EDITORIAL

Paediatric Cerebral Sinovenous Thrombosis: Diagnostic challenges, therapeutic uncertainties, and context-sensitive management opportunities

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Cerebral sinovenous thrombosis (CSVT) constitutes a relatively smaller, but clinically significant and disproportionately morbid cause of childhood cerebrovascular disease. The annual incidence of cerebral sinovenous thrombosis in children (term neonates through 18 years) ranges between 0.4 and 0.7 per 100,000 children per year and is relatively more common in neonates compared with older children.[1] CSVT is often associated with cerebral venous infarction (ischaemia or haemorrhage or both) and increase in intracranial pressure, leading often to significant long-term neurodevelopmental impairment, epilepsy and even death.[2] Considering paediatric arterial ischaemic stroke (AIS) the predominant subtype of paediatric stroke, CSVT remains relatively underexplored across both high-income and resource-limited healthcare settings, resulting in persistent diagnostic and therapeutic gaps. These gaps are particularly consequential in resource-limited low- and middle-income countries (LMICs), frequently resulting in delayed recognition of CSVT and preventable neurological sequelae.[3-5]

CSVT can involve the superficial or deep venous systems (either alone or in combination) {Figure}, with superficial thrombosis (superior sagittal and transverse sinuses) typically causing headache and focal neurologic deficits, while deep system involvement (inferior sagittal and straight sinus, Vein of Galen, and internal cerebral veins) often leading to rapid encephalopathy, seizures, and bilateral neurologic deficits.

The clinical presentation of CSVT also varies considerably with age. Neonates typically manifest with nonspecific features such as lethargy, irritability, poor feeding, or seizures, whereas older children more often present with progressive headache, vomiting, visual disturbances, papilloedema, or focal neurological deficits.[6,7] Heterogeneous and often nonspecific clinical presentation of CSVT hinders timely diagnosis, with recognition sometimes occurring only after substantial brain injury has already developed. Observational data from Pakistan and comparable LMICs demonstrate that symptoms are frequently misattributed to infectious, metabolic, or hypovolaemic causes.[2-5]

The pathophysiology of CSVT reflects the interaction of endothelial injury, venous stasis, and systemic hypercoagulability, as described by Virchow's triad.[1] Structural imaging studies in tertiary care hospitals have highlighted age-specific risk factors, predisposing conditions, and characteristic venous thrombosis patterns. In neonates, perinatal risk factors predominate, including dehydration, sepsis, meningitis, perinatal hypoxic injury, congenital heart disease, and inherited thrombophilia. In older children, head and neck infections, systemic inflammatory disorders, nephrotic syndrome, malignancy, trauma, and prothrombotic states are more commonly implicated.[8] Regional epidemiological patterns are evident, with Pakistani cohorts consistently identifying infection and sepsis as leading risk factors and demonstrating a male predominance, highlighting the combined influence of biological susceptibility and healthcare access.[4,5] Nevertheless, the true etiological spectrum remains incompletely defined due to the absence of large prospective studies.[1]

A high index of clinical suspicion is crucial for guiding prompt diagnosis, treatment and prognostication of CSVT, particularly in resource-constrained settings which includes recognition of age specific clinical presentation and risk factors and venous territory and brain parenchymal involvement. Children presenting with unexplained seizures, progressive headache, altered consciousness, papilloedema, or focal deficits—particularly in the context of systemic infection or dehydration—should prompt urgent consideration of venous imaging, ideally within an organized paediatric stroke care framework, as per AHA/ASA guidelines.[2, 9]

While brain MRI and contrast enhanced MR venography remains the preferred modality for diagnosing CSVT in children, head CT and CT venography (CTV) is often

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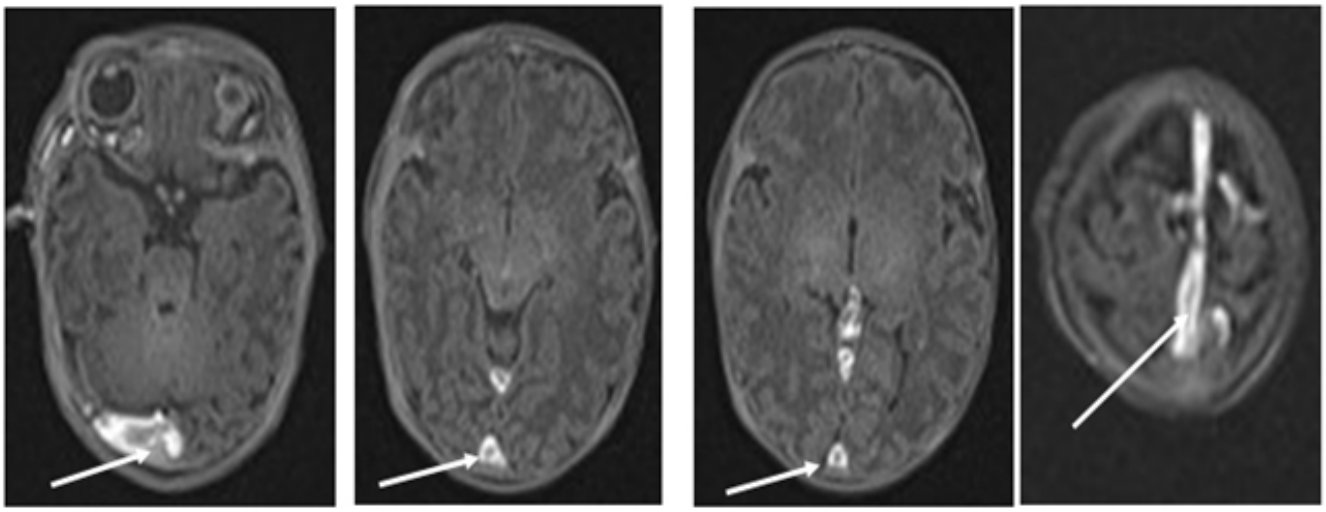

Figure: 15-day old term neonate presenting with lethargy and recurrent focal seizures and phase contrast MR venogram showing extensive filling defect consistent with thrombosis in both the superficial and deep venous systems (torcula, superior sagittal, straight and transverse sinuses, vein of Galen and bilateral internal cerebral veins).

indispensable, providing rapid and widely accessible imaging that enables timely diagnosis with comparable accuracy in acute care settings, particularly in limited resource settings. As a result, CT and CTV frequently serve as the initial imaging modality in most centers.[7,8,10] However compared to MRI, this imaging modality has limited sensitivity for detection of parenchymal brain injury and also cortical vein thrombosis.

Management includes supportive care, treatment of precipitating conditions, and anticoagulation to prevent thrombus propagation and facilitate recanalization. Supportive measures include optimization of hydration, correction of anaemia, treatment of infection, and management of raised intracranial pressure and seizures.[1] Anticoagulation with low-molecular-weight or unfractionated heparin is recommended for most children beyond the neonatal period, generally for 3 to 6 months or until radiological resolution of thrombus, in accordance with international paediatric haematology guidelines.[3,11] Haemorrhagic venous infarction is not an absolute contraindication to anticoagulation when close monitoring is ensured. Over the last few years, direct oral anticoagulants (DOACs) are increasingly favoured over warfarin in paediatric CSVT for delivering effective anticoagulation with predictable dosing, enhanced patient safety and convenience.

Therapeutic uncertainty is greatest in neonatal CSVT, where the risk of intracranial haemorrhage complicates decision-making. Current recommendations vary: the American College of Chest Physicians supports anticoagulation in neonates without extensive intracranial haemorrhage, with close radiological surveillance and escalation if thrombus progression occurs.[11] In contrast, the American Heart Association (AHA) advocates a more conservative approach, reserving anticoagulation for cases with clinical or radiological deterioration/propagation of thrombus.[1] Observational studies suggest that anticoagulation is generally safe in neonates, including those with intracerebral haemorrhage, and may reduce thrombus propagation and adverse outcomes.[4-6] In the absence of randomized controlled trials, variation in clinical practice persists.

Long-term outcomes following paediatric CSVT are highly variable. Venous infarction and seizures at presentation are consistent predictors of adverse neurodevelopmental outcomes, including cognitive impairment, motor disability, and epilepsy.[2,6] Registry data indicate that up to 40% of affected children experience persistent neurological deficits, underscoring the importance of structured, multidisciplinary follow-up beyond the acute phase.[7] Although recurrence is uncommon, children with persistent prothrombotic conditions may require prolonged anticoagulation.

The burden of CSVT is amplified in LMICs, where limited access to neuroimaging, shortages of paediatric neurology expertise, constrained anticoagulation availability, and high rates of infection and malnutrition converge to delay diagnosis and worsen outcomes.[4,5] However, these settings also present opportunities for improvement. Focussed clinician education, pragmatic diagnostic pathways, and integration of CSVT into existing paediatric stroke systems may substantially

improve recognition and management without disproportionate resource investment.[1,2] Emerging Pakistani data challenge the perception that paediatric CSVT is rare and emphasize the need for national awareness initiatives, standardized diagnostic algorithms, and context-sensitive treatment protocols aligned with international guidance.[2,8]

Paediatric CSVT remains a diagnostically challenging, yet clinically significant cause of childhood stroke. While advances in neuroimaging and anticoagulation have improved outcomes, major evidence gaps persist, particularly in management of neonatal CSVT and in resource-limited settings. Strengthening organized paediatric stroke care pathways and elevating awareness of venous stroke are essential steps toward reducing preventable morbidity and preserving long-term neurological function.

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