Abstract:
Pediatric stroke occurs at an incidence of 1.6 to 13/100 000 and may be acute ischemic, hemorrhagic, or of sinus venous thrombosis etiology. As these children present to the emergency department, early consideration for this diagnosis is paramount towards optimizing cerebral perfusion and minimizing secondary injury. There are many identified risk factors in pediatric stroke including arteriopathies, cardiac disease (specifically congenital heart disease), and infection. The most common presenting sign of acute ischemic stroke in all pediatric age groups is a focal neurologic deficit, typically acute hemiplegia. Imaging, specifically magnetic resonance imaging, as well as identification of risk factors will help aid diagnosis and treatment. Treatment for acute ischemic stroke in pediatrics focuses on minimizing injury and preventing early complications by maintaining cerebral perfusion pressure. Hemorrhagic stroke may need acute neurosurgical intervention. Overall outcome of pediatric stroke is good, but long-term complications including depression should be recognized and treated appropriately.

Keywords:
Acute ischemic stroke; hemorrhagic stroke; cerebral venous sinus thrombosis; children

Division of Neurology, Department of Pediatrics, Ann & Robert H. Lurie Children's Hospital of Chicago, Northwestern University Feinberg School of Medicine, Chicago, IL.
Reprint requests and correspondence: Lindsey Morgan, MD, Division of Neurology, Department of Pediatrics, Ann & Robert H.

Evaluation and Management of the Child With Suspected Acute Stroke

Lindsey Morgan, MD

Pediatric stroke, with onset between 30 days and 18 years of age, occurs at an annual average incidence of 1.6 to 13/100 000.[1-3] The diagnosis of acute stroke in children is challenging, but the long-term morbidity for arterial and venous strokes in children is high. Thus, early consideration for this diagnosis in the child presenting to the emergency department (ED) with a new neurologic deficit is an important step in beginning medical management to optimize cerebral perfusion and minimize secondary injury.

Stroke may be caused by arterial ischemic stroke (AIS), hemorrhagic stroke (HS), or cerebral sinus venous thrombosis (CVST). Etiologies and outcomes in neonatal stroke differ, and this entity will not be reviewed here. Approximately 15% of all ischemic strokes occur in young adults and adolescents.[4] Hospitalizations for stroke have increased from 1995-6 to 2007-8 in the 5 to 14 and 15 to 34 year of age groups; this is accounted for by an increase in risk factors such as diabetes, obesity, lipid disorders, congenital heart disease, tobacco use, and hypertension[4] as well as increased recognition and diagnosis of stroke with improved imaging. In children, AIS is most common with overall ranges from 51 to 78% of studied patient populations, whereas HS ranges from 12.7 to 41% and CVST in 8.9 to 20%.[2,5-7] The median age range for all stroke types is 5 to 10 years.[2,5,7]

Lurie Children's Hospital of Chicago, Northwestern University Feinberg School of Medicine, 225 E Chicago Ave, Chicago IL 60611.
lmorgan@luriechildrens.org

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RISK FACTORS

Arterial Ischemic Stroke

Modifiable adult risk factors including hypertension, hyperlipidemia, and diabetes are rarely seen in pediatrics.[8] In contrast, the most common risk factors for stroke in children include arteriopathies, congenital heart disease, and infection (Table 1). Recognition of the importance of these risk factors in the patient's history can help support the inclusion of stroke in the diagnostic evaluation of the child who presents to the ED with a new neurologic deficit.

The most common risk factor for AIS is arteriopathy. This group of disorders includes nontraumatic dissections, vasculitis, moyamoya, postvaricella arteriopathy/vasculitis, transient cerebral arteriopathy, primary vascular disorder/ill-defined vasculopathy, and sickle cell disease. Recent minor infections, such as viral upper respiratory infection or other viral syndromes, are a positive predictor of arteriopathies[7,11] as well as early school age (5-9 years).[11] When arteriopathies are grouped together, they occur at rates of 31 to 60%.[7,9,10] Moyamoya is identified at rates of 11.6 to 22%,[6,8,11] and postvaricella arteriopathy/vasculitis, in 1.5 to 7%.[11-13] Nontraumatic dissection is seen in 1 to 20% of patients.[6,9,11] Sickle cell disease causing stroke is decreasing due to better recognition of this risk and preventative treatment.[4] Still, patients with stroke have sickle cell disease identified ranging from 8 to 17%.[11,14,15]*Arteriopathies* are defined as reversible if there is improvement including normalization and is most frequently seen in males and in the middle cerebral artery (MCA) territory.

A primary cardiac etiology including congenital heart disease is the next most common risk factor, found at rates of 17.9 to 31%.[7,8,16] Rates of stroke are highest after cardiac catheterization or surgery[8,12,17] or in association with systemic infection.[17] Stroke in children with a history of cardiac disease is more likely to have a cardioembolic than vascular origin.[11]

The contribution of infection as a primary cause of stroke in children is uncertain, with the highest rates occurring outside the United States (18.5-40% vs 5-12%).[5,9,10,12,14] Acute infection with sepsis or meningitis has been implicated as a risk factor for stroke in children.[5,9] Herpes and tuberculosis are frequently identified acute pathogens,[5,12] whereas varicella can cause a vasculopathy that presents months later.[12]

Hypercoagulable conditions including methylenetetrahydrofolate reductase deficiency, factor V Leiden mutation, protein C deficiency, and homocystinuria are frequently tested for as a risk factor for pediatric stroke but are present in only a small proportion of stroke cases (11.4-25.6%).[9,12,15] Importantly, these risk factors are rarely present in isolation from other factors discussed above. Accordingly, one should consider prothrombotic states including malignancy, iron deficiency anemia, sickle cell disease, oral contraceptive use, and autoimmune disease.[10,12] One study found 40% of patients that were anemic on admission, and of those, 40% had sickle cell and the rest had iron deficiency anemia.[16]

Risk for AIS is increased in survivors of pediatric central nervous system (CNS) tumors, Hodgkin lymphoma, and acute lymphoblastic leukemia who received radiation to the brain and/or neck.[18] Of the children with new diagnosis of any cancer, 1 to 2.3% have a stroke at some point,[12,19] with the frequency highest in primary central nervous system cancers (1.3%), lymphoma (1.6%), and leukemia (2.9%),[19] and the risk of stroke continues decades out, with 1 study documenting a cumulative incidence of 6.9% at 25 years from initial cancer diagnosis.[18] Of those with stroke and cancer, the mortality rate is quite high (86.7%).[19] Finally, a history of trauma should be obtained in all patients as carotid and vertebral artery dissections can lead to embolic acute ischemic strokes.

Cerebral Venous Sinus Thrombosis

Risk factors for CVST are different than those for AIS and include systemic or CNS infection[7] as well as chronic otitis media and orbital cellulitis,[5] prothrombotic state,[5] and hematologic or metabolic disorders.[7]

Hemorrhagic Stroke

Hemorrhagic stroke risk factors include vascular abnormalities,[6,7] a hematologic disorder,[7] bleeding