pediatric stroke

Fast Progression of Ischemia in Children with Large Vessel Occlusion

Samyami S. Chowdhury, Vivek Pai, Kartik Bhatia, Nomazulu Dlamini, Prakash Muthusami

KEY POINT

Fast progression of ischemic core in children with cardiomyopathy presenting with AIS from LVO – time is brain in children too.

In arterial ischemic stroke (AIS) from large vessel occlusion (LVO), the rate of progression of penumbra to core is a dynamic process dependent on several variables. “Fast progression” in adult AIS has been defined as progression to core >70 mL within 6-hours or ASPECTS decay ≥3 points within 8-hours (1). Fast progression can exclude candidacy for endovascular thrombectomy and is associated with significantly increased morbidity and mortality.

The rate of infarct progression is known to be inversely correlated with the status of leptomeningeal collaterals (2,3). This would imply that children, who have excellent collaterals, would inherently always show slow infarct progression. This has historically excluded some children with LVO from endovascular thrombectomy, citing good outcomes with conservative management only. However, infarct progression also depends on tissue oxygen demand and on cerebrovascular reserve, both of which are not assessed at expedient stroke imaging. The determinants of these are severalfold, including pre-existing comorbidities, genetics, glycemic levels, microcirculatory function, and individual neurovascular anatomy.

Emerging data suggest that collateral status is a dominant determinant of infarct growth kinetics, and abrupt collateral failure may underlie spontaneous, rapid penumbral collapse (4). Acute physiological stressors such as hypotension, hypoxia, hypoglycemia or severe systemic illness may precipitate abrupt failure of cerebral autoregulation, thereby limiting the ability to recruit or sustain leptomeningeal collaterals. This transient blunting of collateral recruitment may be sufficient to drive rapid infarct core expansion.

In contrast, systemic hypoperfusion states, including low cardiac output or evolving shock, may exert a more profound effect by chronically reducing cerebrovascular reserve and lowering the threshold at which penumbral tissue becomes unsalvageable (5). In such settings, even modest additional insults may precipitate collapse of compensatory flow.

Pre-existing comorbidities such as congenital heart disease, chronic anemia, or metabolic derangements may further impair endothelial function and microcirculatory responsiveness, amplifying vulnerability to ischemia. Dysglycemia and inflammatory states may exacerbate oxidative stress and endothelial dysfunction, accelerating microvascular failure and no-reflow phenomena.

In cardioembolic stroke, large clot burden and multi-territory involvement may also play a critical role in ultrafast progression. A substantial clot may not only occlude a proximal large vessel but also propagate distal emboli, overwhelming downstream collateral pathways and impairing capillary perfusion.

Finally, individual neurovascular anatomy, including variability in the circle of Willis completeness, collateral vessel caliber, and leptomeningeal collateral density, likely exert a disproportionate influence in children, in whom traditional adult vascular risk factors like hypertension and atherosclerosis are uncommon.

Taken together, these interacting factors, when present, may produce rapid infarct core expansion in pediatric LVO, affecting collateral flow,

Pediatr Stroke. 2026;13: 101-110

www.pediatricstrokejournal.com

cerebrovascular reserve, and microvascular integrity. These factors need to be further understood and

imaging assessment, and expedited management strategies in this population.

We describe two children who had ultrafast progression of infarct core. In both cases, underlying heart disease presumably resulted in poor cerebral microcirculatory function and long-standing decreased cerebral reserve, which resulted in rapid perfusion failure in the presence of LVO. A limitation of this paper is the small cohort and lack of published data regarding this topic. Further multicenter studies are needed to allow more in-depth analysis and discussion.

Case 1

A seventeen-year-old boy presented to the emergency department with severe abdominal pain. He had a background of Duchenne's Muscular Dystrophy, non-ambulant requiring non-invasive ventilation at night, however excellent cognitive function. His cardiac function two years prior showed extensive fibrosis on cardiac MRI, function was moderately reduced on this presentation but deemed stable. He was receiving immunosuppression.

Urgent CT abdomen showed thrombus in the left common femoral artery, superficial femoral artery, left ventricle cardiac clot with two thrombi present. There were bilateral renal infarcts with liver and splenic infarction. Prior to commencing anticoagulation, a CT head was requested to ensure no concerns; imaging was normal, patent circle of Willis, good flow in both the anterior and posterior cerebral circulations.

Immediately after completion of the CT head, the patient suddenly collapsed, became unresponsive with dense right sided weakness. Urgent CT-angiogram showed abrupt cut-off of the left internal carotid artery (ICA). Extensive ischemic infarct, with low attenuation involving the entire left middle cerebral artery (MCA) territory; caudate, internal capsule, lentiform were all involved. There was evidence of involvement of peripheral vessels, distal emboli visualized. Bilateral flow attenuation in both internal jugular veins (IJVs), terminal ICA and left MCA, ASPECTS 1 at best. Patient not a suitable candidate for IV thrombolysis, mechanical

studied to allow for heightened vigilance, early

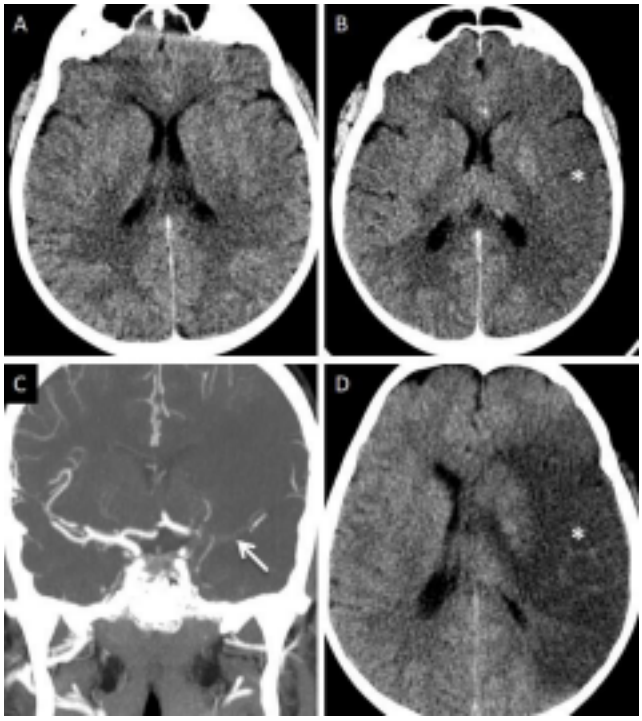


Fig. 1. A 17-year old boy with Duchenne muscular dystrophy and cardiomyopathy received a plain CT head after a CT abdomen incidentally showed left ventricular thrombus with spleen and renal infarcts (A) Axial section from CT head showing no ischemia with ASPECTS score 10. There was no hyperdensity in the large arteries. Two hours later, the patient's level of consciousness deteriorated, and a repeat CT/CT Angiography (B, C) was performed. Axial CT image (B) showing hypodense attenuation (*) of the left fronto-parietal lobes with loss of the grey-white matter differentiation, with an ASPECTS score of 1, suggesting a rapid progression of ischemia. Coronal maximum intensity projection (MIP) reconstruction of the CT Angiogram (C) reveals abrupt cut-off of the left M1-MCA segment (thick arrow). Follow-up CT image (D) obtained 9 hours after the initial imaging showing the extent of established infarct (*).

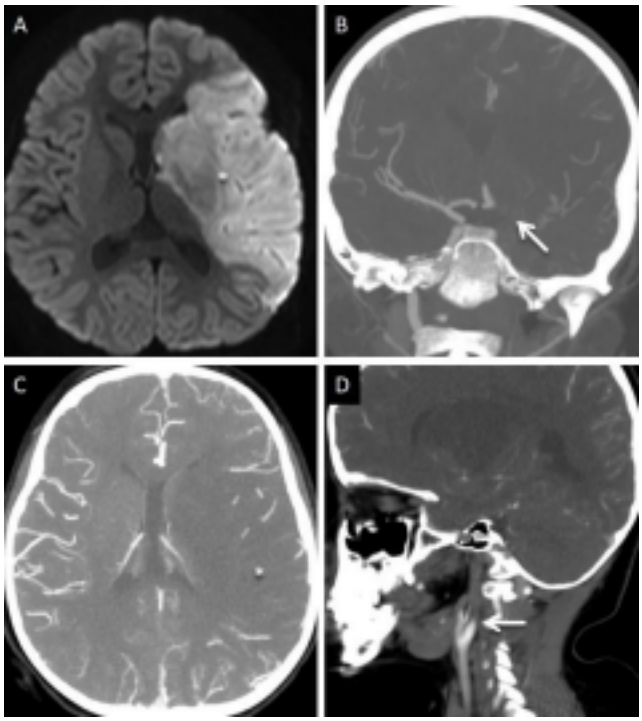
thrombectomy or heparinization. Neuroprotection commenced with symptomatic management. Cardiac intervention or surgery limited due to requirement of extensive heparinization during cardiac bypass and potential requirement of ECMO afterwards. Multidisciplinary discussions were held addressing patients' best interests, parental wishes and serious possibility for further devastating medical or surgical complications with attempts at aggressive intervention.

Following a course of rigorous supportive pediatric intensive care (PICU) management, the patient stabilized and began rehabilitation. He was transitioned from PICU to the ward within ten days and then to local rehabilitation center within a month. He was discharged on Aspirin 81mg daily for secondary stroke prevention.

Six-months post-discharge, the patients right arm remained paretic with ongoing physiotherapy and occupational therapy input, right leg weakness present without spasticity, he remained non-ambulant. His pediatric stroke outcome measure (PSOM) at six months was 2.5; scoring for severe sensorimotor deficit and dysarthria. Modified Rankin Score (mRS) was 4 at 6 months. Patient developed seizures post-discharge, requiring one antiseizure medication for control, he was able to speak slowly in 3 word sentences with some echolalia, he could understand commands and communicate his needs. This patient returned to finish his semester in high school and subsequently graduated.

Case 2

A seven-year-old girl previously fit and well, developmentally appropriate, presented to hospital with myocarditis secondary to influenza. She additionally suffered from rhabdomyolysis (CK 400,000iU/L) with a Troponin peak of 23,000ng/mL. Her initial presentation was cardiogenic shock, she was intubated and supported in PICU. Patient gradually improved over six days and was extubated without any initial neurological concern. Following extubation, there was aphasia, facial asymmetry, and



no movement of her right arm and leg. The PedNIHSS was 16, Code Stroke activated and urgent neuroimaging obtained.

MRI head (Fig 2) showed left MCA infarct, ASPECTS 0 with mild regional mass effect causing sulcal effacement of the left lateral ventricle, no midline shift and swelling of the basal ganglia. Patient was not a candidate for IV thrombolysis, mechanical thrombectomy or anticoagulation. She received supportive and symptomatic care in PICU.

Fig. 2. A 7-year-old with a history of rhabdomyolysis, myocarditis, Influenza A, myositis and bradypnea presented with facial asymmetry and right hemiplegia. Imaging completed 2 hours and 50 minutes from ictus. Axial diffusion weighted imaging (A) showing a large, wedge-shaped area of restricted diffusion (marked as *) involving the left fronto-parietal lobes as well as the left gangliocapsular regions, in keeping with acute left MCA

infarction, with MRI-ASPECTS score 0. Coronal (B) and axial (C) MIP reconstructions of the CT Angiogram in delayed phase showing loss of opacification within the left ICA and the MCA (solid arrow in B) along with poor collaterals in the left MCA territory (marked as * in C). Sagittal MIP reconstructions of the CT Angiogram (D) demonstrating the site of thrombo-occlusion (i.e., proximal left ICA; arrow).

Thrombophilia workup was within normal limits, D-Dimer elevated to 4.07 UG/ml.

Follow up CT-head after 24 hours showed redemonstration of the large left MCA infarct with no new intracranial hematoma, mild increase in swelling overlying the infarction with some effacement of the left cerebral hemisphere sulci and mild midline shift. There was non-opacification of the entire left ICA from approximately 1 centimeter above its origin to involve the entire carotid artery, proximal middle cerebral artery and left A1 ACA. Following multidisciplinary team discussion, it was felt that these could represent clot filling these vessels or alternatively collapsed vessel with clot occlusion

more distally. Patient received a third CT head follow up which was unchanged from previous.

Patient was discharged to the local rehabilitation center after a one-month admission. She was commenced on Aspirin 81mg daily for secondary stroke prevention. PSOM at 2 years post-discharge was 2.5 due to sensorimotor deficits scoring 2 and language deficit with dysarthria scoring 0.5, her mRS is 4.

REFERENCES

1. Rocha M, Desai S, Son J, Tonetti DA, Jovin T, Jadhav AP. Clinical characteristics of fast and slow progressors of infarct growth in anterior circulation large vessel occlusion stroke. J Cereb Blood Flow Metab. 2021 Jun 17; 41(7): 271678X211015068. doi: 10.1177/0271678X211015068.
2. Rocha M, Jovin TG. Fast versus slow progressors of infarct growth in large vessel occlusion stroke: clinical and research implications. Stroke. 2017; 48:2621–2627
3. Ospel JM, Hill MD, Kappelhof M, Demchuk AM, Menon BK, Mayank A, Dowlatshahi D, Frei D, Rempel JL, Baxter B, Goyal M. Which Acute Ischemic Stroke Patients Are Fast Progressors? Stroke. 2021 May; 52(5): 1847-1850. doi: 10.1161/STROKEAHA.120.032950. Epub 2021 Apr 5.PMID: 33813863
4. Patel SD, Liebeskind D. Collaterals and Elusive Ischemic Penumbra. Transl Stroke Res. 2023 Feb;14(1):3-12. 5. Bellomo J, Sebök M, Stumpo V, van Niftrik CHB, Meisterhans D, Piccirelli M, Michels L, Reolon B, Esposito G, Schubert T, Kulcsar Z, Luft AR, Wegener S, Regli L, Fierstra J. Blood Oxygenation Level-Dependent Cerebrovascular Reactivity-Derived Steal Phenomenon May Indicate Tissue Reperfusion Failure After Successful Endovascular Thrombectomy. Transl Stroke Res. 2025 Apr;16(2):207-216.

AFFILIATIONS

Samyami S. Chowdhury, MBChB, MRCPCH Division of Pediatric Neurology, McMaster Children's Hospital, McMaster University, Canada and Division of Pediatric Neurology, The Hospital for Sick Children, University of Toronto, Canada

Vivek Pai, MD
Division of Neuroradiology and Interventional Radiology, University of Toronto, Canada.

Kartik Bhatia, MD, PhD, FRANZR
IDepartment of Pediatric Neurointervention, Sydney Children's Hospital, New South Wales, Australia.

Nomazulu Dlamini, MBBS, PhD, FRCPC
Division of Pediatric Neurology, The Hospital for Sick Children, University of Toronto, Canada.

Prakash Muthusami, MBBS, MD
Division of Neuroradiology and Interventional Radiology, University of Toronto, Canada.

Pediatr Stroke. 2026;13: 101-110
www.pediatricstrokejournal.com