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Topical Review

Pathways for Neuroimaging of Childhood Stroke

David M. Mirsky MD [a,*,1], Lauren A. Beslow MD, MSCE [b,1], Catherine Amlie-Lefond MD [c], Pradeep Krishnan MD [d,e], Suzanne Laughlin MD [d,e], Sarah Lee MD [f], Laura Lehman MD [g], Mubeen Rafay MBBS [h], Dennis Shaw MD [i], Michael J. Rivkin MD [g,j,k,2], Max Wintermark MD [l,2], for the International Paediatric Stroke Study Neuroimaging Consortium and the Paediatric Stroke Neuroimaging Consortium

[a] *Department of Radiology, Children's Hospital Colorado, University of Colorado School of Medicine, Aurora, Colorado*
[b] *Department of Neurology, Perelman School of Medicine at the University of Pennsylvania, Division of Neurology, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania*
[c] *Department of Neurology, Seattle Children's Hospital, University of Washington, Seattle, Washington*
[d] *Division of Neuroradiology, Department of Diagnostic Imaging, The Hospital for Sick Children, Toronto, Ontario, Canada*
[e] *Department of Medical Imaging, University of Toronto, Toronto, Ontario, Canada*
[f] *Department of Neurology & Neurological Sciences, Stanford University School of Medicine, Stanford, California*
[g] *Department of Neurology, Boston Children's Hospital, Harvard Medical School, Boston, Massachusetts*
[h] *Section of Neurology, Children's Hospital, Children's Hospital Research Institute of Manitoba, University of Manitoba, Winnipeg, Manitoba, Canada*
[i] *Department of Radiology, University of Washington School of Medicine, Seattle, Washington*
[j] *Department of Radiology, Boston Children's Hospital, Harvard Medical School, Boston, Massachusetts*
[k] *Department of Psychiatry, Boston Children's Hospital, Harvard Medical School, Boston, Massachusetts*
[l] *Division of Neuroradiology, Department of Radiology, Stanford University School of Medicine, Stanford, California*

ABSTRACT

BACKGROUND: The purpose of this article is to aid practitioners in choosing appropriate neuroimaging for children who present with symptoms that could be caused by stroke. **METHODS:** The Writing Group members participated in one or more pediatric stroke neuroimaging symposiums hosted by the Stroke Imaging Laboratory for Children housed at the Hospital for Sick Children in Toronto, Ontario, Canada. Through collaboration, literature review, and discussion among child neurologists with expertise diagnosing and treating childhood stroke and pediatric neuroradiologists and neuroradiologists with expertise in pediatric neurovascular disease, suggested imaging protocols are presented for children with suspected stroke syndromes including arterial ischemic stroke, cerebral sinovenous thrombosis, and hemorrhagic stroke. **RESULTS:** This article presents information about the epidemiology and classification of childhood stroke with definitions based on the National Institutes of Health Common Data Elements. The role of imaging for the diagnosis of childhood stroke is examined in depth, with separate sections for arterial ischemic stroke, cerebral sinovenous thrombosis, and hemorrhagic stroke. Abbreviated neuroimaging protocols for rapid diagnosis are discussed. The Writing Group provides suggestions for optimal neuroimaging investigation of various stroke types in the acute setting and suggestions for follow-up neuroimaging. Advanced sequences such as diffusion tensor imaging, perfusion imaging, and vessel wall imaging are also discussed. **CONCLUSIONS:** This article provides protocols for the imaging of children who present with suspected stroke.

Keywords: childhood stroke, stroke mimics, magnetic resonance imaging, computed tomography

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* Communications should be addressed to: Dr. Mirsky; Children's Hospital Colorado; 13123 East 16th Avenue; Box B125; Aurora, CO 80045.
E-mail address: david.mirsky@childrenscolorado.org
[1]Co-first authors, the authors contributed equally to this work.
[2]Co-senior authors.

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Introduction and epidemiology

Stroke is a major cause of morbidity and mortality in children worldwide. The reported annual incidence of childhood stroke ranges from 2.3 to 13 per 100,000 children per year in developed countries.[1-3] Despite increasing awareness, this condition is often overlooked by medical providers and families. In adults, presentation with sudden onset hemiparesis with or without facial weakness and language problems constitutes hallmark presenting features of stroke which raise concern for the diagnosis without unnecessary delay. In children, stroke diagnosis is not as straightforward. Despite a growth in awareness about childhood stroke, when children present with acute neurological deficits, stroke is often not the first diagnosis considered by the medical providers. Delay in diagnosis derives, in part, from clinicians' difficulty recognizing that presenting signs and symptoms such as seizure, altered mental status, headache, and lethargy can be associated with acute stroke in children. Neuroimaging is essential for diagnosis and differentiation of stroke from stroke mimics that can present similarly such as hypoglycemia, demyelinating disorders, tumors, posterior reversible leukoencephalopathy syndrome, and complex migraine. Importantly neuroimaging is essential for identification of children who may be candidates for hyperacute therapy.

This report will briefly describe childhood stroke classification and then will discuss the imaging of each major stroke subtype individually. The objective is to provide practitioners with a guide for neuroimaging children with various stroke subtypes.

Pediatric stroke classification

Childhood stroke is defined as occurring in children aged 29 days after birth to 18 years. Perinatal stroke, defined as stroke occurring from birth to 28 days of life (and in some cases *in utero* beginning at 20 weeks' gestation), will be discussed in a separate article. Stroke is traditionally subdivided into two types: ischemic and hemorrhagic. As opposed to adults who have ischemic stroke 85% of the time, stroke in children is almost evenly divided between ischemic and hemorrhagic events.[3] Ischemic stroke is further subclassified into arterial ischemic stroke (AIS) and cerebral sinovenous thrombosis (CSVT). Childhood AIS is defined as presentation with a focal deficit or seizure that localizes to an ischemic area of brain injury in a known arterial territory. Most children present with hemiplegia, with or without aphasia. CSVT can occur alone or in association with venous infarction or hemorrhage. Isolated cortical vein thrombosis (ICVT) is rare, accounting for less than 1% of all cerebral infarctions.[4] Hemorrhagic stroke in children includes spontaneous intracerebral hemorrhage with or without intraventricular extension, intraventricular hemorrhage (IVH), and nontraumatic subarachnoid hemorrhage.

Childhood AIS

After childhood AIS, more than 75% of children will suffer long-term neurological deficits and 10% of children will die.[5-9] Recurrence risk after childhood AIS has been estimated at 12% at one year[10] and 19% at five years.[9]

Approximately 30% of children with AIS encountered in academic centers have an associated cardiac disorder that presumably leads to cardioembolism (Fig 1), whereas cerebral arteriopathy is found in up to half of all children with childhood AIS.[11,12] The presence of cerebral arteriopathy on neuroimaging also predicts recurrent stroke and stroke after transient ischemic attack (TIA).[9,13]

Cervicocephalic arterial dissection, one type of arteriopathy, accounts for 7.5% to 20% of childhood AIS.[14-16] Involvement of

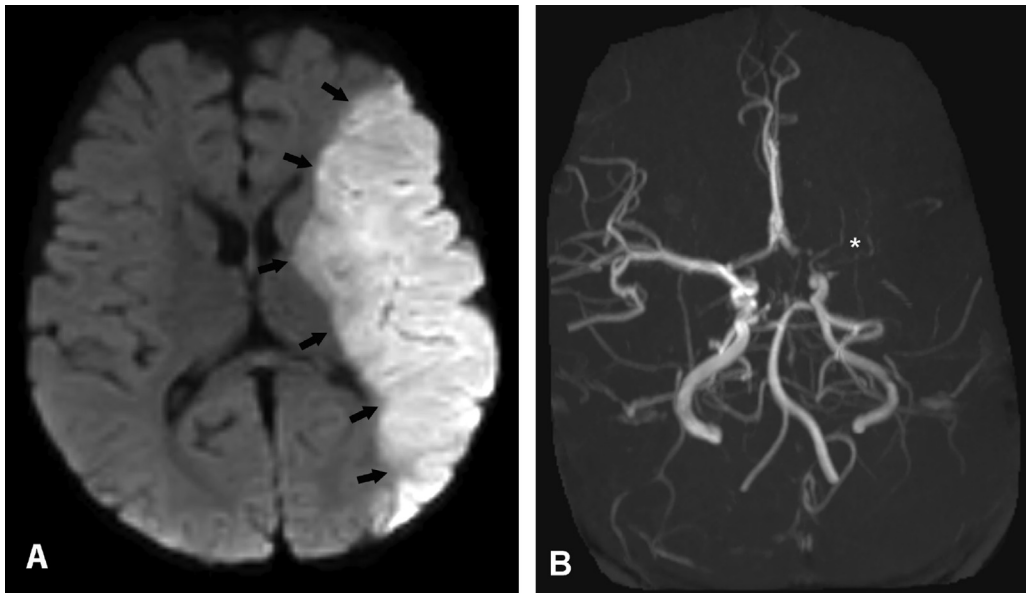

FIGURE 1.
Cardioembolic stroke. (A) Axial diffusion-weighted image (DWI) demonstrates a large left middle cerebral artery (MCA) territory infarct (black arrows) in a one-year-old boy found to have a thrombus within his left ventricle. (B) Three-dimensional time-of-flight magnetic resonance angiography maximum intensity projection image reveals lack of normal flow-related signal involving the left MCA and branch vessels (white asterisk).