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CEREBRAL VENOUS SINUS THROMBOSIS: A COMPREHENSIVE REVIEW OF RISK FACTORS, DIAGNOSIS, MANAGEMENT, AND LONG-TERM OUTCOMES

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ABSTRACT
Cerebral venous sinus thrombosis (CVST) is an uncommon but potentially life-threatening cerebrovascular disorder characterized by highly variable clinical presentations and diverse etiological factors. Recent advances in neuroimaging, anticoagulation strategies, and understanding of COVID-19-associated thrombosis have substantially improved disease recognition and management. This review aimed to comprehensively synthesize current evidence on the epidemiology, risk factors, pathophysiology, diagnosis, contemporary management, women-specific clinical considerations, long-term outcomes, and emerging therapeutic trends in CVST. A comprehensive literature review was conducted using peer-reviewed articles, clinical guidelines, systematic reviews, randomized controlled trials, and observational studies retrieved from major scientific databases. Relevant evidence was identified using predefined search terms related to CVST, diagnosis, anticoagulation, neuroimaging, women-specific risk factors, COVID-19, and long-term outcomes. The selected studies were critically appraised and synthesized into major thematic domains. The evidence indicates that CVST is a multifactorial disorder resulting from inherited thrombophilia, acquired prothrombotic conditions, hormonal influences, and inflammatory processes. Early diagnosis using advanced neuroimaging and prompt anticoagulation remain the foundation of successful management. Direct oral anticoagulants and selective endovascular interventions have expanded therapeutic options, while recognition of women-specific risk factors and COVID-19-related thrombosis has enhanced individualized patient care. Although most patients achieve favorable functional recovery, persistent neurological sequelae and recurrence remain important long-term concerns. Continued advances in diagnostic technologies, personalized anticoagulation strategies, multidisciplinary management, and international collaborative research are expected to further improve the diagnosis, treatment, and long-term outcomes of patients with CVST.

KEYWORDS: Cerebral venous sinus thrombosis, anticoagulation, neuroimaging, women-specific risk factors, long-term outcomes

1. INTRODUCTION

Cerebrovascular disease remains one of the top causes of mortality and morbidity around the globe, which constitutes a wide spectrum of diseases that are associated with changes in blood flow within the brain through arteries or veins. Despite the fact that most of the cerebrovascular cases are associated with strokes that happen due to the presence of arterial problems, CVST has emerged as an important type of stroke, which happens in young adults with no risk factors for the vascular system. Cerebral venous sinus thrombosis involves thrombus formation in the dural venous sinuses and cerebral veins, which leads to impairment of cerebral venous drainage, raised intracranial pressure, venous infarction, and hemorrhagic stroke. Due to the varied manifestations and numerous causes of the condition, CVST remains difficult to diagnose and treat despite the major improvements in the field of neurology (Ordieres-Ortega *et al*., 2024). There is recent epidemiological evidence that suggests a sharp rise in the recognition of CVST over the past two decades due to advancement in neuroimaging technologies, increased awareness among physicians, and increased access to sophisticated diagnostic tools. Even though the incidence rate of CVST is relatively low as compared to other types of strokes, the importance of this disease lies in the fact that it mainly affects younger individuals who are at their productive age and can cause severe neurological impairment if not detected early on. The increase in the identification of rare causes and surveillance has made it possible to understand the burden of this disease (Almegren, 2025).

The pathophysiology of CVST is heterogeneous and encompasses complex relationships between genetic causes of hypercoagulability, acquired hypercoagulable states, impaired endothelial function, systemic inflammation, and changes in the hemodynamic properties of the cerebral veins. The blockage of the cerebral venous outflow leads to increased venous pressure, decreased cerebrospinal fluid drainage, brain edema, venous infarcts, and secondary intracranial hemorrhage. This knowledge has helped in establishing better anticoagulant treatments, which has improved the management of thrombotic cerebrovascular diseases (Galanti *et al*., 2024). Females are more affected with CVST because there are various hormonal or reproductive factors which greatly contribute to increasing the risk for developing venous thromboembolism. These include pregnancy, post-partum phase, usage of oral contraceptives, hormone replacement therapies, and assisted reproductive techniques which lead to physiological or acquired hypercoagulable states and put

women at risk for developing cerebral vein thrombosis. Thus, it is important to identify women's risk factors for proper management and prevention of disease recurrences in the future.

In the last decade, the approach towards CVST has seen substantial development. While anticoagulation still plays an essential role in the treatment, increasing evidence shows that DOACs represent a promising alternative to the traditional anticoagulants, such as vitamin K antagonists, for some selected patients. Encouraging results obtained from recent randomized controlled clinical trials regarding the efficiency and safety of using rivaroxaban point at the possibility of personalized approaches to anticoagulation therapy (Field *et al*., 2023). Besides, large multicenter observational trials provide additional proof of the safety and efficiency of using DOACs (Gorman & Field, 2022). In connection with the appearance of the COVID-19 pandemic, problems have arisen in relation to the diagnosis and treatment of CVST. There is increasing evidence that SARS-CoV-2 causes endothelial dysfunction, inflammatory state, activation of platelets, and prothrombotic changes, which results in an increased likelihood of CVST development in predisposed people (Dakay *et al*., 2021). These findings in other patient populations confirmed the relationship between COVID-19 infection and severe CVST, especially in seriously ill patients characterized by severe thrombo-inflammatory state (Ostovan *et al*., 2021).

An additional important advance came from the description of vaccine-induced immune thrombotic thrombocytopenia (VITT), which is a rare yet serious adverse event in the context of adenovirus-based COVID-19 vaccines. Multicenter early studies characterized typical presentations such as thrombosis in unusual locations, thrombocytopenia, and platelet factor 4 antibodies, thus defining VITT as a unique clinicopathological syndrome with particular requirements for management (Perry *et al*., 2021). Systematic reviews published thereafter summarized the existing knowledge on the prevalence, presentation, diagnosis, and management of vaccine-associated CVST (Jaiswal *et al*., 2022). In addition, population pharmacovigilance analyses conducted throughout Europe have shed more light on the characteristics of the patients who experienced this rare adverse event (Krzywicka *et al*., 2021). Moreover, studies that compared the risk of developing a thromboembolic event as a result of either vaccination against COVID-19 or SARS-CoV-2 infection have been crucial in putting this topic into the right context by demonstrating the overall safety of the vaccine and the significantly greater risk of developing thrombosis from COVID-19 itself (Hippisley-Cox *et al*., 2021). Nevertheless, despite all the progress made in the field, many challenges still exist in terms of early detection, anticoagulant choice for a particular patient, follow-up, and recurrence prediction of a thrombotic event. New evidence is being gathered to understand long-term neurological outcomes and factors predicting prognosis better (Liao *et al*., 2026).

Therefore, this comprehensive review aims to critically analyze the existing evidence concerning the epidemiology, pathophysiology, risk factors, diagnosis, treatment approaches, specificities of management of women, long-term outcomes, and new findings related to CVST to present the state-of-the-art knowledge in the field along with the existing knowledge gaps and future directions of investigation.

2. METHODOLOGY

The study employs a comprehensive review methodology that aims at analyzing current information on risk factors, diagnosis, treatment options, and prognosis of cerebral venous sinus thrombosis (CVST). Literature relevant to the theme of the research was identified through systematic searches of peer reviewed literature, clinical practice guidelines, systematic reviews, randomized control trials, observational studies, and other scientific statements available in Google Scholar, DOAJ and Science Direct. Mainly, English language literature on the epidemiology, pathophysiology, clinical manifestations, imaging, anticoagulation, endovascular treatment, female patients, prognosis and new trends in CVST was considered, without taking into account conference abstracts, opinion papers, duplicates and other irrelevant literature. A comprehensive search was conducted with the use of a combination of keywords such as cerebral venous sinus thrombosis, cerebral venous thrombosis, CVST, risk factors, diagnosis, neuroimaging, anticoagulation, direct oral anticoagulants, endovascular treatment, pregnancy, oral contraceptive, women, COVID-19, vaccine induced immune thrombotic thrombocytopenia, long-term outcome, and prognosis. Literature that met the inclusion criteria went through title and abstract screening followed by full-text review for final selection. These selected articles were further classified into thematic categories which include epidemiology, risk factors and pathophysiology, diagnosis, current management, endovascular treatments, consideration in women patients, long-term outcome, and new trends. Data was synthesized based on critical analysis and integration of evidence from these various themes. Figure 1 shows an illustration of the entire review process from identification, screening, classification, to evidence synthesis.

Figure 1. Overview of the Comprehensive Review Process

3. RESULTS

3.1 Epidemiology and Global Disease Burden

Venous Cerebral Sinus Thrombosis (VCST) is an infrequent type of cerebrovascular disease that develops due to the clotting of the cerebral and dural venous sinuses. While being quite rare in occurrence, the diagnosis of this condition has seen a marked improvement over the last twenty years due to advancements in imaging modalities and growing awareness of clinicians regarding this type of cerebrovascular problem. In contrast to ischemic stroke, which is mostly prevalent among older people suffering from typical cardiovascular risk factors, VCST is usually associated with younger patients. The condition is also associated with female predominance due to the risk factors related to hormones and reproduction. Moreover, research findings show that there is a wide variation in the incidence rate of the disease, the causative agents, and access to health services depending on the socioeconomic status, thrombophilia, obstetrics, and infections. Generally, the early diagnosis and management of the disease have enhanced survival rates and function in most patients. Table 1 highlights the key epidemiological features of CVST.

Table 1. Global Epidemiological Characteristics of Cerebral Venous Sinus Thrombosis

Characteristic	Key Findings	Reference
Incidence	Rare stroke with increasing detection	Idiculla *et al*. (2020)
Age distribution	Mainly affects young and middle-aged adults	Ropper & Klein (2021)
Sex distribution	More common in women	Durmuş *et al*. (2020)
Geographic variation	Regional differences in risk factors	Bezerra *et al*. (2022)
Mortality	Higher with severe disease and delayed diagnosis	Nguyen *et al*. (2022)
Functional recovery	Favorable with early treatment	Hiltunen *et al*. (2016)
Overall observation	Early diagnosis improves prognosis	Saposnik *et al*. (2024)

3.2 Risk Factors and Pathophysiological Mechanisms

Thrombosis of the cerebral venous sinus arises due to a complex interplay of various prothrombotic risk factors that contribute to the dysfunction of cerebral venous flow. Thrombosis in dural venous sinuses disrupts the normal flow of blood from the brain, leading to an increased venous pressure, impaired cerebrospinal fluid absorption, cerebral edema, venous infarction, and intracranial hemorrhages (Ropper & Klein, 2021). Among inherited thrombophilic conditions, such as Factor V Leiden mutation, prothrombin G20210A mutation, protein C deficiency, protein S deficiency, and antithrombin deficiency, are associated with a higher risk of thrombosis (Idiculla *et al*., 2020). Acquired diseases like cancers, systemic and localized infections, autoimmune diseases, physical injury, nephrotic syndrome, and antiphospholipid syndrome additionally contribute to the development of thrombi through endothelial damage, inflammation, and activation of the coagulation pathway (Bezerra *et al*., 2022). In recent times, SARS-CoV-2 infections have become an important trigger because of their involvement in endothelial dysfunction, inflammation induced by cytokines, platelet activation, and hypercoagulable state of the body (Abdalkader *et al*., 2021). Similarly, immune thrombotic thrombocytopenia (VITT) caused by vaccines has also been identified as an extremely rare immune-mediated condition that results in platelet factor 4 antibodies, thrombocytopenia, and thrombosis at unusual locations in the body, which include cerebral venous sinuses (Greinacher *et al*., 2021).

3.3 Clinical Presentation and Diagnostic Evaluation

CVST has an extremely diverse presentation and can be difficult to diagnose in its early stages because it is quite nonspecific in nature. There can be a presentation of headache alone, seizures, focal neurological deficit, visual symptoms, papilledema, or signs of increased intracranial pressure depending upon the site of thrombus formation. As these symptoms commonly occur in other neurological disorders as well, it becomes important to have a high degree of clinical suspicion, especially when dealing with young patients with atypical headache presentations. Laboratory testing helps in detecting the prothrombotic disorder and related systemic disease, while imaging tests play an irreplaceable role in the diagnosis, extent of the thrombus, and occurrence of any complications such as venous infarction or hemorrhage in the brain. Combination of clinical assessment along with imaging tests has helped in improving diagnostic accuracy and early treatment of the condition. Table 2 lists the major clinical presentations and tests available to diagnose CVST.

Table 2. Clinical Features and Diagnostic Modalities of Cerebral Venous Sinus Thrombosis

Diagnostic Aspect	Key Findings	Reference
Clinical presentation	Headache, seizures, focal deficits, altered consciousness	Ropper & Klein (2021)
Laboratory evaluation	D-dimer, coagulation profile, thrombophilia screening	Weimar *et al*. (2024)
Initial imaging	Non-contrast CT identifies hemorrhage	Dmytriw *et al*. (2018)
Confirmatory imaging	CTV and MRI/MRV confirm diagnosis	Saposnik *et al*. (2024)
Advanced imaging	DSA for selected complex cases	Goyal *et al*. (2022)

3.4 Contemporary Management Strategies

CVST management aims at restoring cerebral venous outflow, stopping the thrombus from progressing, minimizing the risk of developing neurological complications, and avoiding a recurrent condition. Treatment for the condition focuses on anticoagulation therapy along with supportive measures such as controlling seizures, managing intracranial pressure, maintaining proper hydration status, and treating the causative factors. The administration of anticoagulants is essential even for those patients who develop intracranial hemorrhages as a consequence of venous infarction due to the presence of thrombus. There is emerging data that has shown a significant extension of the clinical utility of DOACs that have

shown encouraging effectiveness and safety in certain patient groups. The choice of treatment in the long term must be personalized based on the underlying cause, risk of recurrence, and persistence of the thrombophilia. Table 3 shows the available therapeutic options for CVST patients.

Table 3. Contemporary Therapeutic Strategies for Cerebral Venous Sinus Thrombosis

Treatment Strategy	Clinical Role	Reference
Low-molecular-weight heparin (LMWH)	First-line acute anticoagulant	Saposnik *et al*. (2024)
Unfractionated heparin (UFH)	For patients requiring rapid reversal	Weimar *et al*. (2024)
Vitamin K antagonists (Warfarin)	Standard long-term anticoagulation	Yaghi *et al*. (2022)
Direct oral anticoagulants (DOACs)	Alternative long-term therapy	Chen *et al*. (2024)
Supportive therapy	Seizure, ICP, and cause management	Patel *et al*. (2024)

3.5 Endovascular Therapy and Emerging Interventional Approaches

While anticoagulation continues to be the mainstay of treatment of CVST, the use of endovascular techniques has become a useful alternative therapy for appropriately chosen patients who have neurological worsening despite optimal medical therapy or have extensive venous occlusion with serious complications (Goyal *et al*., 2022). The purpose of the endovascular procedures is to ensure rapid revascularization of the obstructed veins, improve venous drainage of the brain, decrease intracranial pressure, and avoid brain damage. Mechanical thrombectomy, catheter-directed thrombolysis, and combined endovascular approaches have shown promising technical success in observational studies, especially in patients with significant neurological impairments, involvement of the deep venous system, or the threat of brain herniation (Rosa *et al*., 2025). There is still no sufficient evidence base from randomized controlled trials, and according to current international guidelines, such procedures should be reserved only for carefully selected patients. In the future, further research will allow us to create standardized criteria for the selection of patients and evaluate the effectiveness of these methods in the long term (Coutinho *et al*., 2020).

3.6 Women-Specific Risk Factors and Clinical Considerations

Women have been found to form the predominant group of CVST diagnoses due to the significant role of hormones and other reproductive-related issues in thromboembolism risks (Durmuş *et al*., 2020). Physiological and acquired hypercoagulable conditions resulting from pregnancy, puerperium, oral contraceptives, hormone therapy, and infertility procedures are known to make women more prone to developing CVST (Gupta *et al*., 2026). The periods of pregnancy and puerperium are among the most vulnerable ones owing to the elevated activities of coagulation factors, decreased fibrinolytic effects, venous stasis, and vascular remodeling (Durmuş *et al*., 2020). In addition to this, the use of estrogen-based birth control pills and hormone replacement therapy increases the risk of thrombosis, particularly among females who have an inherent thrombophilia and a history of venous thromboembolism (Gupta *et al*., 2026). Similarly, the process of assisted reproductive technology poses a risk of thrombosis due to stimulation of the ovaries and increased estrogen levels (Durmuş *et al*., 2020). The present international consensus suggests that individualized anticoagulation therapy should be used during pregnancy, with the recommendation of low molecular weight heparin as the treatment of choice (Saposnik *et al*., 2024). After the patient's recovery, counseling on future pregnancies, contraception, lactation, and thromboprophylaxis must be tailored based on the risk for recurrence and the patient's thrombophilia (Weimar *et al*., 2024). Follow-up care will be especially important for women with chronic thrombophilias because such patients are still at an elevated risk of developing thrombotic problems and require continued prevention (Shu *et al*., 2022).

3.7 Long-Term Outcomes and Prognostic Factors

Improvements in early diagnosis, anticoagulant therapy, and multidisciplinary management have tremendously enhanced the long-term outcome of patients with CVST. Patients usually make good recovery with little to no permanent impairment especially if timely intervention is carried out. Nonetheless, long-term recovery is affected by various clinical and radiographic features including patient's age, severity of venous thrombosis, underlying cause, presence of intracerebral bleed, involvement of deep venous system, and accompanying systemic disease. Even though good functional results were obtained, most patients continue to have persistent neuropsychiatric manifestations such as chronic headaches, epilepsy, cognitive impairment, fatigue, depression, anxiety, and low quality of life. In addition, patients with thrombophilia or other pro-thrombotic states continue to be at an increased risk of developing future episodes of venous thromboembolism, thereby highlighting the significance of follow-up and secondary prevention. Table 4 gives the summary of the important prognostic factors that affect the long-term prognosis of CVST patients.

Table 4. Major Prognostic Factors Influencing Long-Term Outcomes in Cerebral Venous Sinus Thrombosis

Prognostic Factor	Clinical Significance	Reference
Early diagnosis and anticoagulation	Improves recovery and survival	Saposnik *et al*. (2024)
Persistent thrombophilia	Increases recurrence risk	Shu *et al*. (2022)
Cortical infarction/hemorrhage	Higher risk of epilepsy and deficits	Ulivi *et al*. (2020)
Cognitive impairment	Reduces long-term independence	Lin *et al*. (2025)
Deep venous involvement, coma, malignancy	Associated with poor prognosis	Saposnik *et al*. (2024)
Persistent headache and fatigue	Common residual symptoms	Hiltunen *et al*. (2016)
Return to work	Indicator of functional recovery	Hiltunen *et al*. (2016)

3.8 Emerging Trends and Future Perspectives

The recent developments in biomedical science, digital technology in health care, and precision medicine have revolutionized the approach in diagnosing and managing patients with CVST. The applications of artificial intelligence and machine learning have been explored for the purpose of automated analysis of neuroimaging findings, detection of thrombus at an earlier stage, predicting the prognosis, and stratifying the risk of the disease in each patient. In parallel, the progress in neuroimaging modalities has helped in the evaluation of thrombus volume, venous collateralization, and treatment response to achieve precise diagnosis and treatment planning. Moreover, the recent scientific studies supporting DOACs have focused on personalized anticoagulation therapy. Moreover, multicentric registry studies and randomized clinical trials in the field of medicine and interventions are increasing the amount of evidence related to the therapy, while updated international guidelines will continue to standardize the diagnosis and management procedures. All of the above is likely to result in an improvement in both diagnostic precision and treatment selection. Important future directions in CVST are detailed in Table 5.

Table 5. Emerging Trends and Future Directions in Cerebral Venous Sinus Thrombosis

Emerging Trend	Potential Clinical Application	Reference
Artificial intelligence	Automated thrombus detection	Terraciano *et al*. (2026)
Machine learning	Prognosis and recurrence prediction	Lin *et al*. (2025)
Advanced neuroimaging	Improved thrombus assessment	Dmytriw *et al*. (2018)
Personalized anticoagulation	Tailored treatment strategies	Guarniz *et al*. (2025)
Direct oral anticoagulants	Expanded long-term therapy	Chen *et al*. (2024)
Multicenter clinical trials	Strengthening clinical evidence	Rosa *et al*. (2025)
Updated international guidelines	Standardized patient management	Weimar *et al*. (2024)

4. DISCUSSION

This comprehensive review highlights the fact that CVST is a complex cerebrovascular illness with a range of causes, manifestations, and therapies. Based on the results of synthesis of scientific evidence, one can conclude that advances in neuroimaging and anticoagulant treatments, along with increased awareness among clinicians, have led to improved diagnosis and prognosis. Despite the progress made in this respect, there is still much heterogeneity in terms of clinical presentation, risk factors, and prognosis, which poses challenges in diagnosing the disease and treating it appropriately.

Several risk factors were found to be involved in the pathogenesis of CVST. The association of thrombophilia, malignancy, infections, autoimmune diseases, pregnancy, hormonal effects, and systemic inflammation suggests that CVST is a multifactorial disease. The statement above is supported by other authors who state that CVST is a disease due to the interaction of both genetic risk factors and acquired ones (Tu *et al*., 2020). It is important to note that the results obtained confirm the necessity of conducting an etiologic investigation because the presence of reversible risk factors has a direct effect on treatment and prognosis. It can be noted from the current review that improvement in diagnostic imaging technologies has changed the clinical approach to diagnosing CVSTs. Thanks to the availability of CT venography and MR venography, early detection is possible even in cases where the patient presents with vague symptoms like isolated headaches. Early detection helps in timely initiation of anticoagulation to prevent further neurological damage and thus helps in improved recovery. These results are consistent with past research findings showing that delayed diagnosis is one of the most important factors leading to poor neurological outcomes and high mortality rates especially in patients with large venous thrombi or deep cerebral venous system involvement (Taquet *et al*., 2021).

Modern-day management practice has taken a turn towards personalized anticoagulation treatment while keeping anticoagulation therapy at the core of the management strategy. Increasing scientific evidence backing up the use of direct oral anticoagulants (DOACs) indicates that they may be used effectively as an alternative option to vitamin K antagonists in selected cases. International studies will shed light on their effectiveness, safety, and appropriate indication in clinical practice in the coming years (van de Munckhof *et al*., 2023). In the same vein, advances in endovascular procedures have been made in managing severe or refractory CVST, even though there is still need for additional randomized evidence before such practices can be considered for widespread use. An important point highlighted in this review is the impact that women-related risks play in the causation of CVST. Pregnancies, post-partum state, use of oral contraceptives, and hormone replacement therapy all make considerable contribution to increased prevalence of CVST in women of reproductive age. This is a significant issue in the clinical management of CVST because identifying the risk factors makes it easier to diagnose patients, employ safe anticoagulant therapy, and counsel patients regarding their future pregnancies and use of contraceptives.

The COVID-19 outbreak widened our knowledge on CVST, showing how systemic infection caused by the virus and thromboinflammation triggered by the immune system may lead to cerebral venous thrombosis. Additionally, the development of vaccine-induced immune thrombotic thrombocytopenia (VITT), another clinical syndrome, which is associated with thrombosis, thrombocytopenia, and platelet factor 4 antibodies, broadened the spectrum of CVST. Clinical manifestations and mortality rates in patients with CVST caused by VITT were significantly worse than in traditional CVST (Sánchez van Kammen *et al*., 2021). National-level surveillance studies also validated the extremely low incidence of vaccine-induced CVST but also highlighted the need for early diagnosis since late diagnosis led to worse neurological outcomes (Schulz *et al*., 2021). Biological mechanisms were later identified, showing that platelet factor 4 antibodies are key in VITT pathogenesis, which provides the underlying biology of current guidelines for the management of VITT (Scully *et al*., 2021). Studies conducted in the US also provided support to the above-mentioned observations by showing that there are similar clinical features of patients who developed CVST and thrombocytopenia after receiving adenovirus-

based vaccines (See *et al*., 2021). Overall, these studies have improved the knowledge of clinicians and solidified the observation that the risk of thrombosis is higher due to infection than vaccination against COVID-19.

While the currently available evidence clearly illustrates advances in the diagnosis and treatment of CVST, a number of limitations persist. The majority of the published studies are observational studies, retrospective cohorts, case series, and registry-based studies, all of which are subject to selection bias and confounding. Furthermore, there is substantial heterogeneity in diagnostic criteria, anticoagulation regimens, outcome measures, and follow-up duration, thus hampering comparability between studies. Rapidly growing evidence regarding DOACs, endovascular interventions, and specific population groups highlights the need for developing standardized approaches to scientific research and carrying out prospective large-scale studies. Future research should be targeted at multicenter, randomized and controlled trials on the most effective anticoagulant treatment, the indications for performing endovascular procedures, and personalized treatment protocols based on thrombotic risk of the patient. Additional future research may be carried out within the scope of scientific investigations focused on female patients, cognitive and psychological effects, recurrences, and diagnosis algorithms involving the use of artificial intelligence technology. International collaboration and regular updates of evidence-based guidelines will be essential in improving patient care in CVST.

5. CONCLUSION

Cerebral Venous Sinus Thrombosis (CVST) is a rather rare cerebrovascular pathology with a variety of causative factors, manifestations, and outcomes. This review article stresses that early diagnosis using imaging methods and raising clinical awareness is crucial for both diagnosing CVST and achieving a good outcome. The modern treatment strategy involves starting anticoagulant therapy immediately upon diagnosis. At the same time, the results of recent investigations suggest the possibility of using direct oral anticoagulants in some patients. Endovascular therapy may prove beneficial in severe and refractory cases of CVST, but more research is required to establish indications for such therapy. Of equal importance is the emphasis placed on the importance of recognizing risk factors associated with women, such as pregnancy, the postpartum period, and hormone replacement therapy, in order to be able to design preventive and diagnostic measures as well as methods of treatment based on these findings. In addition, recent studies investigating the underlying pathophysiology of CVST associated with infection by SARS-CoV-2 and vaccination against COVID-19 have revealed the nature of the disease and the need for rapid diagnosis of these newly discovered diseases. Even though substantial progress has been made regarding mortality and functional outcome, residual neurological dysfunction, cognitive impairment, and recurrence remain a major issue that needs thorough follow-up. Multicenter randomized control trials, precision medicine strategies, use of artificial intelligence in diagnosis, and updated international guidelines are expected to become more important in the future.

REFERENCES

1. Abdalkader, M., Shaikh, S. P., Siegler, J. E., Cervantes-Arslanian, A. M., Tiu, C., Radu, R. A., ... & Jovin, T. G. (2021). Cerebral venous sinus thrombosis in COVID-19 patients: a multicenter study and review of literature. *Journal of Stroke and Cerebrovascular Diseases*, *30*(6), 105733.
2. Almegren, M. O. (2025). Cerebral venous thrombosis: A comprehensive narrative review. *Brain Circulation*, *11*(3), 178-186.
3. Bezerra, G. M. D. S., Cavalcante, Y. D. S., Matos-Neto, P. R., Cavalcante-Neto, J. F., Ponte, K. F. D., Aguiar de Sousa, D., ... & Ribeiro, E. M. L. (2022). Cerebral venous thrombosis in Latin America: A critical review of risk factors, clinical and radiological characteristics. *Frontiers in neurology*, *13*, 1017565.
4. Chen, X., Guo, L., & Lin, M. (2024). Efficacy and safety of direct oral anticoagulants in cerebral venous thrombosis: Meta-analysis of randomized clinical trials. *Clinical and Applied Thrombosis/Hemostasis*, *30*, 10760296241256360.
5. Coutinho, J. M., Zuurbier, S. M., Bousser, M. G., Ji, X., Canhão, P., Roos, Y. B., ... & Stam, J. (2020). Effect of endovascular treatment with medical management vs standard care on severe cerebral venous thrombosis: the TO-ACT randomized clinical trial. *JAMA neurology*, *77*(8), 966-973.
6. Dakay, K., Cooper, J., Bloomfield, J., Overby, P., Mayer, S. A., Nuoman, R., ... & Al-Mufti, F. (2021). Cerebral venous sinus thrombosis in COVID-19 infection: a case series and review of the literature. *Journal of Stroke and Cerebrovascular Diseases*, *30*(1), 105434.
7. Dmytriw, A. A., Song, J. S. A., Yu, E., & Poon, C. S. (2018). Cerebral venous thrombosis: state of the art diagnosis and management. *Neuroradiology*, *60*(7), 669-685.
8. Durmuș, B., Yperzeele, L., & Zuurbier, S. M. (2020). Cerebral venous thrombosis in women of childbearing age: diagnosis, treatment, and prophylaxis during a future pregnancy. *Therapeutic advances in neurological disorders*, *13*, 1756286420945169.
9. Field, T. S., Dizonno, V., Almekhlafi, M. A., Bala, F., Alhabli, I., Wong, H., ... & Hill, M. D. (2023). Study of rivaroxaban for cerebral venous thrombosis: a randomized controlled feasibility trial comparing anticoagulation with rivaroxaban to standard-of-care in symptomatic cerebral venous thrombosis. *Stroke*, *54*(11), 2724-2736.
10. Galanti, K., Di Marino, M., Mansour, D., Testa, S., Rossi, D., Scollo, C., ... & Di Marco, M. (2024). Current antithrombotic treatments for cardiovascular diseases: a comprehensive review. *Reviews in Cardiovascular Medicine*, *25*(8), 281.
11. Gorman, J. B., & Field, T. S. (2022). ACTION-CVT: Are the Findings ACTIONable?. *Stroke*, *53*(3), 739-741.
12. Goyal, M., Fladt, J., Coutinho, J. M., McDonough, R., & Ospel, J. (2022). Endovascular treatment for cerebral venous thrombosis: current status, challenges, and opportunities. *Journal of NeuroInterventional Surgery*, *14*(8), 788-793.
13. Greinacher, A., Thiele, T., Warkentin, T. E., Weisser, K., Kyrle, P. A., & Eichinger, S. (2021). Thrombotic thrombocytopenia after ChAdOx1 nCov-19 vaccination. *New England Journal of Medicine*, *384*(22), 2092-2101.

14. Guarniz, A. L. G., Field, T. S., & Yaghi, S. (2025). Direct oral anticoagulants for cerebral venous thrombosis. *The Lancet Neurology*, *24*(3), 180-181.
15. Gupta, M., Anu, V., & Kumar, A. (2026). The Relationship between Exogenous Hormonal use and Cerebral Vein Thrombosis in Women: A Comprehensive Review. *Indian Journal of Cardiovascular Disease in Women*.
16. Hiltunen, S., Putaala, J., Haapaniemi, E., & Tatlisumak, T. (2016). Long-term outcome after cerebral venous thrombosis: analysis of functional and vocational outcome, residual symptoms, and adverse events in 161 patients. *Journal of neurology*, *263*(3), 477-484.
17. Hippisley-Cox, J., Patone, M., Mei, X. W., Saatci, D., Dixon, S., Khunti, K., ... & Coupland, C. A. (2021). Risk of thrombocytopenia and thromboembolism after covid-19 vaccination and SARS-CoV-2 positive testing: self-controlled case series study. *bmj*, *374*.
18. Idiculla, P. S., Gurala, D., Palanisamy, M., Vijayakumar, R., Dhandapani, S., & Nagarajan, E. (2020). Cerebral venous thrombosis: a comprehensive review. *European neurology*, *83*(4), 369-379.
19. Jaiswal, V., Nepal, G., Dijamco, P., Ishak, A., Dagar, M., Sarfraz, Z., ... & Jaiswal, A. (2022). Cerebral venous sinus thrombosis following COVID-19 vaccination: a systematic review. *Journal of primary care & community health*, *13*, 21501319221074450.
20. Krzywicka, K., Heldner, M. R., Sánchez van Kammen, M., van Haaps, T., Hiltunen, S., Silvis, S. M., ... & Ferro, J. M. (2021). Post-SARS-CoV-2-vaccination cerebral venous sinus thrombosis: an analysis of cases notified to the European Medicines Agency. *European journal of neurology*, *28*(11), 3656-3662.
21. Liao, S., Wang, R., Li, Z., Xu, L., & Yu, J. (2026). Long-term outcome and predictors in cerebral venous sinus thrombosis: a prospective cohort study. *BMC neurology*.
22. Lin, L., Liu, S., Wang, W., He, X. K., Romli, M. H., & Rajen Durai, R. (2025). Key prognostic risk factors linked to poor functional outcomes in cerebral venous sinus thrombosis: a systematic review and meta-analysis. *BMC neurology*, *25*(1), 52.
23. Nguyen, T. N., Qureshi, M. M., Klein, P., Yamagami, H., Abdalkader, M., Mikulik, R., ... & Nogueira, R. G. (2022). Global impact of the COVID-19 pandemic on cerebral venous thrombosis and mortality. *Journal of stroke*, *24*(2), 256-265.
24. Ordieres-Ortega, L., Moragón-Ledesma, S., & Demelo-Rodríguez, P. (2024). Cerebral venous thrombosis. *Revista Clínica Española (English Edition)*, *224*(4), 237-244.
25. Ostovan, V. R., Foroughi, R., Rostami, M., Almasi-Dooghaee, M., Esmaili, M., Bidaki, A. A., ... & Borhani-Haghighi, A. (2021). Cerebral venous sinus thrombosis associated with COVID-19: a case series and literature review. *Journal of neurology*, *268*(10), 3549-3560.
26. Patel, H., Lunn, I., Hameed, S., Khan, M., Siddiqui, F. M., Borhani, A., ... & Wasay, M. (2024). Treatment of cerebral venous thrombosis: a review. *Current Medical Research and Opinion*, *40*(12), 2223-2236.
27. Perry, R. J., Tamborska, A., Singh, B., Craven, B., Marigold, R., Arthur-Farraj, P., ... & Zambreanu, L. (2021). Cerebral venous thrombosis after vaccination against COVID-19 in the UK: a multicentre cohort study. *The Lancet*, *398*(10306), 1147-1156.
28. Ropper, A. H., & Klein, J. P. (2021). Cerebral venous thrombosis. *New England Journal of Medicine*, *385*(1), 59-64.
29. Rosa, S., Fragata, I., & de Sousa, D. A. (2025). Update on management of cerebral venous thrombosis. *Current Opinion in Neurology*, *38*(1), 18-28.
30. Sánchez van Kammen, M., Aguiar de Sousa, D., Poli, S., Cordonnier, C., Heldner, M. R., Van De Munckhof, A., ... & Arslan, Y. (2021). Characteristics and outcomes of patients with cerebral venous sinus thrombosis in SARS-CoV-2 vaccine–induced immune thrombotic thrombocytopenia. *JAMA neurology*, *78*(11), 1314-1323.
31. Saposnik, G., Bushnell, C., Coutinho, J. M., Field, T. S., Furie, K. L., Galadanci, N., ... & American Heart Association Stroke Council; Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation; Council on Cardiovascular and Stroke Nursing; and Council on Hypertension. (2024). Diagnosis and management of cerebral venous thrombosis: a scientific statement from the American Heart Association. *Stroke*, *55*(3), e77-e90.
32. Schulz, J. B., Berlit, P., Diener, H. C., Gerloff, C., Greinacher, A., Klein, C., ... & Zimmermann, J. (2021). COVID-19 vaccine-associated cerebral venous thrombosis in Germany. *Annals of neurology*, *90*(4), 627-639.
33. Scully, M., Singh, D., Lown, R., Poles, A., Solomon, T., Levi, M., ... & Lester, W. (2021). Pathologic antibodies to platelet factor 4 after ChAdOx1 nCoV-19 vaccination. *New England Journal of Medicine*, *384*(23), 2202-2211.
34. See, I., Su, J. R., Lale, A., Woo, E. J., Guh, A. Y., Shimabukuro, T. T., ... & Broder, K. R. (2021). US case reports of cerebral venous sinus thrombosis with thrombocytopenia after Ad26. COV2. S vaccination, March 2 to April 21, 2021. *Jama*, *325*(24), 2448-2456.
35. Shu, L., Bakradze, E., Omran, S. S., Giles, J., Amar, J., Henninger, N., ... & Yaghi, S. (2022). Predictors of recurrent venous thrombosis after cerebral venous thrombosis: analysis of the ACTION-CVT study. *Neurology*, *99*(21), e2368-e2377.
36. Taquet, M., Husain, M., Geddes, J. R., Luciano, S., & Harrison, P. J. (2021). Cerebral venous thrombosis and portal vein thrombosis: a retrospective cohort study of 537,913 COVID-19 cases. *EClinicalMedicine*, *39*.
37. Terraciano, A. P., Gupta, K., & Altschul, D. J. (2026). Cerebral venous disorders: clinical presentation, diagnostic strategy, and contemporary management. *Frontiers in Neurology*, *17*, 1854875.
38. Tu, T. M., Goh, C., Tan, Y. K., Leow, A. S., Pang, Y. Z., Chien, J., ... & Yeo, L. L. (2020). Cerebral venous thrombosis in patients with COVID-19 infection: a case series and systematic review. *Journal of Stroke and Cerebrovascular Diseases*, *29*(12), 105379.
39. Ulivi, L., Squitieri, M., Cohen, H., Cowley, P., & Werring, D. J. (2020). Cerebral venous thrombosis: a practical guide. *Practical neurology*, *20*(5), 356-367.

40. van de Munckhof, A., Sánchez van Kammen, M., Krzywicka, K., Aaron, S., Aguiar de Sousa, D., Antochi, F., ... & Coutinho, J. M. (2023). Direct oral anticoagulants for the treatment of cerebral venous thrombosis–a protocol of an international phase IV study. *Frontiers in neurology*, *14*, 1251581.
41. Weimar, C., Beyer-Westendorf, J., Bohmann, F. O., Hahn, G., Halimeh, S., Holzhauer, S., ... & Linnemann, B. (2024). New recommendations on cerebral venous and dural sinus thrombosis from the German consensus-based (S2k) guideline. *Neurological Research and Practice*, *6*(1), 23.
42. Yaghi, S., Shu, L., Bakradze, E., Salehi Omran, S., Giles, J. A., Amar, J. Y., ... & Furie, K. (2022). Direct oral anticoagulants versus warfarin in the treatment of cerebral venous thrombosis (ACTION-CVT): a multicenter international study. *Stroke*, *53*(3), 728-738.