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Cerebral Sinovenous Thrombosis: A Pediatric Tertiary Center Case Series From the United Arab Emirates (UAE)

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Abstract

Background: Cerebral sinovenous thrombosis (CSVT) is a rare but significant cause of pediatric morbidity and mortality, with management strategies often extrapolated from adult data due to a paucity of pediatric-specific evidence. This study aims to characterize the clinical presentations, etiological profiles, neuroimaging findings, therapeutic approaches, and outcomes of pediatric CSVT at a single pediatric tertiary center in the UAE, making this the first pediatric case series from the region.

Methods: A retrospective case series was conducted at Al Jalila Children's Hospital, Dubai, including all children under 18 years with radiologically confirmed CSVT between 2015 and 2025. Data on demographics, clinical features, risk factors, imaging, treatment, and outcomes were collected.

Results: Thirteen children (median age: 6 years, 54% male) were identified. Trauma was the predominant etiology (46%), followed by infection (38%). Headache (82%) and vomiting (69%) were the most common symptoms; cranial nerve involvement occurred in 46%, and seizures in 31%. The sigmoid sinus was the most frequently involved site (62%), and more than half of the patients (54%) had more than one sinus involved. Anticoagulation was administered to 62% of patients and was well tolerated. Complete recanalization was demonstrated in 100% of the cohort with follow-up imaging (n=8), including 6 who received anticoagulation and 2 who underwent conservative management without anticoagulation. Favorable neurological outcome (modified Rankin Scale: 0-2) was observed in 89% of patients with available follow-up data (8 of 9; excluding the deceased patient). One remaining patient experienced an unfavorable outcome characterized by focal symptomatic epilepsy and global developmental delay, while the deceased patient succumbed during the initial hospitalization due to systemic sepsis and uncontrolled intracranial hypertension.

Conclusions: Pediatric CSVT represents a diagnostic and therapeutic challenge. Awareness is especially important in children with risk factors such as head and neck infections, trauma, and anemia. Anticoagulation is both safe and effective for restoring venous flow, though a high rate of recanalization can be achieved with conservative management. Clinicians should routinely include venography in the neuroimaging workup of children with risk factors presenting with a combination of headache, vomiting, seizures, and cranial nerve palsies, and consider anticoagulation for all symptomatic patients lacking major intracranial hemorrhage to mitigate acute CSVT complications, shorten the course of illness, and optimize outcomes.

Categories: Neurology, Pediatrics, Neurosurgery
Keywords: anticoagulation, cerebral sinovenous thrombosis, csvt, cvst, infection, pediatric, risk factors, trauma, treatment outcome, venography

Introduction

Cerebral sinovenous thrombosis (CSVT) encompasses a spectrum of disorders involving thrombosis of the cerebral venous system, a network of cortical, medullary, and deep veins that drain into dural venous sinuses. Thrombotic occlusion of this system precipitates a cascade of pathophysiological events: obstructed venous outflow elevates central venous pressure, increases intracranial pressure (ICP), and impairs cerebral perfusion. In severe cases, this progression culminates in venous ischemia, which may evolve into hemorrhagic infarction [1].

The reported annual incidence of pediatric CSVT ranges from 0.4 to 0.7 cases per 100,000 children, though this likely underestimates the true burden due to diagnostic challenges related to non-specific presentations [2]. Clinical manifestations vary considerably by age and chronicity. Neonates typically present with encephalopathy and seizures, whereas older children classically exhibit a triad of headache, vomiting, and altered mental status that progresses over days [1].

CSVT is associated with a wide variety of predisposing factors, which align with Virchow's triad: endothelial injury, hypercoagulable states, and venous stasis. These factors also demonstrate age-dependent patterns; acute systemic illness (bacterial sepsis and perinatal complications) is the predominant risk factor for neonatal CSVT, while head/neck infections, chronic systemic diseases, iron-deficiency anemia, and prothrombotic conditions prevail in older children [1,3]. Head trauma has emerged as an increasingly recognized precipitant, particularly when fractures involve dural venous sinuses [4].

Neuroimaging remains the cornerstone of diagnosis. Magnetic resonance imaging (MRI) combined with magnetic resonance venography (MRV) constitutes the gold-standard modality, offering superior sensitivity for parenchymal assessment and direct visualization of clots [1,5]. Computed tomography (CT) with CT venography (CTV) provides a practical alternative with rapid acquisition and high thrombus detection, albeit with ionizing radiation exposure and limited parenchymal characterization [1].

According to the American Society of Hematology (ASH)/International Society on Thrombosis and Haemostasis 2024 guidelines, pediatric CSVT should generally be treated with anticoagulation (unfractionated heparin or low-molecular-weight heparin (LMWH)), even in the presence of intracranial hemorrhage, unless contraindicated [6]. Treatment is typically continued for at least 3 months, with duration guided by clinical factors and follow-up imaging [7]. Heparin is typically the first-line therapy, followed by oral anticoagulants such as warfarin or novel oral anticoagulants [3].

This study aims to characterize the clinical presentations, neuroimaging findings, etiological profiles, therapeutic approaches, and outcomes of pediatric CSVT at a tertiary referral center. By analyzing our institutional experience, we seek to contribute to the growing body of evidence informing evidence-based management of this challenging condition.

Materials And Methods

Study design and setting

This retrospective case series was conducted at Al Jalila Children’s Hospital, a tertiary care and academic medical center in Dubai, United Arab Emirates (UAE). The study period extended from January 2015 to December 2025. The study protocol was reviewed and approved by the institutional review board (reference number: MBRU IRB-2025-1047), with a waiver of informed consent granted due to the study's retrospective design and the use of de-identified data. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and adhered to Good Clinical Practice (GCP) guidelines. Patient confidentiality was maintained throughout, and all data were handled in compliance with applicable institutional and national data protection regulations.

Study population

Potential subjects were identified using the Slicer-Dicer tool in the electronic medical record system (Epic Systems Corporation, Verona, Wisconsin, United States). The initial query captured all patients under 18 years of age who underwent diagnostic cerebral venography (brain CTV or MRV) during the study period, to comprehensively screen for CSVT. Two independent investigators, a pediatric neurology resident and a general pediatrics resident, reviewed each potential case, with disagreements resolved by consensus with a senior pediatric neurologist.

Inclusion criteria encompassed patients under 18 years at diagnosis (i.e., pediatric as defined by our institution) with radiological confirmation of CSVT by CTV, MRI/MRV, or conventional angiography who were managed at our institution during the acute or subacute phases (operationally defined as symptom onset to presentation within 48 hours for the acute phase, and between 48 hours and 30 days for the subacute phase).

Exclusion criteria were patients undergoing diagnostic cerebral venography who were ultimately found not to have CSVT, incidental CSVT diagnosed postmortem, isolated superficial cortical vein thrombosis without dural sinus involvement, and incomplete medical records precluding adequate data extraction.

Data collection and variables

A standardized data abstraction form was developed in Microsoft Excel (Microsoft Corp., Redmond, WA, USA) following a priori variable definitions. Data were extracted from electronic health records by two trained abstractors who were blinded to the study objectives, and a third investigator verified a random 20% sample to ensure accuracy, achieving an inter-rater reliability κ greater than 0.85 for all key variables.

The collected data encompassed demographic characteristics, including age at presentation (categorized as neonate (0-28 days), infant (29 days-1 year), early childhood (1-5 years), middle childhood (6-12 years), adolescence (13-18 years)), gender, and nationality. Clinical presentation data included symptom duration before admission, presence of symptoms, including headache, vomiting, altered mental status (Glasgow Coma Scale (GCS) <15 or age-appropriate modified GCS) [8], epileptic seizures (focal/generalized/status

epilepticus), focal neurological deficits (hemiparesis, cranial nerve palsies), signs of elevated ICP (papilledema on fundoscopy, bulging fontanelle in infants), and documented abnormal movements such as ataxia.

Risk factors and etiology were categorized hierarchically. Infection encompassed mastoiditis, meningitis/encephalitis, otitis media, and post-infectious cerebellitis. The trauma category comprised documented craniocerebral injury, irrespective of skull fracture, characterized by a latency period of one to seven days between the precipitating event and the emergence of symptoms. Hematologic causes included iron-deficiency anemia (hemoglobin <2 SD for age with microcytosis) and other prothrombotic conditions. Dehydration required clinical documentation with corresponding laboratory evidence. Cases with no identifiable cause after comprehensive evaluation were classified as idiopathic. Thrombophilia evaluation data were recorded when available, including protein C, protein S, antithrombin III, factor V Leiden, prothrombin gene mutation, antiphospholipid antibodies, and homocysteine levels.

Neuroimaging data included the performed modalities, timing relative to admission, involved sinuses (superior sagittal, inferior sagittal, transverse, sigmoid, straight, torcula, internal jugular, cavernous), parenchymal abnormalities (venous infarction, hemorrhage, edema), and the presence of concurrent pathology (mastoiditis, subdural hematoma, space-occupying lesion).

Treatment data encompassed anticoagulation type and duration, adjunctive therapies (antibiotics, antiepileptic drugs, acetazolamide, and surgical interventions), and management of underlying conditions. In-hospital complications were categorized as hemorrhagic, thrombotic progression, medication-related, neurological sequelae, and mortality.

Follow-up and outcomes included repeat imaging timing and findings (complete recanalization, partial recanalization, no change, progression), clinical status at discharge based on modified Rankin Scale (mRS) [9], and follow-up assessment (neurological examination findings, mRS for children where documented).

Outcome definitions

The primary outcome was radiological outcome at last follow-up, categorized as complete recanalization (restoration of normal flow in all previously thrombosed sinuses), partial recanalization (residual non-occlusive thrombus or persistent occlusion of some but not all affected sinuses), no recanalization (persistent occlusion without improvement), and progression (extension of thrombus to additional sinuses).

Secondary outcomes included neurological outcomes assessed with the mRS for children, a validated instrument that grades functional independence from 0 (no symptoms) to 6 (death). Neurological outcome was dichotomized as favorable (mRS: 0-2, indicating no significant disability) and unfavorable (mRS: 3-6, representing moderate to severe disability or death). The mRS was retrospectively assigned through a systematic review of clinical records at both hospital discharge and the final documented follow-up, with the latter serving as the primary endpoint for outcome analysis.

Data analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 28.0 (IBM Corp., Armonk, NY). Descriptive statistics summarized patient characteristics: continuous variables were reported as medians with interquartile ranges (IQRs) due to non-normal distributions (Shapiro-Wilk test), and categorical variables were reported as frequencies with percentages.

Given the small sample size, multivariable logistic regression with Firth's penalized likelihood method was planned but not reliably performed due to the limited number of events.

Results

Baseline characteristics

From the electronic medical record, 40 patients who underwent diagnostic cerebral venography (brain CTV or MRV) were identified. After applying inclusion and exclusion criteria and removing duplicate entries, 13 cases with radiologically proven CSVT were included in the analysis.

The cohort comprised 7 (54%) males and 6 (46%) females, yielding a male-to-female ratio of 1.17:1. The median age at presentation was 6 years (IQR: 3-11 years; range 5 weeks to 14 years). Age distribution revealed: infants (<1 year): 2 (15%), early childhood (1-5 years): 6 (46%), middle childhood (6-12 years): 3 (23%), and adolescence (13-18 years): 2 (15%). No neonatal cases were identified. Ethnic distribution showed that 9 (69%) patients were of Middle Eastern origin, 2 (15%) were South Asian, 1 (8%) was African, and 1 (8%) was Caucasian (Table *1*).

Characteristic	n (%)
Sex	
Male	7 (54)
Female	6 (46)
Age category	
Infant (<1 year)	2 (15)
Early childhood (1-5 years)	6 (46)
Middle childhood (6-12 years)	3 (23)
Adolescence (13-18 years)	2 (15)
Ethnicity	
Middle Eastern	9 (69)
South Asian	2 (15)
African	1 (8)
Caucasian	1 (8)

TABLE 1: Baseline demographics

Clinical presentation in this cohort was predominantly acute, with 69% (n=9) of patients presenting with symptoms of less than 2 days' duration.

Four (31%) patients presented with subacute symptoms lasting more than 2 days. The duration of symptoms among these patients ranged from 5 to 11 days, with a mean duration of 7 days and a maximum duration of 11 days. The most prevalent clinical features included headache (82%) and vomiting (69%), reflecting a high likelihood of increased ICP. Nearly half of the cohort (46%) exhibited cranial nerve involvement, while more severe neurological manifestations, including status epilepticus (15%), hemiparesis (15%), and ataxia (8%), were less frequent. Altered mental status and papilledema were each observed in 23% of cases. None of the cases presented with chronic symptoms of raised ICP. Interestingly, one of the cases did not have any of the specific symptoms described earlier and was diagnosed incidentally after post-trauma neuroimaging, highlighting the clinical variability of pediatric CSVT and the necessity of high clinical suspicion in at-risk populations (Table *2*).

Symptom duration	N (%)
Acute (≤48 hours)	9 (69)
Subacute (>2 days to 30 days)	4 (31)
Presenting symptoms	
Headache	9/11 (82)*
Vomiting	9 (69)
Cranial nerve involvement	6 (46)
Status epilepticus	2 (15)
Altered mental status/encephalopathy	3 (23)
Papilledema	3 (23)
Hemiparesis	2 (15)
Ataxia	1 (8)
Asymptomatic	1 (8)

TABLE 2: Clinical characteristics

*We excluded 2 infants in whom headache could not be assessed.

Risk factors and etiology

Trauma was identified as preceding event in 6 patients; mechanisms included falls from height (n=3) and motor vehicle accidents (n=2), and one case of non-accidental injury. Infectious/parainfectious association was identified in 5 patients, including acute mastoiditis (n=2), meningitis (n=2), and post-infectious cerebellitis (n=1). Two patients had anemia, one with severe iron-deficiency with a ferritin level of <2 ng/mL, while the other had underlying sickle cell anemia. Additionally, 1 patient had severe dehydration. (Table *3*).

Risk factors/associations	n (%)
Trauma	6 (46)
With skull fracture	3 (23)
Infection	5 (38)
Acute mastoiditis	2 (15)
Meningitis/encephalitis	2 (15)
Post-infectious cerebellitis	1 (8)
Hematologic	2 (15)
Iron-deficiency anemia	1 (8)
Sickle cell anemia	1 (8)
Dehydration	1 (8)

TABLE 3: Distribution of etiologies and risk factors

Investigations

Ferritin levels were available for 5 patients, with a median of 44 ng/mL (IQR: 44-153.5). These values were evaluated against age-adjusted reference ranges (newborns: 25-200 ng/mL; ⩽1 month: 200-600 ng/mL; 2-5

months: 50-200 ng/mL; 6 months-15 years: 7-142 ng/mL). Normal values were observed in 4 of 5 patients; 1 patient had low ferritin (<2 ng/mL), consistent with iron-deficiency anemia. Furthermore, thrombophilia testing was performed in 9 (69%) patients, all of whom yielded normal results.

Initial imaging was CT brain in all cases (n=13), with CTV performed in 11 (85%) patients, and MRI with MRV in the remaining 2 (15%) patients. Results showed that 12 of 13 patients had superficial venous sinus thrombosis, while 1 patient had deep venous system involvement. The sigmoid sinus was the most commonly involved (62%). Multiple sinus involvement was found in 7/13 patients (Table *4*).

System involved	n (%)
Superficial	12 (92)
Deep	1 (8)
Sinus involved	
Sigmoid sinus	8 (62)
Right	6 (46)
Left	2 (15)
Transverse sinus	7 (54)
Right	5 (38)
Left	2 (15)
Internal jugular vein	5 (38)
Right	3 (23)
Left	2 (15)
Superior sagittal sinus	4 (31)
Straight sinus	1 (8)
Torcula	1 (8)
Cavernous sinus	0 (0)
Multiple sinus involvement (>1)	7 (54)

TABLE 4: Distribution of thrombosed venous sinuses

Treatment approaches

Eight (62%) patients received anticoagulation with LMWH (enoxaparin). Conservative management (no anticoagulation) was used in five (38%) patients, mainly due to intracranial hemorrhage, clinical instability, or parental refusal. The median duration of anticoagulation was 3 months (range 1-6 months). In addition to LMWH, patients were treated for the associated etiologies, including antibiotics where an infectious etiology was noted. Surgical interventions included decompressive craniectomy in 1 patient with cerebral edema and myringotomy in 1 patient with mastoiditis (Table *5*).

Intervention	n (%)
Anticoagulation	
LMWH (enoxaparin)	8 (62)
Conservative (no anticoagulation)	5 (38)
Antibiotics	4 (31)*
Anti-seizure medications	4 (31)*
Acetazolamide	2 (15)*
Decompressive craniectomy	1 (8)*
ICP monitoring/management	1 (8)*
Myringotomy	1 (8)*

TABLE 5: Therapeutic interventions

*These adjunctive therapies were used in both anticoagulated and conservatively managed patients as clinically indicated; numbers reflect total patients receiving each intervention regardless of anticoagulation status.

LMWH, low-molecular-weight heparin; ICP, intracranial pressure.

Complications

During the acute phase of hospitalization, 7 (54%) patients experienced an uncomplicated clinical course. Conversely, neurological complications were observed in the following patients: 2 (15%) patients exhibited strabismus, 1 (8%) presented with ataxia accompanied by nystagmus, and 1 (8%) developed hemiparesis. Notably, a 5-year-old female presenting with suspected encephalitis and intraparenchymal hemorrhage developed refractory intracranial hypertension; despite undergoing an emergency decompressive craniectomy, the patient died during the initial hospitalization. Additionally, 1 (8%) patient sustained trauma-related hearing loss. The cohort remained free of major hemorrhagic events, heparin-induced thrombocytopenia, or thrombus propagation.

Radiological outcomes

Repeat neurovascular imaging was performed in 8 (62%) patients, encompassing 6 treated with anticoagulation and 2 under conservative management, with follow-up intervals ranging between 2 and 3 months. Six patients underwent MRV (n=6), while the remaining two patients underwent CTV. Notably, complete recanalization was observed in all 8 patients with follow-up imaging (n=8; 6 anticoagulated and 2 managed conservatively), but the small denominator warrants cautious interpretation. This finding reflects a high capacity for recanalization, whether spontaneous or treatment-facilitated, rather than definitive evidence of therapeutic efficacy.

Neurological outcomes

At discharge, mRS scores were available for 11 patients (2 infants <2 months of age could not be evaluated, as the mRS is not validated in this age group). Among those scored, 6 patients had mRS: 0, 2 had mRS: 1, 2 had mRS: 3, and 1 died (mRS: 6).

Excluding the deceased patient, follow-up data were available for 9 (69%) patients at a median of 4 months (range, 1-12 months). Among these, 7 (78%) patients achieved a normal neurological examination (mRS: 0), 1 (11%) had a favorable outcome (mRS: 2), and 1 (11%) had an unfavorable outcome (mRS: 3). Three patients were lost to follow-up.

At long-term follow-up (≥3 months), the previously documented hemiparesis resolved completely, whereas strabismus and ataxia persisted. Delayed morbidity included 1 (8%) patient who developed global developmental delay and focal symptomatic epilepsy; a second patient who developed seizures during the acute phase was subsequently lost to follow-up.

Discussion

This retrospective cohort study of thirteen children with CSVT at a tertiary pediatric hospital in the UAE provides valuable insights into the clinical spectrum, etiological profile, management, and outcomes of this

uncommon but potentially devastating condition. Our findings underscore several important observations that merit discussion in the context of the existing literature.

The demographic characteristics of our cohort align with previously published series, with a median age of 5 years and a slight male predominance (54%) consistent with the International Pediatric Stroke Study, which found 54% male representation among CSVT cases [10]. The absence of neonatal cases in our series likely reflects referral patterns and the specialized nature of neonatal care at separate facilities rather than true absence.

The clinical presentation in our cohort was dominated by headache (82%), vomiting (69%), and cranial nerve involvement (46%), mirroring the classic triad described in pediatric CSVT [4]. The high proportion of cranial nerve deficits observed in 46% of patients warrants particular emphasis, as these findings provide important localizing value and should prompt urgent and appropriate neuroimaging when present to exclude CSVT. The 15% seizure frequency falls within the reported range of 20%-50% in pediatric series [11,12].

A striking finding in our series is the predominance of trauma as the most common association, accounting for 46% of cases, exceeding the frequency of infection at 38%. This contrasts with much of the published literature, in which head and neck infections are traditionally the most common risk factor, accounting for 25%-50% of cases [5,8]. Several explanations may account for this discrepancy, including referral bias (our institution being the regional referral center for pediatric head trauma), increased awareness, and a lower threshold for vascular imaging in patients with head trauma. Monagle et al. recently highlighted that trauma-induced CSVT may be substantially under-recognized, as only a fraction of head trauma cases undergo dedicated venous imaging [6]. The mechanism involves skull fractures crossing dural sinuses, causing local venous stasis and turbulence from disrupted venous drainage, particularly in displaced fractures affecting the superior sagittal or transverse-sigmoid junctions [13]. This emphasizes the importance of considering CSVT in children presenting with neurological symptoms following head trauma [14].

The pathophysiology of infection-associated CSVT involves direct inflammation and thrombus extension from contiguous foci such as mastoiditis or meningitis, potentially creating a self-limited process that responds well to antibiotics and anticoagulation. Roth et al. similarly observed faster recanalization at three months in infection-associated CSVT, proposing that earlier reimaging at 6 to 8 weeks may help guide treatment duration [5]. Our practice of obtaining follow-up MRI at 2 to 3 months aligns with this approach. However, the optimal timing for reimaging remains undefined and warrants further investigation through prospective studies.

Anemia is a known risk factor for pediatric CSVT and was identified in 15% of our patients. Barnes et al. demonstrated that children with iron-deficiency anemia have a tenfold increased ischemic stroke risk (encompassing both arterial and venous ischemic stroke), accounting for over half of such cases in previously healthy pediatric populations [15]. The pathophysiology involves anemia-induced microcytosis, impaired erythrocyte deformability, turbulent flow from reactive thrombocytosis, and altered platelet regulation [16,17]. Those patients also had a favorable prognosis, as evidenced by complete recanalization and improvement in mRS score on follow-up despite deep venous system involvement. Favorable recovery has been reported in similar pediatric cases [18]. Thus, iron-deficiency anemia is a recognized but reversible prothrombotic risk factor in pediatric CSVT [19]. This supports recommendations for routine anemia screening in all children presenting with CSVT and aggressive iron replacement therapy alongside anticoagulation when indicated. This represents a readily modifiable risk factor that may be incorporated into primary prevention strategies for at-risk populations [20].

All patients in our series underwent initial CT imaging; 85% underwent additional CTV, and 15% underwent MRI with MRV. Notably, Cornelius reported that in the absence of clinical suspicion for CSVT, unenhanced brain CT may miss up to 53% of cases, highlighting its limited sensitivity as a screening modality [18]. Various studies recommend that, when CT appears normal but clinical suspicion persists based on presenting symptoms and risk factors, MRI with MRV should be performed promptly [4,21].

The distribution of sinus involvement in our cohort, with sigmoid sinus involvement in 62%, transverse sinus in 54%, and internal jugular vein in 39%, differs from some series reporting the superior sagittal sinus as the most common site [22]. However, our findings align closely with those of Sellers et al. who identified the transverse sinus in 72% and the sigmoid sinus in 53% as the predominant sites in their case-control study [3]. This variation likely reflects differences in etiological profiles across studies.

Historically, data have demonstrated thrombus progression in 37% of untreated patients compared with only 7% of those receiving anticoagulation therapy [23]. While our specific cohort achieved a 100% recanalization rate among all patients with follow-up imaging, including those managed conservatively, these findings are inherently limited by our small sample size and are thus non-conclusive. Importantly, we observed no major hemorrhagic complications among anticoagulated patients, consistent with Monagle et al. who reported minimal adverse events in pediatric trauma-associated CSVT [6].

Our findings suggest that LMWH is well-tolerated in children, even in the context of traumatic brain injury, provided careful patient selection and appropriate monitoring are implemented. However, given the limited scale of our observation, therapeutic decisions should continue to be guided by the updated ASH 2024 guidelines, which recommend anticoagulation for pediatric CSVT even in the presence of hemorrhage [7]. Adhering to these international standards ensures that clinical practice remains evidence-based, despite encouraging outcomes reported in smaller regional series.

However, the therapeutic decision cannot be reduced to a simple binary choice. Among conservatively managed patients in our series, two had significant intracranial hemorrhage at presentation, representing a clinical situation of true equipoise where anticoagulation risk may outweigh potential benefit. Donohue et al. similarly emphasized the importance of individualized decision-making based on hemorrhage size, clinical stability, and risk of thrombus progression [23]. Furthermore, the 62% anticoagulation rate in our series falls within the 60%-69% range reported in North American and European centers [22], suggesting that our practice patterns align with international standards.

In the present cohort, the overall survival rate at discharge was 92%, and 89% (8/9) of patients with available follow-up achieved a favorable neurological outcome (mRS <3). Notably, of the two patients presenting with seizures, one experienced a poor outcome (mRS: 3), while the other was lost to follow-up. These observations align with existing literature, which frequently identifies seizures, coma, and parenchymal brain lesions as predictors of adverse neurological sequelae in pediatric CSVT. In contrast, an isolated headache is typically associated with a more favorable prognosis [18]. Multiple venous sinus involvement is a significant predictor of poor outcome in pediatric CSVT, being associated with severe clinical presentation and long-term sequelae.

Conversely, isolated sinus thrombosis generally confers a more favorable prognosis [18], a trend mirrored in our cohort. While Maguire et al. reported variable outcomes in their series of 148 patients [12], Shah et al. observed that involvement of the superior sagittal sinus was specifically associated with poorer neurological outcomes [13].

The loss-to-follow-up rate in our cohort was 23% (3 of 13 patients; 25% of 12 survivors), highlighting a critical challenge in pediatric CSVT research and clinical care. This may reflect the transient nature of our expatriate population, where families frequently return to their countries of origin, or the perception among families that complete recovery obviates the need for continued follow-up. Moreover, Dubai's expatriate-heavy demographic contributes to a transient clinical population, further underscoring the need for regional multicenter registries to ensure robust longitudinal outcome capture. However, given reports of late neurocognitive sequelae even after apparent clinical recovery [22], including subtle deficits in attention, executive function, and academic performance that may emerge years after the acute event, strategies to improve long-term retention are urgently needed.

Limitations, recommendations, and future directions

This study has several important limitations. The small sample size limits statistical power and precludes meaningful multivariable analysis; therefore, findings should be considered hypothesis-generating. The retrospective design introduces potential information bias, particularly regarding symptom onset and neurological findings that may not have been uniformly documented. Loss to follow-up may have biased outcome estimates, as differential retention of patients with better or worse outcomes cannot be excluded. Thrombophilia testing was incomplete, limiting conclusions regarding prothrombotic risk and recurrence. The single-center setting restricts generalizability, and the absence of standardized outcome measures, including psychometric assessments and inconsistent pediatric mRS assessments, leading to retrospective application in some cases, limits comparability with other cohorts.

Despite these limitations, the study has notable strengths. This is the only case series of pediatric CSVT from a tertiary pediatric center in the UAE. Cases were rigorously validated through independent review, minimizing misclassification. Detailed clinical characterization provides granular insights often unavailable in administrative database studies. Inclusion of both anticoagulated and conservatively managed patients reflects real-world practice and informs decision-making. Furthermore, data from an underrepresented Middle Eastern population enhances geographic diversity in the CSVT literature and generates hypotheses regarding regional risk factors and outcomes.

Clinically, our findings support several practical considerations. A high index of suspicion is warranted in children presenting with headache, vomiting, and cranial nerve deficits, particularly following head trauma (even if minor) or head and neck infection. Venography should be routinely included in the neuroimaging workup for these cases. MRI with MRV should be obtained when CT is non-diagnostic, but suspicion persists. Screening for iron-deficiency anemia should be routine, with appropriate correction when identified. Anticoagulation decisions should be individualized, balancing thrombus progression against hemorrhagic risk; LMWH appears safe in selected patients, including those with traumatic brain injury, and this should be considered in all patients with CSVT presenting with neurological symptoms and signs. Structured long-term follow-up using standardized outcome measures is essential to detect persistent or evolving deficits.

Future research should prioritize prospective multicenter registries with standardized data collection to enable adequately powered analyses. Comparative effectiveness studies of anticoagulation strategies, including evaluation of direct oral anticoagulants, are needed to inform evidence-based guidelines. Long-term neurocognitive outcome studies and the development of pediatric-specific risk stratification tools would further refine prognosis and management. Finally, given that nearly a quarter of the cohort was lost to follow-up, strategies to improve retention are critical to strengthening outcome assessment in pediatric CSVT.

Conclusions

Pediatric CSVT poses a diagnostic and therapeutic challenge due to its rarity and diverse clinical presentation. Clinicians should maintain a high index of suspicion in children presenting with headache, vomiting, and cranial nerve deficits, particularly following head trauma or acute head and neck infections, and should routinely include venography in the neuroimaging. Although our cohort showed no apparent difference in recanalization rates between the anticoagulation and conservative management groups, a meaningful comparison was precluded by the small sample size. Nonetheless, anticoagulation was exceptionally well tolerated, with no major hemorrhagic events, heparin-induced thrombocytopenia, or thrombus propagation. In alignment with current ASH 2024 guidelines and the broader pediatric literature, clinicians should consider anticoagulation for all symptomatic patients in the absence of major intracranial hemorrhage while recognizing that its efficacy relative to conservative management cannot be established from this case series. Furthermore, proactively managing associated risk factors such as anemia, infection, and dehydration remains essential to mitigate acute complications and optimize long-term neurological outcomes.

Additional Information

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All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Mohammed Bin Rashid University of Medicine and Health Sciences issued approval MBRU IRB-2025-1047. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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