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Impact of the COVID-19 pandemic on cerebral venous sinus thrombosis in China: a comparative study

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Abstract

Background Cerebral venous sinus thrombosis (CVST) is a rare yet significant neurological disorder with high mortality. Understanding its evolving characteristics, risk factors, and outcomes, particularly in Chinese patients after the COVID-19 pandemic, is critical for developing effective preventive and therapeutic strategies.

Methods A retrospective analysis was conducted on 471 CVST cases from Xuanwu Hospital, comparing data before (2013–2017, $n=243$) and after (2021–2023, $n=228$) the COVID-19 pandemic. Data on demographics, clinical features, risk factors, and outcomes were evaluated, with subgroup analyses based on gender and age.

Results The mean patient age was 38 ± 14 years, with a female preponderance (55.0%). After the COVID-19 pandemic, significant changes in symptoms and neuroimaging findings were observed, including increased visual impairment and decreased headache, neurological deficits, and seizures. Infection emerged as a prominent risk factor, including eight cases related to COVID-19 or vaccination. At discharge, favorable outcomes (mRS 0–2) were noted in 86.6% of patients. Poor outcomes were associated with central nervous system (CNS) infection, oral contraceptive use or hormone replacement therapy (HRT), hematologic disorders, anemia, and prothrombotic conditions. Anemia was identified as an independent predictor of survival.

Conclusions The pandemic has significantly altered the clinical and epidemiological profile of CVST in China. Infections have emerged as key risk factors, while anemia remains a critical prognostic indicator. These findings highlight the need for targeted clinical strategies to improve outcomes.

Trial registration This study protocol was reviewed and approved by the ethics committee of Xuanwu Hospital, Capital Medical University (No. 2022-004, dated on November 20, 2022). The clinical trial was registered at Chinese Clinical Trial Registry (ChiCTR2200057621).

Keywords Cerebral venous sinus thrombosis, COVID-19 pandemic, Chinese patients, Risk factors, Outcomes

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Introduction

Cerebral venous sinus thrombosis (CVST) is a rare but potentially life-threatening neurological condition characterized by the occlusion of cerebral venous sinuses and veins, often leading to a wide range of clinical manifestations [1–3]. The existing literature emphasizes considerable geographic variability in CVST risk factors, with dehydration, pregnancy, the postpartum period, and infections identified as major contributors in Asian and Middle Eastern populations [4–8]. Prior to the COVID-19 pandemic, our team conducted extensive research into CVST risk factors and associated outcomes in a substantial cohort of Chinese patients [9]. However, the global pandemic introduced profound changes in healthcare systems, lifestyle behaviors, and disease dynamics, necessitating an updated analysis of CVST characteristics, particularly in China. This study endeavors to conduct a thorough analysis of CVST in Chinese patients before and after the COVID-19 pandemic to identify any shifts in risk factors and outcomes. We collected data from 471 patients across 24 Chinese provinces, covering approximately 78% of the national geographic regions. The study cohort was divided into two groups: one from the pre-pandemic era (2013–2017) and the other from the post-pandemic period (2021–2023) [9]. This comprehensive investigation encompasses demographic information, symptomatology, risk factors, and clinical outcomes, with additional subgroup analyses stratified by gender and age. Through this work, we aim to provide essential insights that could inform new preventive and therapeutic strategies for CVST in China.

Methods

Study population

The study included a cohort of 471 Chinese patients diagnosed with CVST, divided into two groups (Fig. 1): Group A, comprising 243 patients diagnosed before the COVID-19 pandemic (March 2013 to April 2017), and Group B, consisting of 228 patients diagnosed after the pandemic (January 2021 to May 2023). The diagnosis of CVST was confirmed using multiple imaging modalities, including computed tomography, computed tomography venography, magnetic resonance venography, magnetic resonance imaging, and/or digital subtraction angiography. The inclusion and exclusion criteria were as follows:

Inclusion criteria

(1) Patients meeting the diagnostic criteria for CVST;
(2) Age between18 to 80 years;
(3) Diagnosis confirmed by at least two imaging modalities;
(4) Signed informed consent.

Exclusion criteria

(1) Patients diagnosed with CVST by a single imaging modality;
(2) Allergy to contrast agents or inability to undergo cerebral venography;
(3) Incomplete patient data, such as missing demographics, clinical presentations, diagnostic tests, or treatment outcomes.

Subgroup analyses were conducted based on age (≤44 years and >44 years) and gender groups (male and female).

Data collection

Data were comprehensively collected, including demographic information, symptomatology, risk factors, modified Rankin Scale (mRS) scores at admission and discharge, laboratory test results, neuroimaging findings,

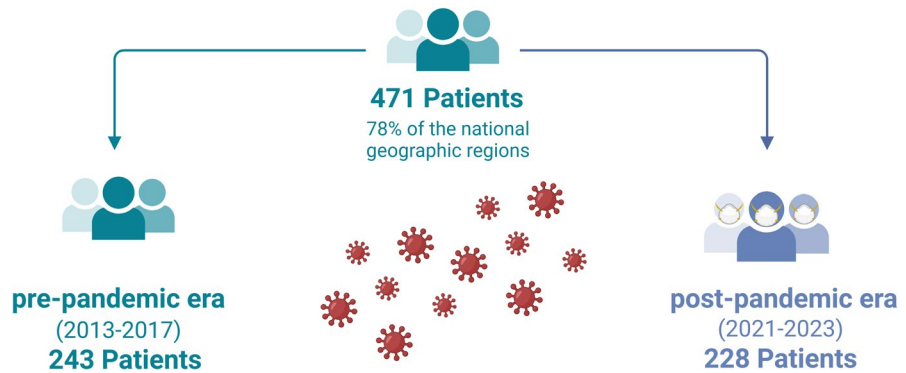

Fig. 1 A cohort of 471 Chinese patients diagnosed with cerebral venous sinus thrombosis, divided into two groups based on the timeline: before and after the COVID-19 pandemic

and the location of occluded venous sinuses. Basic laboratory tests performed upon admission included complete blood count, serum chemistry, coagulation function tests, and assessments for hyperhomocysteinemia, thyroid function, and serum tumor markers. Additionally, serological tests for HIV, syphilis, inflammatory markers (e.g., C-reactive protein, erythrocyte sedimentation rate), and immunological assessments were also conducted. Lumbar puncture was performed in most patients, except those critically ill, to analyze cerebrospinal fluid for cell count, protein and glucose levels, and the presence of infectious agents. In patients with more severe or complicated CVT, lumbar puncture was performed to assess intracranial pressure and explore potential secondary causes of CVT, such as infections, immunological disorders, or tumors.

Treatment and outcome

All patients received subcutaneous enoxaparin treatment during hospitalization, dosed at 100 IU/kg twice daily. In cases where the condition worsened despite anticoagulation therapy, endovascular treatment, including direct catheter thrombolysis and mechanical thrombectomy, was considered. The choice of technique was made by the interventional physician based on the patient's clinical evaluation. After discharge, patients continued oral anticoagulant therapy for at least 3–6 months. The selection of anticoagulants (either vitamin K antagonists or non-vitamin K antagonist oral anticoagulants) was tailored to each patient's condition. Clinical outcomes were assessed using the mRS score at discharge, where scores of 0–2 were considered favorable, and scores of 3–6 indicated poor outcomes.

Statistical analysis

Statistical analyses were performed using SPSS version 27. Continuous variables were expressed as mean ± standard deviation. Categorical variables were represented as numbers (percentages) and analyzed using the chi-square test. Logistic regression analysis was employed to identify prognostic factors associated with unfavorable clinical outcomes. Statistical significance was defined as $P < 0.01$.

Results

Baseline characteristics

The study included 471 eligible patients, with a mean age of 38 ± 14 years, and a female predominance (55.0%). The cohort was recruited from 26 provinces, covering approximately 78% of China (Fig. 2). Headache was the most common symptom, reported in 84.7% of cases, followed by visual impairment (34.6%), neurological deficits (24.4%), and seizures (22.3%). Neuroimaging revealed lateral sinus involvement in 80% of cases (80.0%), followed by sagittal sinus (58.8%), sigmoid sinus (57.5%), cortical veins (24.4%), jugular veins (19.5%), straight sinus (17.4%), and the deep cerebral venous system (3.0%).

When comparing Group A (243 cases; mean age: 36 ± 13 years; female: 54.3%) to Group B (228 cases; mean age: 40 ± 14 years; female: 56.1%), significant differences were observed in clinical presentation and neuroimaging findings. Group B exhibited decreased occurrences of headache (OR [95% CI]: 0.411 [0.242–0.697], $p < 0.01$), neurological deficits (OR [95% CI]: 0.491 [0.318–0.758], $p < 0.01$), and seizures (OR [95% CI]: 0.359 [0.225–0.573], $p < 0.01$), but an increased incidence of visual impairment (OR [95% CI]: 2.616 [1.767–3.872], $p < 0.01$). Both groups had the highest proportion of lateral sinus involvement; however, Group B showed reduced involvement of the sagittal and straight sinuses, but increased involvement of the cortical veins and jugular veins. The mRS at admission did not significantly differ between the two groups. Detailed information regarding these findings is presented in Table 1.

Risk factors for CVST before and after the COVID-19 pandemic

The primary risk factors for CVST are summarized in Table 2, and changes observed before and after the COVID-19 pandemic are shown in Fig. 3. Prothrombotic conditions (51.6%), infection (27.6%), and hematologic disorders (25.9%) were identified as the most prevalent risk factors. Among these, infection showed a significant increase post-pandemic (OR [95% CI]: 2.870 [1.878–4.386], $p < 0.01$), while the prevalence of prothrombotic conditions and hematologic disorders did not differ significantly between the two periods (OR [95% CI]: 0.650 [0.452–0.934], $p = 0.020$; OR [95% CI]: 0.835 [0.552–1.263], $p = 0.393$). Extra-meningeal infections were notably higher in Group B compared to Group A (14.4% vs. 36.0%, $p < 0.01$). Eight cases related to COVID-19 or vaccination were included in Group B. Other risk factors, such as obstetric causes (16.1%), thyroid diseases (10.8%), and oral contraceptives or hormone replacement therapy (HRT) (6.8%), showed no significant differences before and after the pandemic, except for an increased occurrence of autoimmune diseases in Group B (OR [95% CI]: 3.262 [1.546–6.811]; $p < 0.01$).

Subgroup analyses based on gender and age in Group B

Gender-based subgroup analysis (Supplementary Table 1) revealed that traditional female-specific risk factors, such as obstetric causes (12.3%), and oral contraceptive use or HRT (3.9%), were no longer the primary risk factors in females following the outbreak of the COVID-19 pandemic. Instead, prothrombotic conditions (22.4%), hematologic disorders (18.4%), and infections (18.0%) emerged

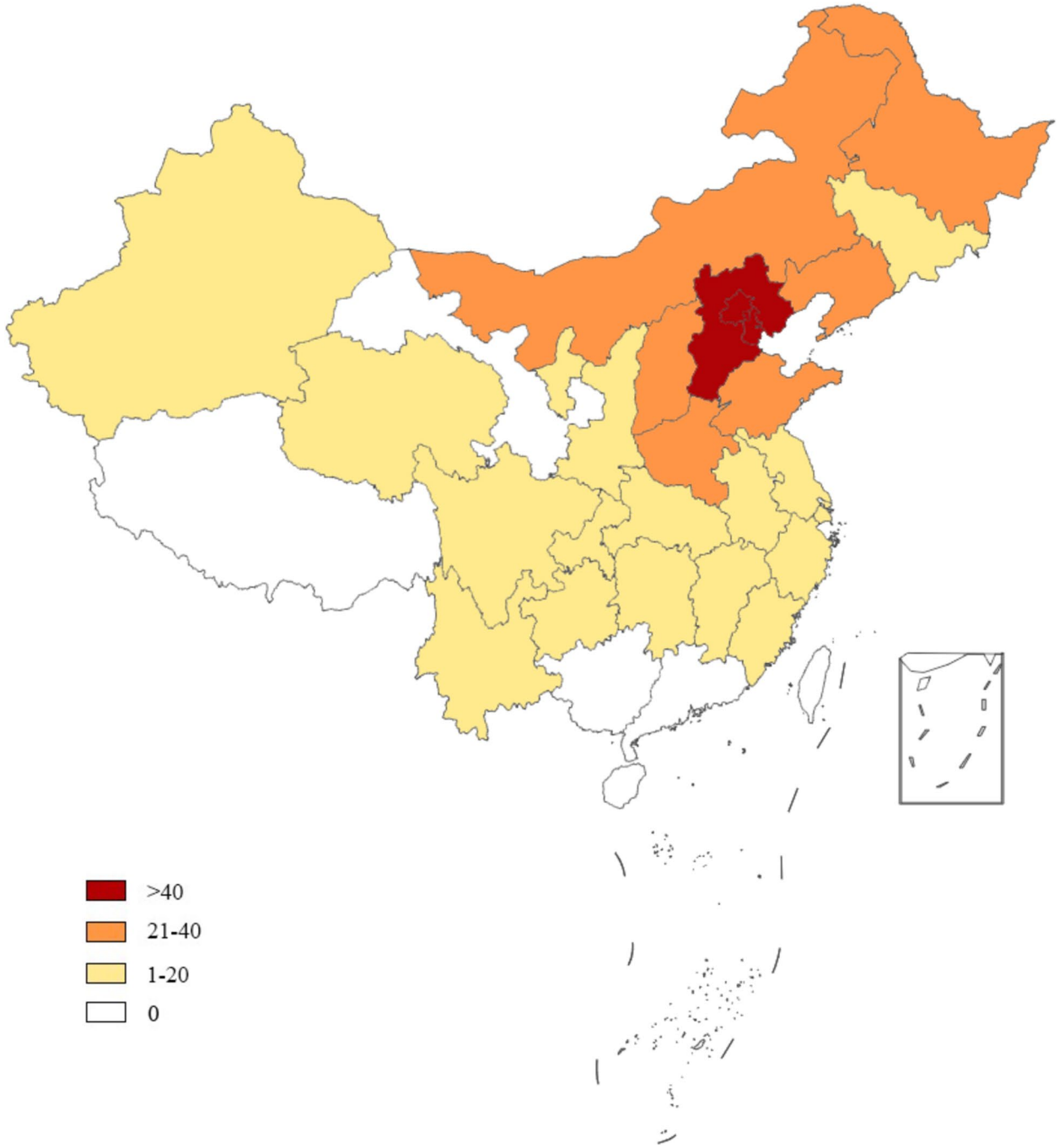

Fig. 2 Provincial distribution of Chinese patients enrolled in the study on cerebral venous sinus thrombosis

as the top three risk factors in females. Similarly, in males, prothrombotic conditions (23.7%) and infections (20.2%) were found to be the most prevalent risk factors. Statistically significant differences were observed in anemia (2.6% vs. 13.6%, $p < 0.01$), hyperhomocysteinemia (12.7% vs. 1.8%, $p < 0.01$), and systemic disorders (6.1% vs. 17.5%, $p < 0.01$).

Age-based subgroup analysis (Supplementary Table 2) exhibited no statistically significant differences, except for obstetric causes, which were more prevalent in patients aged ≤ 44 years compared to those > 44 years (11.4% vs. 0.9%, $p < 0.01$). Infection remained the predominant risk factor in both age subgroups, with

Table 1 Baseline characteristics of patients with cerebral venous sinus thrombosis before and after the COVID-19 pandemic

Characteristic	Group A (*n*=243)	Group B (*n*=228)	Odds ratio (95% CI)	*P* value	All patients (*n*=471)
Female, n (%)	131 (54.3%)	128 (56.1%)	1.094 (0.761-1.574)	0.627	259 (55.0%)
Age, years	36±13	40±14	-	<0.01	38±14
Involved sinus, n (%)					
Lateral sinus	197 (81.1%)	180 (78.9%)	0.876 (0.557-1.376)	0.565	377 (80.0%)
Sagittal sinus	186 (76.5%)	91 (40.0%)	0.204 (0.137-0.303)	<0.01	277 (58.8%)
Sigmoid sinus	144 (59.3%)	127 (55.7%)	0.864 (0.600-1.246)	0.435	271 (57.5%)
Straight sinus	55 (22.6%)	27 (11.8%)	0.459 (0.278-0.758)	<0.01	82 (17.4%)
Cortical veins	25 (10.3%)	90 (39.5%)	5.687 (3.478-9.299)	<0.01	115 (24.4%)
Jugular veins	25 (10.3%)	67 (29.4%)	3.629 (2.196-5.998)	<0.01	92 (19.5%)
Cerebral deep venous system	6 (2.5%)	8 (3.5%)	1.436 (0.491-4.206)	0.507	14 (3.0%)
Clinical manifestations, n (%)					
Headache	219 (90.1%)	180 (79.0%)	0.411 (0.242-0.697)	<0.01	399 (84.7%)
Neurological deficits	74 (30.5%)	41 (18.0%)	0.491 (0.318-0.758)	<0.01	115 (24.4%)
Visual impairment	59 (24.3%)	104 (45.6%)	2.616 (1.767-3.872)	<0.01	163 (34.6%)
Seizure	74 (30.5%)	31(13.6%)	0.359 (0.225-0.573)	<0.01	105 (22.3%)
mRS at admission (IQR)	1 (1,1)	1 (0,1)	-	-	1 (0,1)

Abbreviations: *COVID-19* Coronavirus disease 2019, *mRS* Modified Rankin Scale

no significant difference in frequency between them (25.0% vs. 13.2%, $p=0.226$).

Risk factors for prognosis

At discharge, 86.6% of the 471 patients had favorable outcomes, as indicated by an mRS score of 0–2, while 13.4% experienced poor outcomes. Univariate binary logistic regression analysis identified several factors significantly associated with unfavorable outcomes at discharge. These included central nervous system infection (OR [95% CI]: 6.013 [1.390–26.011]; $P=0.016$), oral contraceptives, and HRT use (OR [95% CI]: 1.995 [1.043–3.819]; $P=0.037$), hematologic disorders (OR [95% CI]: 1.947 [1.115–3.397]; $P=0.019$), anemia (OR [95% CI]: 2.232 [1.213–4.107]; $P=0.010$), and prothrombotic conditions (OR [95% CI]: 1.901 [1.093–3.304]; $P=0.023$). In the adjusted analysis, anemia (OR [95% CI]: 6.000 [1.445–24.919]; $P=0.014$) remained an independent predictor of poor outcomes at discharge, underscoring its critical role in the prognosis of CVST (Tables 3 and 4).

Discussion

To our knowledge, this study is among the first to provide a comprehensive analysis of CVST in Chinese patients before and after the COVID-19 pandemic. With data from 471 patients across 24 provinces, the robust sample enhances the generalizability of our findings. This study highlights significant shifts in clinical presentation, risk factors, and outcomes in the post-pandemic period, which have important implications for clinical practice and future research.

Impact of the COVID-19 pandemic on CVST presentation

A key finding of our study is the change in the clinical presentation of CVST post-pandemic. While traditional symptoms such as headaches, neurological deficits, and seizures decreased, visual impairment became more common. This shift could be attributed to the pathophysiological effects of COVID-19, including systemic inflammation and a hypercoagulable state. These conditions may exacerbate venous congestion, leading to increased intracranial pressure and subsequent visual disturbances [10]. Furthermore, COVID-19 can trigger a systemic inflammatory response that may affect ocular tissues, leading to ocular inflammation and damage. In severe cases, hypoxia may disrupt the blood supply to ocular tissues like the retina, contributing to vision problems [11, 12]. Given these findings, clinicians should remain vigilant for CVST in patients presenting with visual symptoms, particularly those with recent or concurrent COVID-19 infection. However, the small number of confirmed COVID-19 cases in the study suggests that other factors may also play a role in these clinical changes, necessitating further research to differentiate the impacts of COVID-19 from other conditions.

Infection as a rising risk factor

Infection, particularly systemic infections like COVID-19, has emerged as a more prevalent risk factor in the post-pandemic period [13]. This finding aligns with existing literature indicating a strong association between COVID-19 and a hypercoagulable state, which predisposes patients to venous thromboembolism,

Table 2 Comparison of risk factors between before and after the COVID-19 pandemic

Risk factors	Group A, *n* (%) (*N* = 243)	Group B, n (%) (*N* = 228)	Odds ratio (95% CI)	$P^{\perp}$ value	All patients, n (%) (*N* = 471)
Infection	43 (17.7)	87 (38.2)	2.870 (1.878–4.386)	< 0.01	130 (27.6)
CNS infection	8 (3.3)	13 (5.7)	1.776 (0.722–4.368)	0.205	21 (4.5)
COVID-19 or vaccine	0	8 (3.5)	18.773 (1.077–327.148)	< 0.01	8 (1.7)
Obstetric causes	48 (19.8)	28 (12.3)	0.569 (0.343–0.943)	0.028	76 (16.1)
Oral contraceptives, HRT	23 (9.5)	9 (3.9)	0.393 (0.178–0.869)	0.017	32 (6.8)
Hematologic disorders	67 (27.6)	55 (24.1)	0.835 (0.552–1.263)	0.393	122 (25.9)
Thrombocythemia	15 (6.2)	20 (8.8)	1.462 (0.729–2.930)	0.282	35 (7.4)
JAK2 mutations	12 (4.9)	6 (2.6)	0.520 (0.192–1.410)	0.192	18 (3.8)
Anemia	43 (17.7)	37 (16.2)	0.901 (0.556–1.459)	0.672	80 (17.0)
Polycythemia	2 (0.8)	3 (1.3)	1.607 (0.266–9.705)	0.943	5 (1.1)
Transfusion	1 (0.4)	9 (3.9)	9.945 (1.250–79.137)	0.019	10 (2.1)
Nephritic syndrome	7 (2.9)	1 (0.4)	0.149 (0.018–1.217)	0.090	8 (1.7)
Prothrombotic conditions	138 (56.8)	105 (46.1)	0.650 (0.452–0.934)	0.020	243 (51.6)
PC reduction	21 (12.3)	25 (11.0)	1.302 (0.707–2.397)	0.396	46 (9.8)
PS reduction	94 (55.0)	63 (27.6)	0.605 (0.410–0.893)	0.011	157 (33.3)
AT reduction	21 (11.5)	13 (5.7)	0.639 (0.312–1.309)	0.218	34 (7.2)
Hyperhomocysteinemia	35 (14.4)	33 (14.5)	1.006 (0.601–1.682)	0.983	68 (14.4)
Antiphospholipid and anticardiolipin antibodies	25 (10.3)	23 (10.1)	0.978 (0.538–1.778)	0.943	48 (10.2)
Any systemic disorders	31 (12.8)	54 (24.6)	2.122 (1.307–3.447)	< 0.01	85 (18.0)
Autoimmune diseases[a]	10 (4.1)	28 (12.3)	3.262 (1.546–6.881)	< 0.01	38 (8.1)
Thyroid diseases	23 (9.5)	28 (12.3)	1.221 (0.689–2.164)	0.326	51 (10.8)
Surgery or trauma	9 (3.7)	21(9.2)	2.638 (1.182–5.888)	0.014	30 (6.4)
Surgery	8 (3.3)	17 (7.5)	2.367 (1.001–5.597)	0.044	25 (5.3)
Trauma	1 (0.4)	4 (1.6)	4.321 (0.479–38.957)	0.155	5 (1.1)
Any malignancies	8 (3.3)	3 (1.3)	0.392 (0.103–1.495)	0.156	11 (2.3)
Drugs[b]	16 (6.6)	5 (2.2)	0.318 (0.115–0.883)	0.021	21 (4.5)
Dehydration	2 (0.8)	2 (0.9)	1.066 (0.149–7.634)	1.000	4 (0.8)
None identified	42 (17.3)	38 (16.7)	0.957 (0.591–1.549)	0.858	80 (17.0)

Abbreviations: *COVID-19* Coronavirus disease 2019, *CNS* Central nervous system, *HRT* Hormone replacement therapy, *PC* Protein C, *PS* Protein S, *AT* Antithrombin

$^{\perp}$ *P* value for differences between before and after the COVID-19 pandemic in risk factors

[a] Autoimmune diseases include systemic lupus erythematosus, Crohn's disease, Behcet's disease, rheumatoid arthritis, ankylosing spondylitis, and intestinal inflammatory disease

[b] Drugs include tamoxifen, steroids, and chemotherapeutic agents

including CVST [14]. The hypercoagulability associated with COVID-19 may result from direct endothelial damage, cytokine storms, and the potential presence of antiphospholipid antibodies, all contributing to increased thrombotic risk [15–19]. Our study also found that extra-meningeal infections, which were less common before the pandemic, have become a more prominent risk factor post-pandemic. This underscores the need for strict infection control and management practices to prevent CVST, especially in the current pandemic context.

Gender and age-related differences in risk factors

Subgroup analyses revealed that traditional gender-specific risk factors, such as obstetric causes and oral contraceptive use, have become less prominent in females following the pandemic, with prothrombotic conditions and infections taking precedence. This change may reflect broader epidemiological trends influenced by the pandemic, including changes in healthcare access and behavior. It should also be acknowledged that evolving birth control policies and economic factors in China may have contributed to these changes,

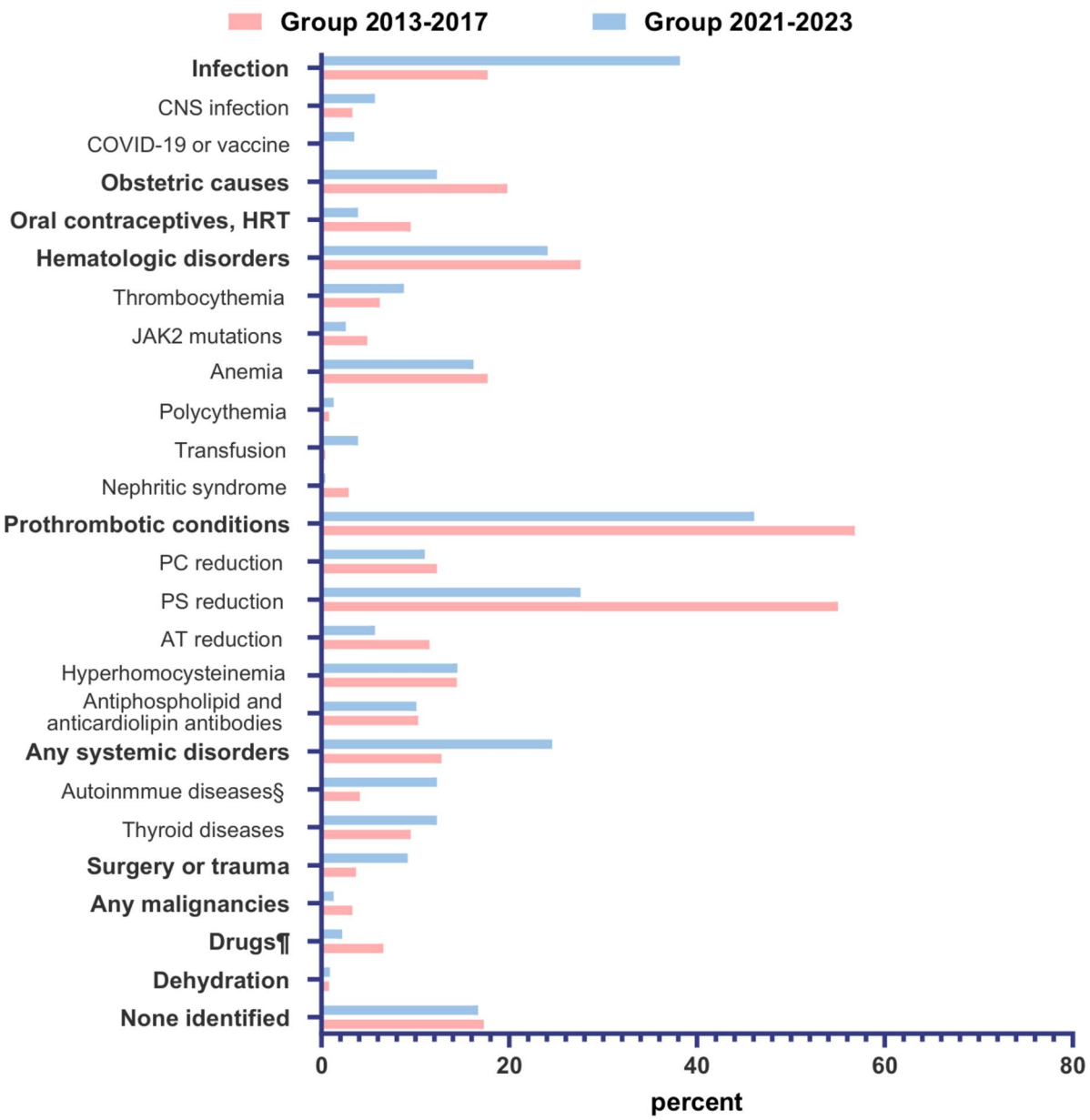

Fig. 3 The primary risk factors for cerebral venous sinus thrombosis before and after the COVID-19 pandemic. [§]Autoimmune diseases include systemic lupus erythematosus, Crohn's disease, Behcet's disease, rheumatoid arthritis, ankylosing spondylitis, and intestinal inflammatory disease. [¶]Drugs include tamoxifen, steroids, and chemotherapeutic agents

although they were not directly addressed in our study. In males, prothrombotic conditions and infections also emerged as the leading risk factors, suggesting that the pandemic has homogenized some gender-related differences in CVST risk. Age-related differences were less pronounced, though younger patients were more likely to present with obstetric causes, while older patients exhibited a more diverse risk factor profile.

Prognostic factors and clinical outcomes

The identification of central nervous system infections, oral contraceptives and HRT, hematologic disorders, anemia, and prothrombotic conditions as significant predictors of poor outcomes is consistent with previous studies [20, 21]. However, our study highlights anemia as an independent predictor of survival in CVST patients. Anemia may exacerbate cerebral hypoxia and increase

Table 3 Logistic regression analysis evaluating the association between risk factors and outcomes at discharge in all 471 patients

Risk Factor	Unadjusted OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
CNS infection	6.013 (1.390–26.011)	0.016	0.615 (0.099–3.823)	0.602
Obstetric causes	1.116 (0.553–2.253)	0.759	-	-
Oral contraceptives, HRT	1.995 (1.043–3.819)	0.037	3.000 (0.556–16.186)	0.201
Hematologic disorders	1.947 (1.115–3.397)	0.019	1.778 (0.411–7.697)	0.442
Anemia	2.232 (1.213–4.107)	0.010	6.000 (1.445–24.919)	0.014
Polycythemia	4.426 (0.725–27.028)	0.107	2.889 (0.325–25.702)	0.341
Transfusion	1.639 (0.340–7.901)	0.538	-	-
Prothrombotic conditions	1.901 (1.093–3.304)	0.023	1.821 (0.885–3.747)	0.104
PS reduction	1.604 (0.934–2.754)	0.087	0.482 (0.129–1.795)	0.277
AT reduction	1.429 (0.567–3.601)	0.450	-	-
Hyperhomocysteinemia	1.479 (0.742–2.946)	0.266	-	-
Antiphospholipid and anticardiolipin antibodies	1.119 (0.479–2.616)	0.795	-	-
Any malignancies	1.454 (0.307–6.887)	0.637	-	-

Abbreviations: *CNS* Central nervous system, *HRT* Hormone replacement therapy, *PS* Protein S, *AT* Antithrombin, *OR* Odds ratio, *95% CI* 95% confidence interval, - not included in the analysis

Table 4 A summary of logistic regression analysis evaluating the association between risk factors and outcomes at discharge in all 471 patients

Risk Factor	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
CNS infection	6.013 (1.390-26.011)	0.016	0.615 (0.099-3.823)	0.602
Obstetric causes	1.116 (0.553-2.253)	0.759	-	-
Oral contraceptives, HRT	1.995 (1.043-3.819)	0.037	3.000 (0.556-16.186)	0.201
Hematologic disorders	1.947 (1.115-3.397)	0.019	1.778 (0.411-7.697)	0.442
Anemia	2.232 (1.213-4.107)	0.010	6.000 (1.445-24.919)	0.014
Prothrombotic conditions	1.901 (1.093-3.304)	0.023	1.821 (0.885-3.747)	0.104

Abbreviations: CNS central nervous system, *HRT* hormone replacement therapy, *OR* odds ratio, *95% CI* 95% confidence interval, - not included in the analysis

the risk of venous infarction, underscoring the importance of early identification and management of hematologic abnormalities in improving patient outcomes. The generally favorable prognosis observed in this cohort, with 86.6% of patients achieving good outcomes, indicates the effectiveness of current treatment protocols, including anticoagulation therapy. However, the 13.4% of patients who experienced poor outcomes highlight the need for continued vigilance and targeted interventions, especially for those with identified risk factors.

Study limitations and future directions

Despite its strengths, several limitations must be acknowledged. The retrospective nature of the study introduces potential biases due to incomplete data and reliance on historical medical records. Moreover, while our sample size is large and geographically diverse, the limited number of patients with specific risk factors or outcomes restricts the statistical power of some analyses. The small number of confirmed COVID-19 cases in our cohort does not establish a direct causal relationship between COVID-19 and the observed changes in CVST symptoms. Future research should focus on prospective, multicenter studies to elucidate the molecular and genetic underpinnings of CVST, particularly in the context of COVID-19. Such studies could provide deeper insights into the pathogenesis of CVST and identify novel therapeutic targets. Finally, changes in health-seeking behavior and healthcare systems post-pandemic should also be considered.

Implications for clinical practice

The findings of this study have significant implications for clinical practice, especially in the post-pandemic healthcare landscape. First, the study emphasizes the need for heightened vigilance in recognizing CVST as a potential complication of COVID-19, particularly with the shift in symptoms, such as the increased incidence of visual disturbances. Clinicians should maintain a high index of suspicion for CVST in patients with recent COVID-19

or vaccination history who present with atypical neurological symptoms. Second, the rise in infection-related CVST cases underscores the importance of early and robust infection control measures. Routine screening for hypercoagulability in at-risk patients and prompt treatment of infections are essential to prevent severe thrombotic events, making these strategies vital in reducing the incidence and severity of CVST. Third, anemia as an independent predictor of survival suggests the importance of routine hematologic evaluations and early management of anemia in CVST patients. Tailored treatment strategies that address hematologic imbalances could significantly improve outcomes. Last but not least, the study challenges traditional gender-specific risk profiles, which indicate that the pandemic has reshaped the risk landscape for CVST. Clinicians should adapt treatment guidelines to these evolving risks, ensuring that interventions are responsive to the current context.

Conclusions

This study provides an in-depth analysis of the evolving characteristics, risk factors, and outcomes of CVST in Chinese patients before and after the COVID-19 pandemic. Significant changes observed in the clinical presentation and risk profile of CVST post-pandemic underscore the need for ongoing research and adaptation of clinical practices. Prothrombotic conditions, infections, and hematologic disorders have emerged as the primary risk factors, with infections showing a marked increase in the post-pandemic period. Recognizing these factors in predicting patient outcomes is essential for guiding clinical interventions and improving prognosis. Early identification and management of anemia and other hematologic abnormalities could significantly enhance patient survival.

Abbreviations

CVST	Cerebral venous sinus thrombosis
mRS	The modified Rankin scale
COVID-19	The coronavirus disease 2019
HRT	Hormone replacement therapy

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

XZ wrote the first draft of the manuscript. KF, DL, and XH performed material preparation, data collection, and statistical analysis. XJ, RM, and DZ wrote sections of the manuscript and contributed to its revision. RM and DZ took full responsibility for the data, analyses, interpretation, and conduct of the research. All authors have read and approved the final version of the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding authors upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Ethics Committee of Xuanwu Hospital, Capital Medical University, and was conducted in accordance with the guidelines of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to any study procedures.

Consent for publication

Consent for publication was obtained from all participants prior to any study procedures.

Competing interests

The authors declare no competing interests.

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