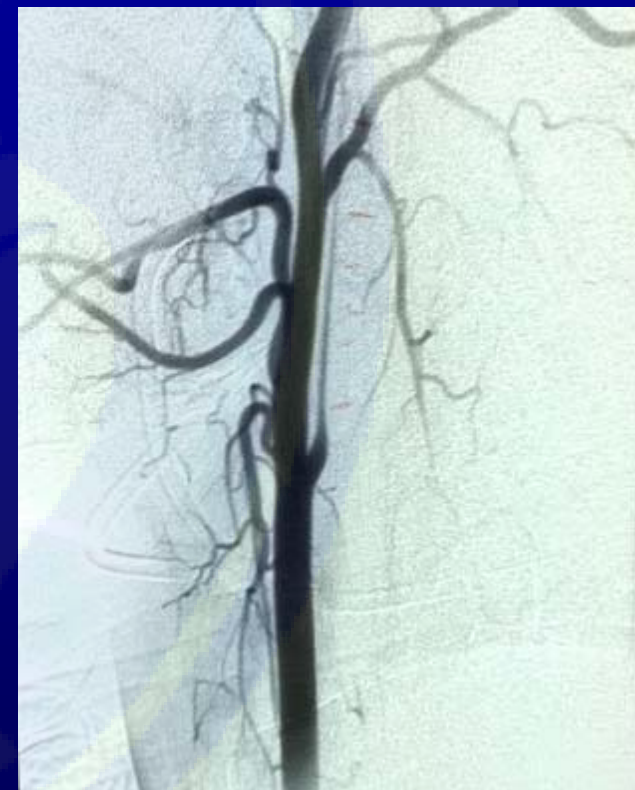


Cervicocephalic Artery Dissection

Characteristics of children with CCAD	N=46
Age at diagnosis (years)	9.7 (1.5 – 17.3)
Male gender, N (%)	27 (57)
Median time from presentation to diagnosis (days)	1.0 (0 – 374)

Vascular features of CCAD	Total N = 46	Traumatic N = 26(57%)	Spontaneous N = 18 (39%)	Activity related N=2 (4%)
Anterior circulation (ACAD)	23 (51%)	15	7	1
Posterior circulation (PCAD)	23 (49%)	11	11	1
Intracranial	18 (39%)	9	8	1
Extracranial	13 (28%)	6	7	0
Intra- and extracranial	15 (33%)	9	4	1
Pseudoaneurysm	13	5	8	0

Infarction with CCAD	N (%)
No infarct	15 (34)
Infarct present	29 (66)

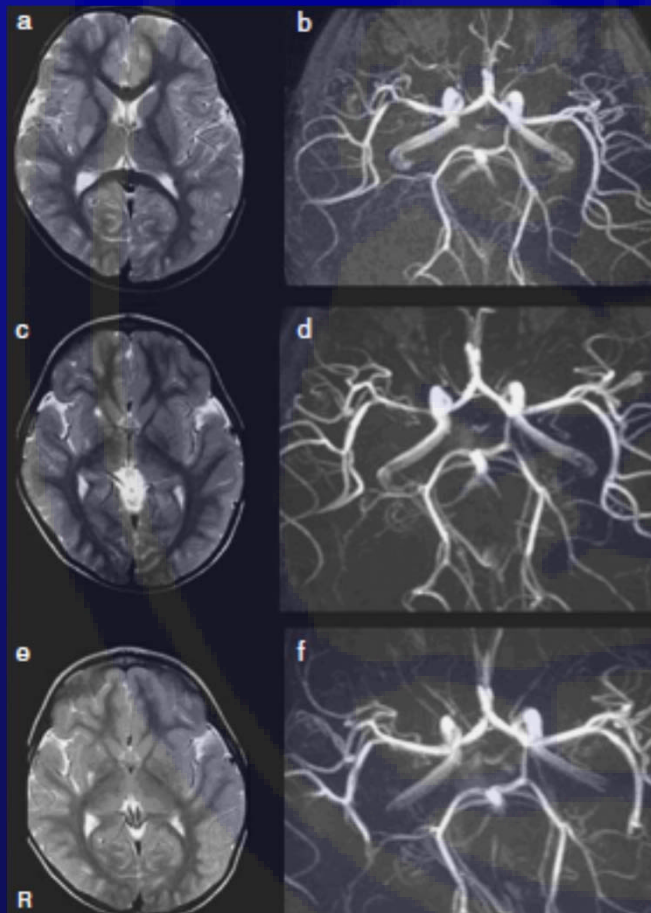


Ho, Ullrich, Danehy, Rivkin, Stroke, 2011

Treatment of children with CCAD	No Treatment	Treatment		
		Anticoagulation (LMWH or Warfarin)	Antiplatelet (Aspirin)	Both
Total	17	23	5	1
Dissection Location				
Intracranial	10	4	3	1
Extracranial	4	8	1	0
Intra and Extracranial	3	11	1	0
Presence/absence infarct				
No infarct	11	3	2	0
Infarct	6	19	3	1

Arterial Ischemic Stroke

Post-Varicella Arteriopathy



Features

- Occurs ≤ 12 months after a varicella infection
- Hemiparesis; stuttering course at onset
- Infarction commonly in basal ganglia
- Arteriopathy involves distal large or proximal portions of medium vessel, more often in the AC
- Arterial condition can worsen for up to 6 months after appearance and then stabilize or improve

Focal Cerebral Arteriopathy of Childhood (FCA)

- Stenosis evident on cerebrovascular imaging of large or medium sized vessels
- Vessels can be affected unilaterally or bilaterally
- Etiology is NOT moyamoya, sickle cell arteriopathy, post varicella arteriopathy, systemic vasculitis or post radiation arteriopathy
- Monophasic process
- Clinical picture is similar to that of post VZV arteriopathy but there is no history of varicella infection

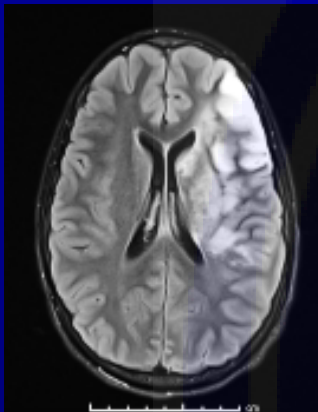
Arterial Ischemic Stroke

Cerebral Arteriopathy and Stroke

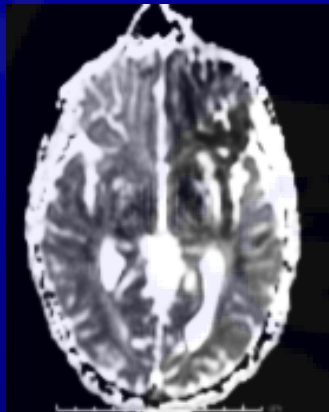
- As many as 64% of healthy children with first AIS have evidence of stenosing arteriopathy
- The presence of arteriopathy on vascular imaging of a previously healthy child found to have AIS imparts significant risk of AIS recurrence in the first 5 years following the event.
 - Among children with findings of arteriopathy who have had first time AIS and are otherwise healthy, 30 % had recurrence of AIS (Chabrier, J Child Neurol, 2000)
 - Arteriopathy in the first ischaemic stroke contributed significantly to the onset of a second stroke (OR 3.9(1.4-10.6); $p < 0.007$) (Strater, Lancet, 2002)
 - Previously healthy children with first time AIS and arteriopathy on neurovascular imaging->66% cumulative 5 yr recurrence rate (Fullerton, Pediatrics, 2007)
 - Herpes Family virus infection is particularly common in children with medium to large vessel vasculitis arteriopathy (Elkind et al, Circulation, 2016; Wintermark et al, AJNR, 2017)



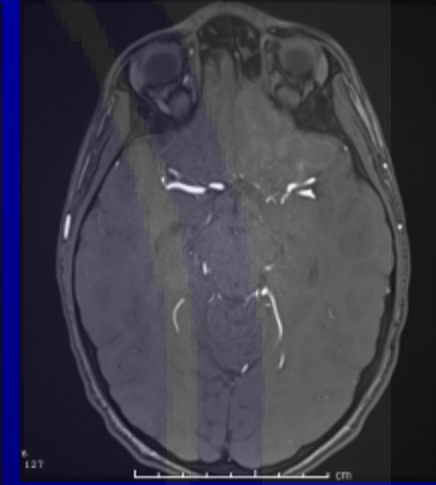
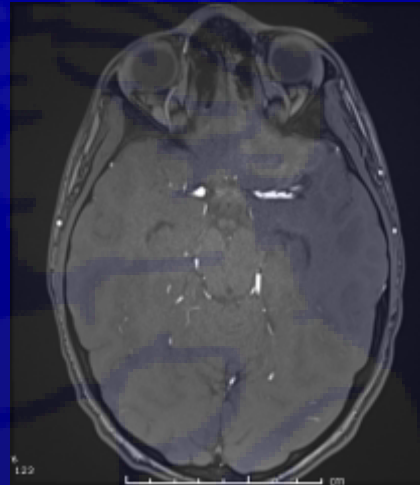
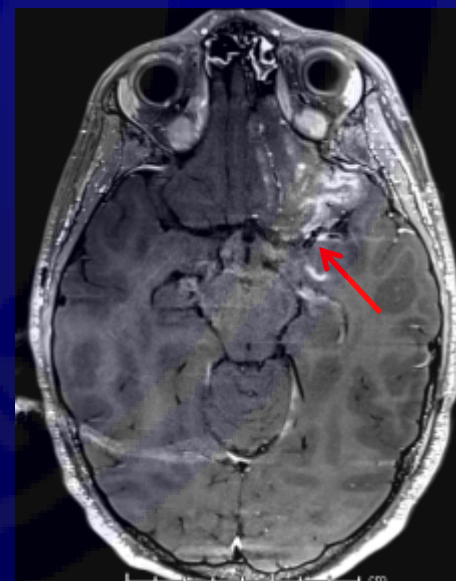
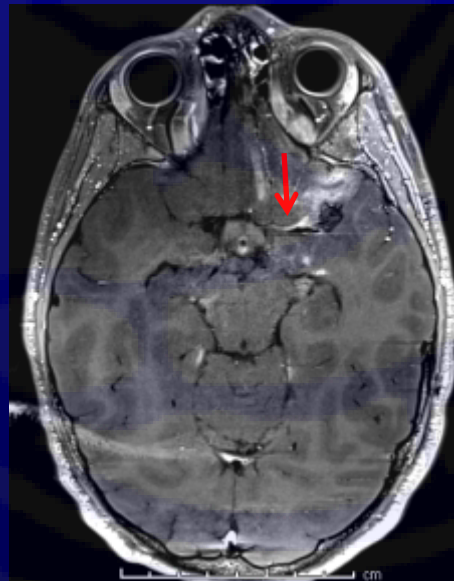
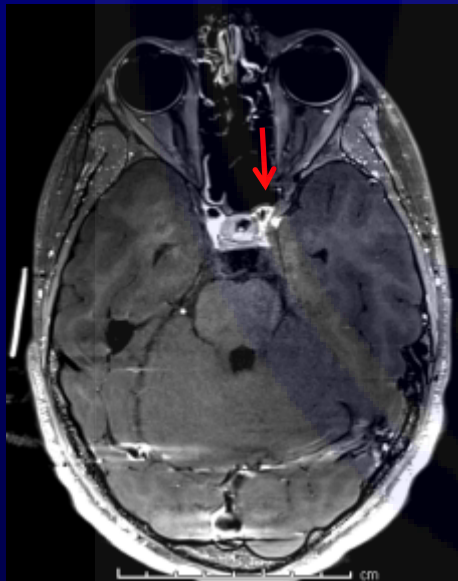
Clinical case: 11 yo m at trampoline park found lying down, lethargic with difficulty speaking and right hemiparesis.



FLAIR



DWI

MRA-
TOF

VWI

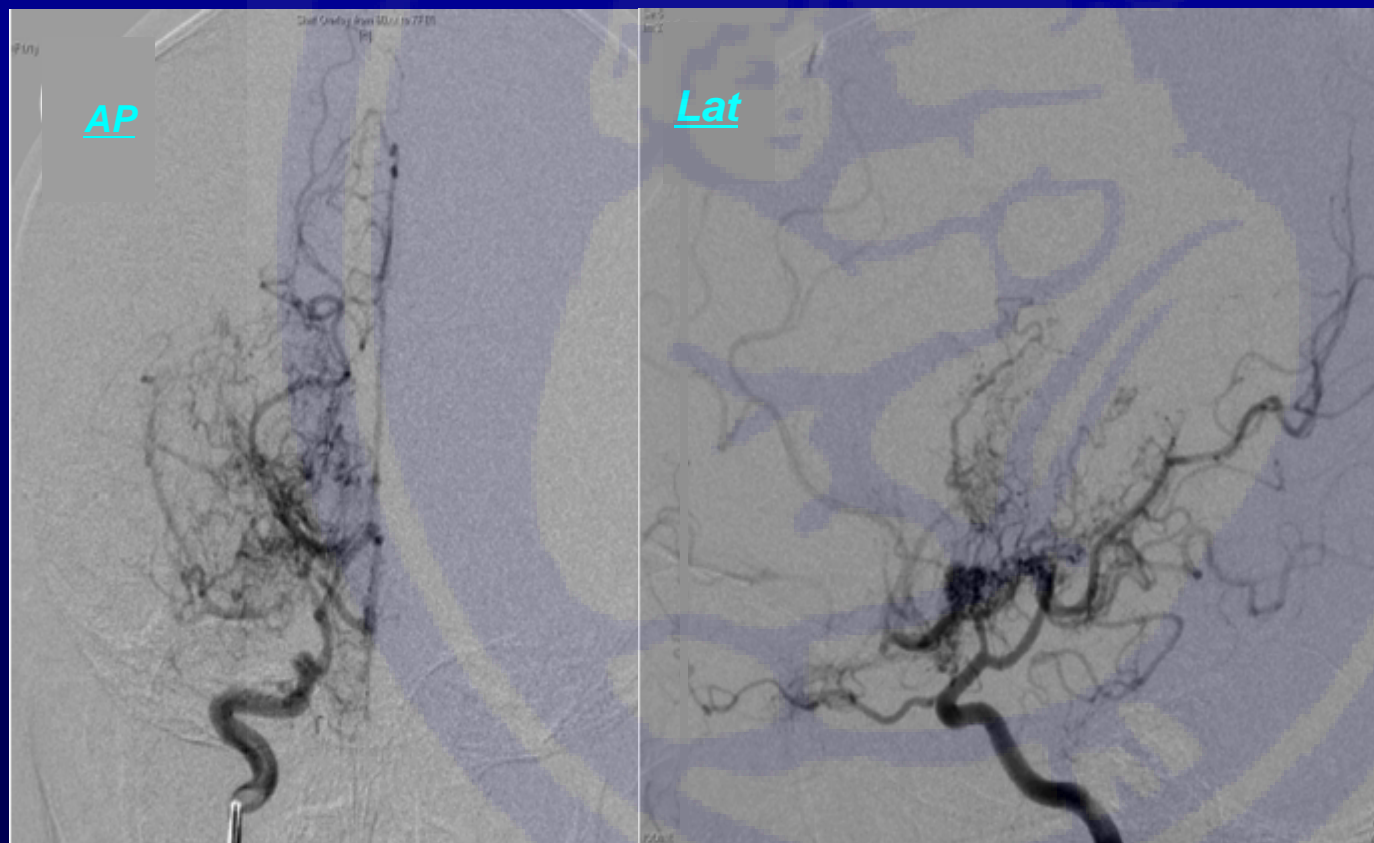
Differential diagnosis: medium-to-large vessel vasculitis in childhood

<p>Infectious or postinfectious</p> <p>Bacterial</p> <p>Viral</p> <p>Spirochete</p> <p>Fungal</p>	<p><i>Mycobacterium tuberculosis, Mycoplasma pneumoniae, Streptococcus pneumoniae, T. pallidum</i></p> <p>CMV, VZV, HSV 1 and 2, EBV, HCV, HIV, JC virus, parvovirus B19</p> <p><i>Borrelia burgdorferi</i></p> <p><i>Actinomyces, Aspergillus, Candida albicans</i></p>
<p>Inflammatory or Autoimmune</p> <p>Collagen vascular disease</p> <p>Systemic vasculitides</p> <p>Inflammatory bowel disease</p> <p>Hemophagocytic lymphohistiocytosis</p>	<p>SLE, Sjogren's syndrome, Parry Romberg syndrome, Behcet's disease</p> <p>Juvenile dermatomyositis, Deficiency of adenosine deaminase 2 (DADA2)</p> <p>Kawasaki disease, HSP, PAN, Granulomatous angiitis of the CNS</p>
<p>Other</p> <p>Drug-induced CNS vasculitis</p> <p>Graft versus host disease</p> <p>Radiation vasculopathy</p> <p>Arterial dissection</p> <p>Fibromuscular dysplasia</p> <p>Vasoregulatory disorders</p> <p>Connective tissue disorders</p>	<p>Treatment for progressive medium-to-large vessel vasculitis:</p> <ol style="list-style-type: none"> 1. High dose IV methylprednisolone followed by 2. Oral steroid 3. Cyclophosphamide monthly for 6 months 4. Mycophenolate mofetil for 12 months



Arterial Ischemic Stroke

Moyamoya Disease



Primary Moyamoya

assoc. w 3p and 7q

ACTA2; GUCY1A3

Secondary Moyamoya

neurofibromatosis

tuberous sclerosis

homocystinuria

sickle cell anemia

trisomy 21

Williams syndrome

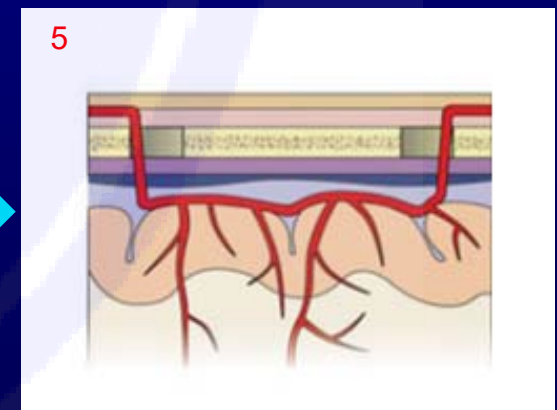
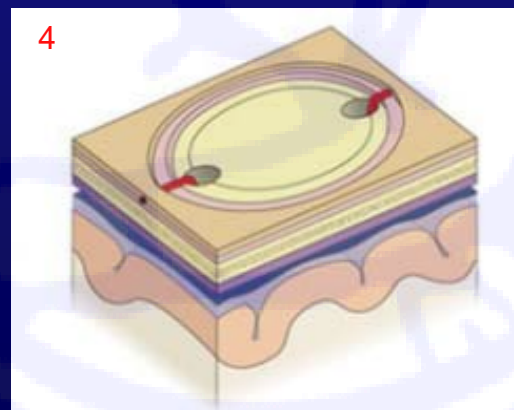
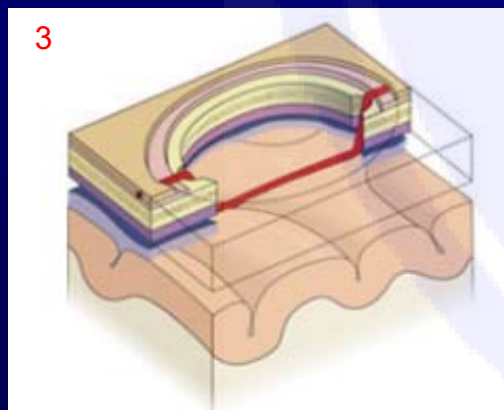
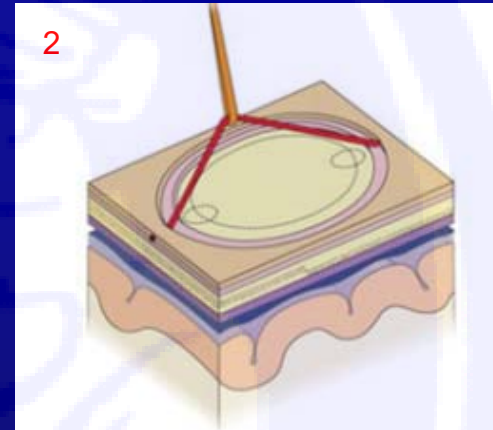
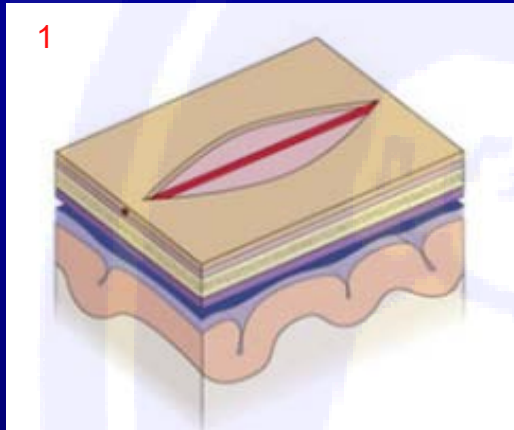
Alagille syndrome

cranial irradiation

Vascular Pathology:
Smooth muscle hyperplasia;
Luminal thrombosis



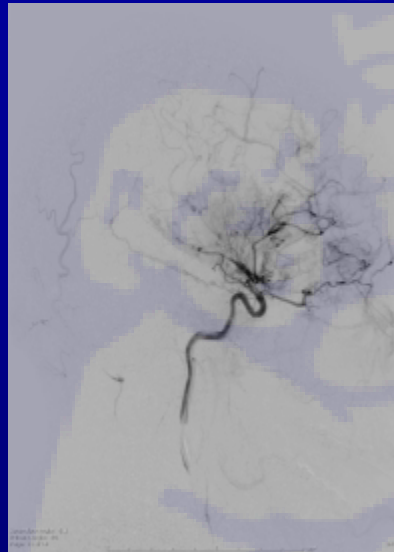
Pial Synangiosis for Moyamoya Disease



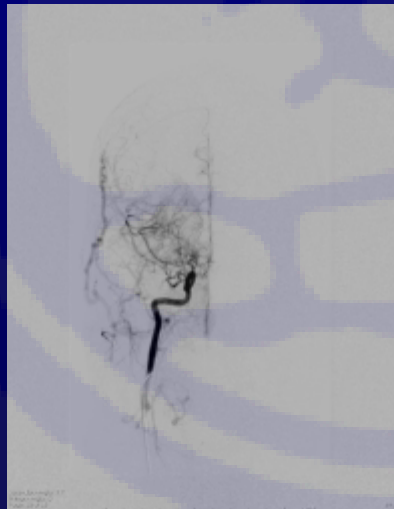
Smith E, Curr Treat Options Neurol, 2012

Surgical treatment: Pial Synangiosis

Right IC injection

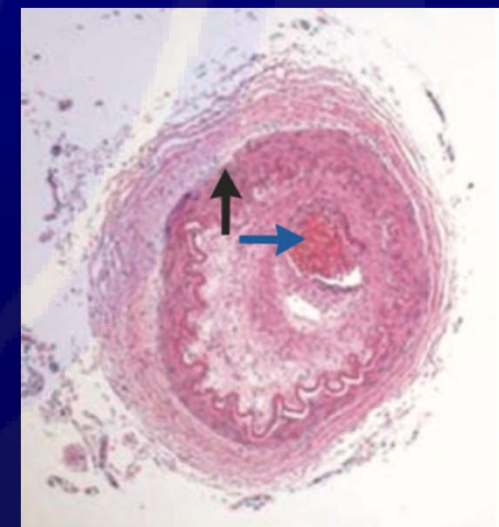
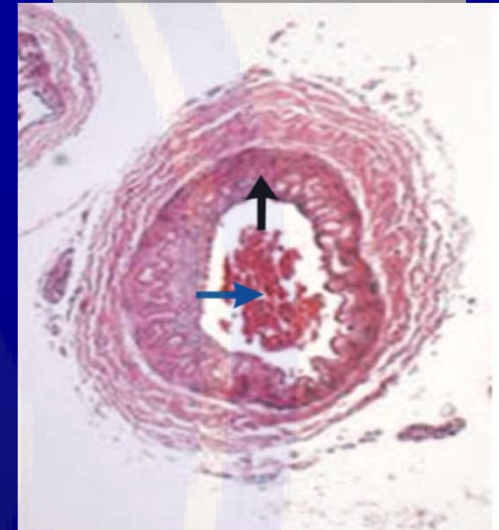


Lateral view



Coronal view

Right EC injection



Presentation of Arterial Ischemic Stroke in Children

- Sudden-onset, focal neurologic deficits in 85% of non-neonates
 - Hemiparesis 60-80%
 - Speech difficulty 10-35%
 - Visual field defects 5-20%
 - Other 18%

Arterial Ischemic Stroke

Important Overlooked Clinical Signs

Headache

- Occurs in 45% of children who present with stroke
- Associated with arteriopathy, including inflammatory origin

Seizure

- Occurs in 30% of children who present with stroke
- In a child who presents with first time seizure with postictal lateralized paresis

Rafay, J Child Neurol, 2006:8
Giroud et al, Acta Neurol Scand, 1997:401



Anterior cerebral artery

Weakness of contralateral leg
Behavior changes

Middle cerebral artery

Weakness of contralateral face and arm
Speech disturbance (aphasia, dysarthria)
Visual field deficit (hemianopia)
Inattention to stimuli (hemineglect)
Sensory deficits

Posterior cerebral artery

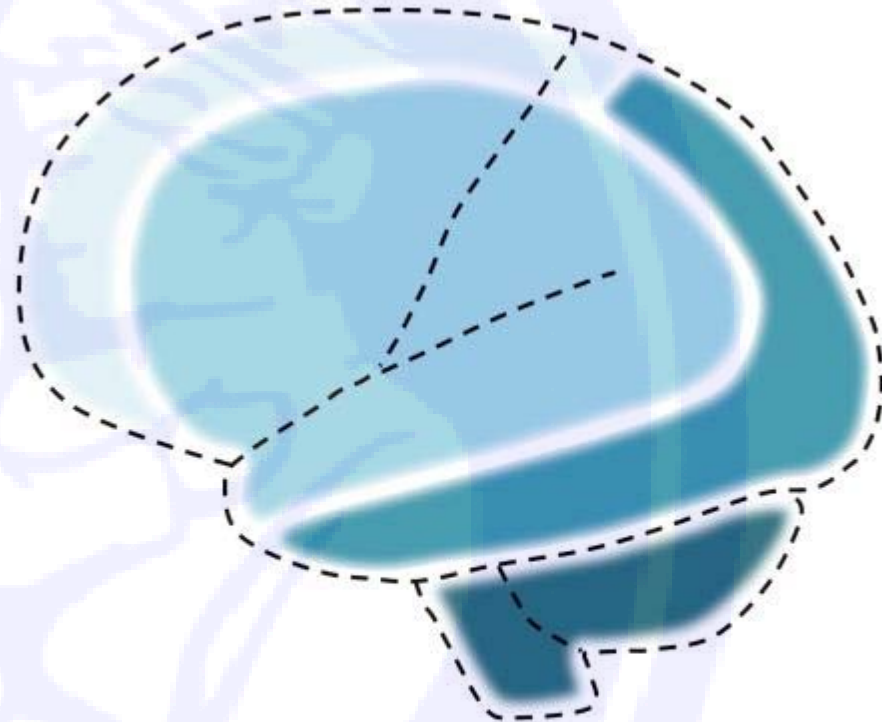
Visual field deficit (hemianopia)
Sensory deficits

Vertebrobasilar system

Dizziness, ataxia, impaired balance
Pupil and eye movement abnormalities
Changes in voice and swallowing
Weakness and sensory changes
Decreased level of consciousness

Cerebral veins and sinuses (not shown)

Decreased level of consciousness
Headache
Vomiting
Papilledema (late)



Bernson-Leung and Rivkin, PIR, 2016



Perinatal Arterial Ischemic Stroke

Rare?

Occurrence:

Full terms, ~1 in 1,600-4,000 births

Prematures, 1/1,000 births

Two types

1. Neonatal stroke
2. Presumed perinatal stroke



Causes (Risk Factors) for AIS Neonates (0-28 days in age)

Risk factors for Perinatal Stroke

Maternal disorders

- Preeclampsia
- Infertility
- Chorioamnionitis
- Autoimmune disorders
- Coagulation disorders
- Anticardiolipin antibodies
- Twin-to-twin transfusion syndrome
- In utero exposure to cocaine and inhaled solvents

Placental disorders

- Placental thrombosis
- Placental abruption
- Placental infection

Blood, homocysteine, and lipid disorders

- Polycythemia
- Disseminated intravascular coagulopathy
- Factor V Leiden mutation
- Protein S deficiency
- Protein C deficiency
- Prothrombin mutation
- Homocysteine
- Lipoprotein a
- Factor VIII

Cardiac disorders

- Congenital heart disease
- Patent ductus arteriosus
- Pulmonary valve atresia

Vasculopathy

Vascular maldevelopment

Arterial dissection

Infectious disorders

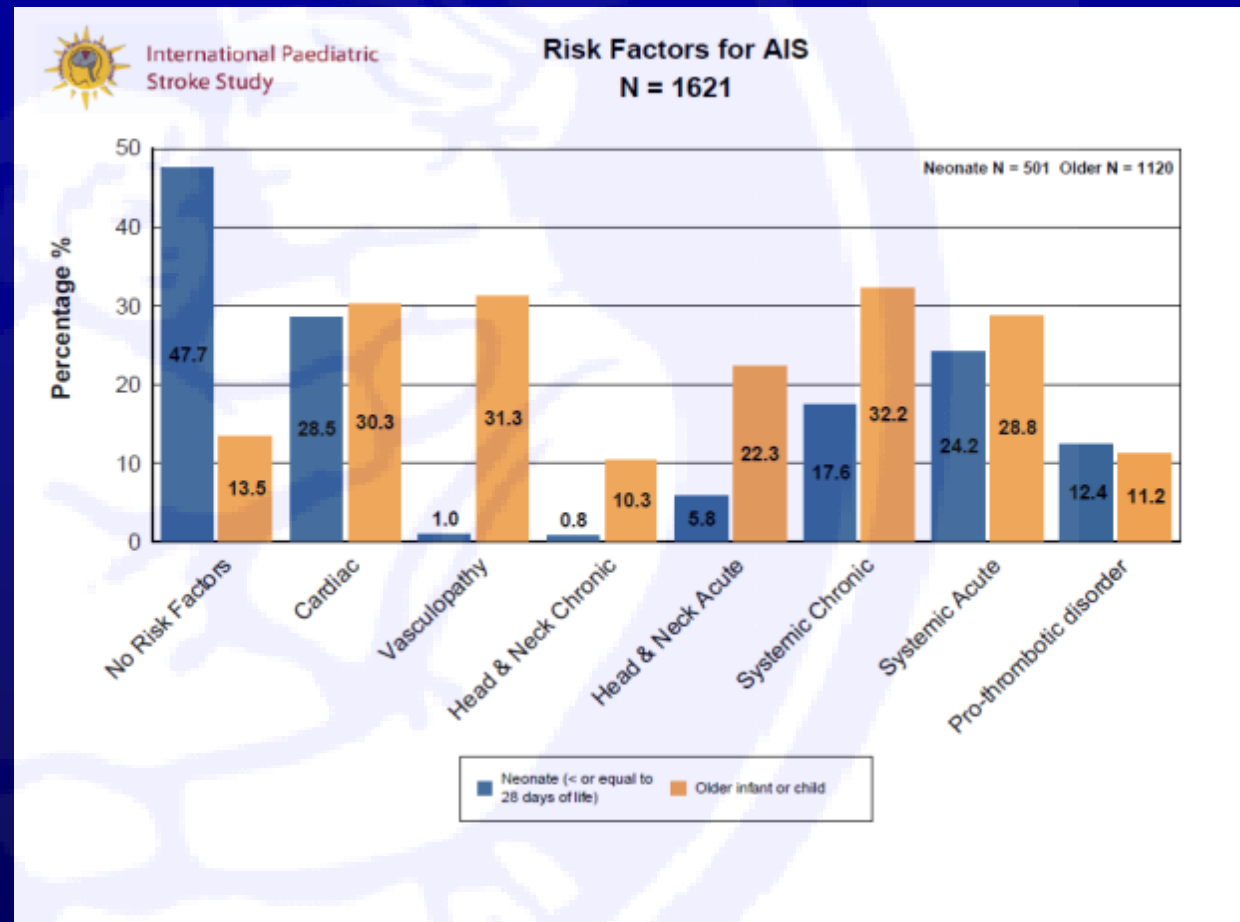
CNS infection

Systemic infection

Trauma and catheterization

Dehydration

Extracorporeal membrane oxygenation



The materno-placental-fetal unit

Maternal thrombophilia



Pregnancy assoc.
hypercoaguability

Pre-eclampsia

Mother

Fetus

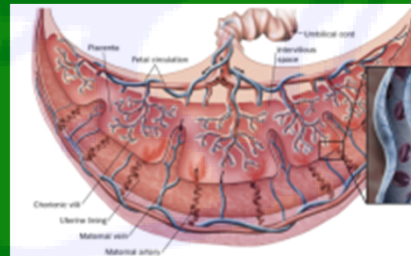
Fetal thrombophilia



IUGR

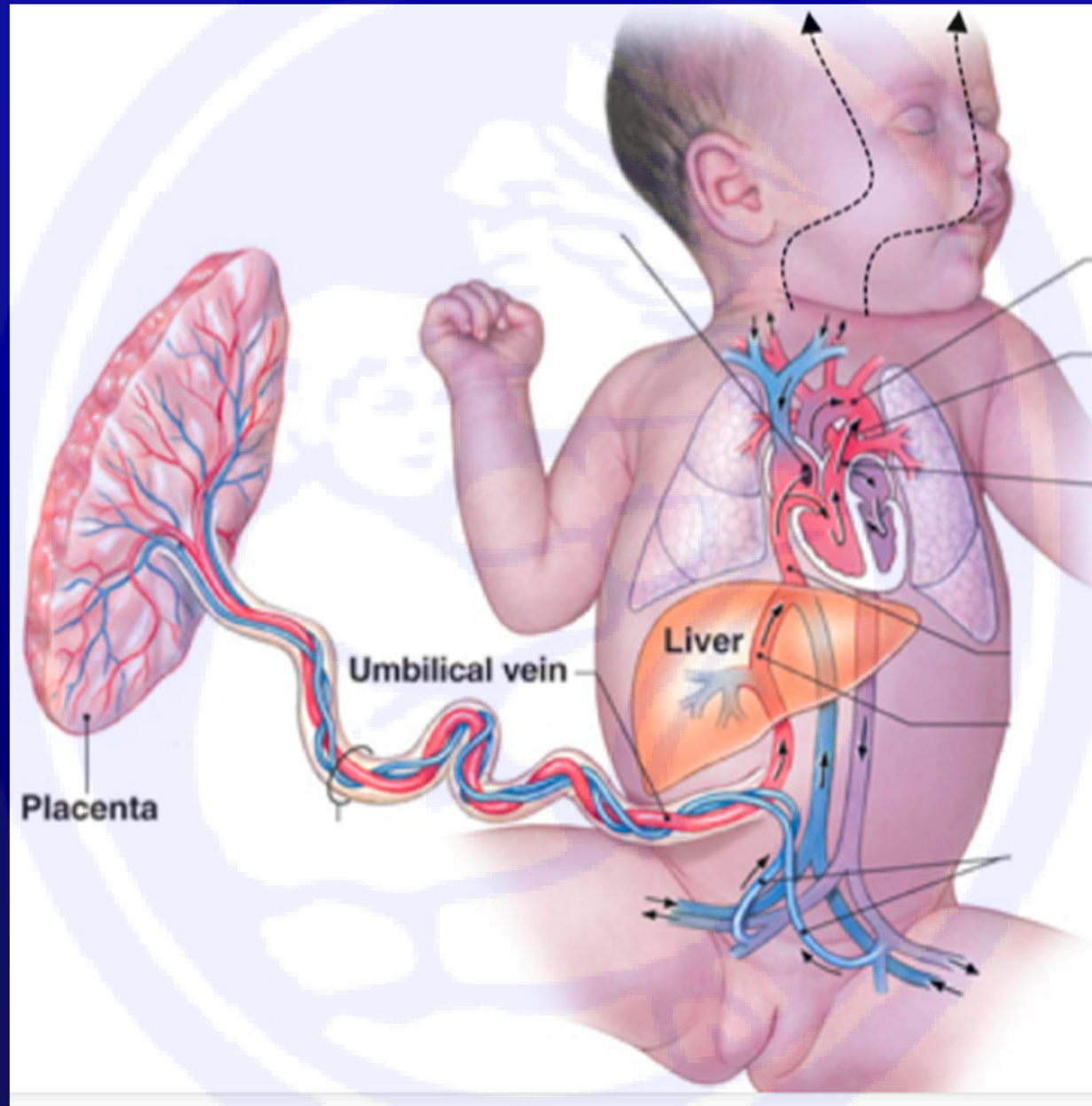
Fetal infection/
Inflammation

Placenta



Chorioamnionitis





Martini and Ober, Visual Anatomy and Physiology, Pearson Science, 2012



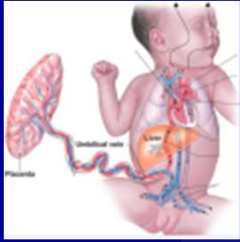
Stroke and Cerebrovascular Center, Department of Neurology, Boston Children's Hospital

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The Michael J. Bresnan Child Neurology Course



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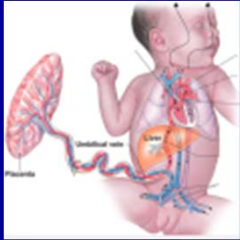


Neonates with Stroke and Their Placentas

- Captured all cases of neonatal stroke for which placental pathology was available, 2005-2015
- Central review of placentas by a single placental pathologist
- Collected intrapartum clinical data of mothers
- Collected clinical data of infants
- Found 46 infant-placenta dyads

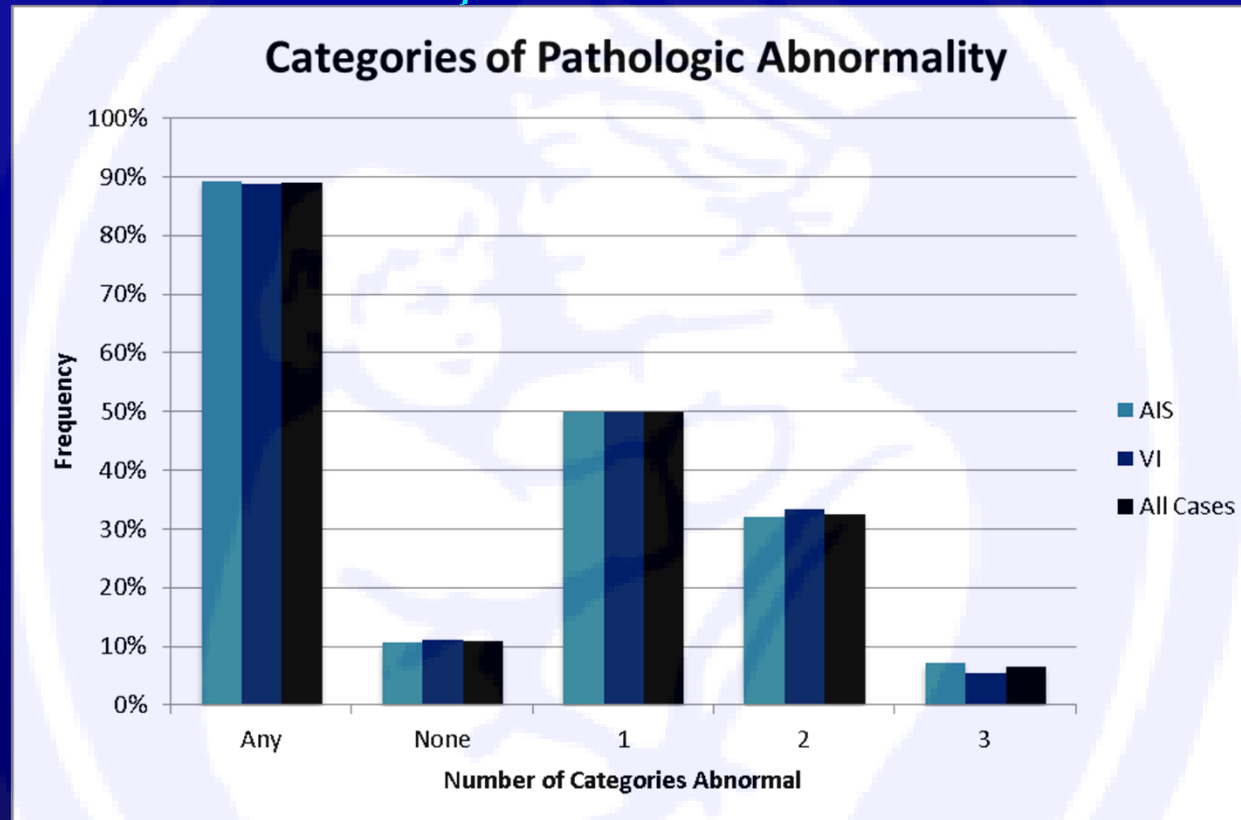
Martini and Ober, Visual Anatomy and Physiology, Pearson Science, 2012





Neonates with stroke and their placentas

- All but one placenta was abnormal!*



Placental Pathology	Neonatal Stroke (n=46)	Hypoxic-Ischemic Encephalopathy (n=23)
Uteroplacental Malperfusion	30%	78%
Chorioamnionitis	41%	30%

Martini and Ober, Visual Anatomy and Physiology, Pearson Science, 2012; Bernson-Leung, Boyd, Meserve, Danehy, Kapur, Trenor, Lehman and Rivkin, J Peds, 2018



Neonates with stroke and their placentas

Placental findings in case subgroups versus controls										
	Controls		Cases: AIS [§]		Odds ratio (AIS versus controls)	p value (AIS versus controls)	Cases: VI*		Odds ratio (VI versus controls)	p value (VI versus controls)
Any abnormal finding	94/99	(94%)	28/28	(100%)	N/A	0.35	17/18	(94%)	-	-
Any category abnormal	61/99	(62%)	25/28	(89%)	5.2 (1.4 – 18)	0.005*	16/18	(89%)	5.0 (1.1 – 23)	0.03*
2 or more categories abnormal	8/99	(8%)	11/28	(39%)	7.4 (2.6 – 21)	0.002*	7/18	(39%)	7.2 (2.2 – 24)	0.002*
Category 1: <u>Uteroplacental malperfusion</u>	22/99	(22%)	9/28	(32%)	1.7 (0.7 – 4.2)	0.32	5/18	(28%)	-	-
Category 2: <u>Fetal vascular flow restriction</u>	17/99	(17%)	13/28	(46%)	4.2 (1.7 – 10.4)	0.002*	10/18	(56%)	6.0 (2.1 – 18)	0.0011*
Category 3: <u>Inflammation due to amniotic fluid infection</u>	Maternal: 25/99	(25%)	Maternal: 13/28	(46%)	2.6 (1.1 – 6.1)	0.037*	Maternal: 6/18	(33%)	-	-
	Maternal + fetal: 19/99	(19%)	Maternal + fetal: 11/28	(39%)	2.7 (1.1 – 6.8)	0.042*	Maternal + fetal: 4/18	(22%)	-	-
Category 4: <u>Extensive non-specific chronic villitis</u>	3/99	(3%)	0/28	(0%)	N/A	0.59	1/18	(6%)	-	-
Category 5: <u>Large placenta with chorangioma</u>	3/99	(3%)	4/28	(14%)	5.3 (1.1 – 25)	0.042*	1/18	(6%)	-	-
Meconium + nRBCs ("stress response")	1/99	(1%)	8/28	(29%)	39 (4.6 – 331)	< 0.0001*	3/18	(17%)	19.6 (1.9 – 201)	0.011*

* Difference between populations statistically significant by Chi-square or Fisher's exact test (two-tailed p-value ≤ 0.05), not adjusted for multiple comparisons; § AIS = arterial ischemic stroke; ♦ VI = venous infarction

Bernson-Leung, Boyd, Meserve, Danehy, Kapur, Trenor, Lehman and Rivkin, J Peds, 2018



Arterial Ischemic Stroke

Stroke in Neonates

Clinical Presentation

- Focal seizures
- Lethargy
- Apnea
- Encephalopathy



Arterial Ischemic Stroke

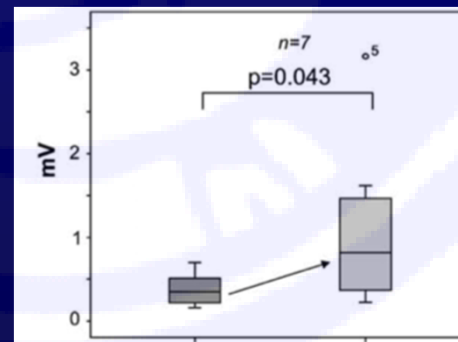
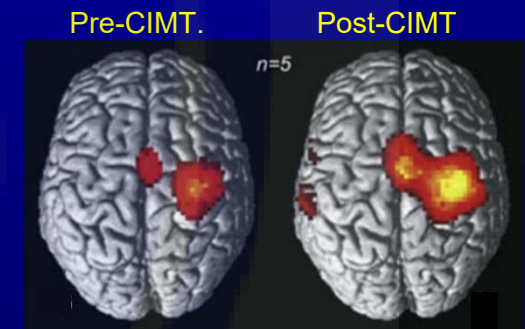
Treatment of Arterial Ischemic Stroke in Children

- **Oxygenation** : $\geq 95\%$
- **Normothermia**:
 - Hyperthermia- **treat fever!** If present, each degree of \downarrow , improves outcome
 - Hypothermia - interest is high based on success with neonatal HIE
- **Euglycemia**: goal is 70-120 mg/dl; treat if >200 mg/dl
- **Blood pressure** adequacy:
 - Maintain cerebral perfusion to brain to avoid exacerbating infarct
 - Targets have not been proven- developmental increment in blood pressure with age



Early institution of treatment for perinatal stroke

- Early start of occupational therapy
- Use of modified pediatric Constraint Induced Movement Therapy (pediCIMT) in infancy.
- Focus on upper extremity
- Use of transcranial magnetic stimulation



Marcroft et al, J Phys Occ Ther Peds, 2018; Basu et al, BMC Neurol, 2018; Walther et al Ped Neurol, 2009



Arterial Ischemic Stroke

Outcome after Stroke in Childhood

Neonatal Arterial Ischemic Stroke

Motor deficits	30-50%
Cognitive deficits	up to 60%
Executive function	
Language	
Epilepsy	15-55%

Arterial Ischemic Stroke in Children > 1 month of age

Motor deficits	65%
Cognitive deficits	40-50%

Westmacott et al, DMCN, 2010
Kolk et al, Pediatr Neurol, 2011
Lee et al, Ann Neurol, 2005
Ricci et al, Stroke, 2008
Wanigasinghi et al, DMCN, 2010
Ganesan et al, DMCN, 2000
De Veber et al, J Child Neurol, 2000



Arterial Ischemic Stroke

Stroke in Children: Cognitive Outcome

Table II: Intellectual outcome for children with unilateral arterial ischaemic stroke, stratified by age at stroke and by lesion location, mean (SD)

Group	Age at test	Years since stroke	FSIQ	VIQ/VCI	PIQ/PRI	WMI	PSI
All	9y1m (3y10m)	4y9m (3y9m)	94.74 ^a (14.70)	95.99 ^a (14.41)	96.48 ^a (14.54)	93.69 ^a (15.09)	92.14 ^a (13.91)
Perinatal	8y0m (3y1m)	8y0m (3y1m)	91.63 ^a (14.30)	92.20 ^a (14.17)	94.33 ^b (13.31)	88.10 ^a (16.00)	89.63 ^a (14.44)
1mo – 5y	7y5m (2y9m)	4y6m (3y1m)	95.42 ^b (15.65)	97.60 (15.20)	96.37 (14.62)	93.98 ^b (14.92)	93.31 ^a (12.56)
6–16y	12y6m (3y9m)	1y6m (1y10m)	97.21 (13.51)	97.98 (13.04)	99.00 (15.62)	97.40 (13.67)	93.17 ^a (14.89)
Subcortical	8y9m (4y3m)	3y6m (3y0m)	98.23 (14.68)	99.25 (13.68)	101.12 (13.72)	96.49 (15.34)	95.79 ^b (13.39)
Cortical	9y3m (3y4m)	4y9m (4y0m)	95.12 ^b (12.86)	96.10 (13.15)	95.03 ^b (14.26)	95.58 ^b (15.53)	92.24 ^a (13.77)
Combined	9y4m (3y7m)	6y6m (3y10m)	87.95 ^a (14.24)	89.82 ^a (14.74)	90.09 ^a (15.09)	87.63 ^a (12.81)	84.38 ^a (12.75)

Scores that are significantly lower than normative data are denoted as follows: ^a $p < 0.01$; ^b $p < 0.05$. FSIQ, Full-scale IQ; PIQ, Performance IQ; PRI, Perceptual Reasoning Index; PSI, Processing Speed Index; VCI, Verbal Comprehension Index; VIQ, Verbal IQ; WMI, Working Memory Index.

Westnmacott, DMCN 2011



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Arterial Ischemic Stroke in Children: Wrap Up

1. Reviewed the characteristics of AIS in children
2. Etiologies and some clinical features distinguish AIS in children from AIS in adults
3. Looked at recent developments in treatment of acute stroke that now available
4. The outcome in children with stroke is mixed, affecting both motor and cognitive domains

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Visit us at our website:

<http://www.childrenshospital.org/centers-and-services/cerebrovascular-disorders-and-stroke-program>

Thanks for your interest and attention!

