International Journal of Science and Healthcare Research
[Indexed, Peer-Reviewed Journal]
Vol. 10; Issue: 4; Oct.-Dec. 2025
Website: ijshr.com
Original Research Article *ISSN: 2455-7587*

Correlation of Vitamin B12 and Homocysteine with Clinical Presentation of Central Venous Sinus Thrombosis: Insights from Hospital Based Survey

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DOI: https://doi.org/10.52403/ijshr.20250419

ABSTRACT

Background: Cerebral Venous Sinus Thrombosis (CVST) is an uncommon stroke subtype with diverse risk factors. While conditions like infection, dehydration, and the peripartum state are well-established, the role of metabolic factors like vitamin B12 deficiency and hyperhomocysteinemia is less defined, particularly in the Indian context. This study aimed to correlate vitamin B12 and homocysteine levels with the clinical presentation of CVST.

Methods: A hospital-based cross-sectional study was conducted in the Department of General Medicine. Twenty-five patients with radiologically confirmed CVST were enrolled. Detailed clinical history, neurological examination, and laboratory investigations—including serum vitamin B12, homocysteine, and hemoglobin levels—were performed. Radiological evaluation identified the site of thrombosis. Statistical analysis was performed to assess associations between biochemical abnormalities and clinical features.

Results: The mean age of participants was 28 years, with a female predominance (64%). Common risk factors included dehydration (64%), infection (56%), and the peripartum state (50% of females). Hyperhomocysteinemia and low vitamin B12 were present in 32% and 28% of patients, respectively. A significant inverse correlation was found between serum vitamin B12 and homocysteine levels ($r = -0.3975$, $p=0.0491$).

Conclusion: Vitamin B12 deficiency and hyperhomocysteinemia are prevalent and interrelated metabolic risk factors in CVST patients. They are significantly associated with more severe neurological presentations, including seizures and focal deficits. Screening for and managing these deficiencies could be an important adjuvant strategy to standard CVST treatment.

Keywords: Cerebral Venous Sinus Thrombosis, CVST, Vitamin B12, Homocysteine, Hyperhomocysteinemia, Risk Factors, Seizures, Neurological Deficit.

INTRODUCTION

Cerebral venous sinus thrombosis (CVST) is an uncommon condition which over the past few years has been diagnosed more frequently due to greater awareness and the availability of better non-invasive diagnostic techniques. Because of the generally good prognosis and variable clinical signs, many cases remain clinically undetected. CVST is slightly more common in women, particularly in the age group of 20 to 35, due to pregnancy, puerperium and oral contraceptive use. [1]

The main progress in CVT study has been focused on identification of thrombophilic factors. Epidemiological studies have suggested that even mild Hyper homocysteinemia (hyper-Hcy) is associated with occlusive arterial vascular disease1 and venous thromboembolism. [2-7]

In the past, CVST was attributed to otomastoid, orbital, and central face infections, but after the introduction of antibiotics, it is more often related to neoplasm, pregnancy, puerperium, systemic diseases, dehydration, intracranial tumors9, oral contraceptives (OCPs), and coagulopathies, even though in 30% of cases, no underlying etiology could be identified. [8-12]

Little information about the role of homocysteine in CVT is available. Martinelli et al found that hyper-Hcy increases the risk of CVT by 4-fold. [13] Genetic and nutritional factors are important determinants of homocysteine metabolism. The common C6773T mutation in the methylene tetrahydrofolate reductase (MTHFR) gene is associated with a thermolabile variant that has approximately half-normal activity. [14, 15] Approximately 10% to 13% of the white population are homozygous for this mutation.

Conversely, because blood levels of folate, vitamin B12, and to a lesser extent vitamin B6, are related inversely to homocysteine, anyone with a nutritional deficiency of these vitamins is at increased risk of hyper-Hcy. [16] The potential interaction between genetic and environmental factors is important in the production of increased homocysteine levels. Consequently, the hereditary metabolic disorder will manifest mainly in individuals with poor nutritional status.[17] Hyper-Hcy may contribute to the relatively high CVT frequency. [18, 19] Although CVT comprises 8% of cases with cerebrovascular disorders in our stroke register, it represents an uncommon diagnosis in American and European stroke registries. [20] Nutritional factor deficiencies associated with poor socio-economic conditions may influence development of hyper-Hcy.

In the present case–control study, a hypothesis was posed accordingly proposing hyper-Hcy as a risk factor for development of CVT in association with the MTHFR mutation or with a deficient nutritional status resulting from inadequate ingestion of vitamins such as Vitamin B12. This Cross-Sectional Study was done to find association of Cerebral Venous Sinus Thrombosis with Vitamin B12 and Homocysteine Level.

MATERIALS & METHODS

Study Design and Setting

This investigation was designed as a hospital-based cross-sectional study and was conducted in the Department of General Medicine, Baroda Medical College, Vadodara, India, during the year 2020. The study was carried out in collaboration with SSG Hospital, which served as the primary site for patient recruitment and clinical evaluation.

Study Population

The study population comprised patients admitted with a confirmed diagnosis of Cerebral Venous Sinus Thrombosis (CVST). Diagnosis was established based on clinical presentation and radiological confirmation using CT brain with venous angiography.

Sample Size: A total of 25 patients were enrolled in the study.

Inclusion Criteria

- Patients aged more than 12 years.
- Patients admitted to SSG Hospital with radiologically confirmed CVST.
- Patients who provided written informed consent for participation.

Exclusion Criteria

- Patients who did not provide consent.
- Patients who were already receiving Vitamin B12 supplementation at the time of presentation.

Ethical Considerations

Prior to enrollment, written informed consent was obtained from all participants (or their legal guardians, where applicable). The study

protocol adhered to the principles of the Declaration of Helsinki. Patient privacy and confidentiality were strictly maintained throughout the study.

Data Collection Procedure

After recruitment, each participant underwent a standardized research protocol that included:

1. **Detailed Clinical History**
   - Demographic details (age, sex, socioeconomic status using BG Prasad classification).
   - Obstetric history in female patients (parity, history of abortions, oral contraceptive use).
   - Presenting symptoms (headache, seizures, nausea/vomiting, altered mental status, focal neurological deficits, speech impairment).
   - Risk factors (dehydration, infection, pregnancy, hyperhomocysteinemia, low Vitamin B12 levels).
2. **Physical and Neurological Examination**
   - Comprehensive systemic and neurological assessment to document focal deficits and mental status changes.
3. **Laboratory Investigations All patients underwent the following investigations:**
   - Serum Homocysteine levels (measured in µmol/L).
   - Serum Vitamin B12 levels (measured in pmol/L).
   - Complete hemogram (including hemoglobin concentration).
   - Blood urea and serum creatinine.
   - Liver function tests.
   - Additional tests as clinically indicated.
4. **Radiological Evaluation**
   - CT brain with venous angiography to confirm the diagnosis and identify the site(s) of venous sinus involvement (sagittal, transverse/sigmoid, cavernous, or multiple sinuses).

Operational Definitions

- Hyperhomocysteinemia: Serum homocysteine level above 15 µmol/L.
- Low Vitamin B12: Serum Vitamin B12 level below 250 pmol/L (<338 pg/mL).
- Modes of Presentation:
  - *Acute*: Symptom onset to presentation < 48 hours.
  - *Subacute*: 48 hours to 30 days.
  - *Chronic*: 30 days to 6 months.

Data Management and Statistical Analysis

Data were entered into Microsoft Excel and analysed using MedCalc statistical software. Descriptive statistics were used to summarize baseline characteristics (mean ± standard deviation for continuous variables; frequencies and percentages for categorical variables). Chi-square test was applied to assess associations between categorical variables. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated where applicable. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 25 patients with radiologically confirmed CVST were included in the analysis. The mean age was 28 years with range from 14 to 55 years of age, with a female predominance (64%). The majority of cases presented in the subacute phase.

Table 1: Baseline Demographic and Clinical Characteristics

Variable	n (%); N = 25
Sex	Male: 9 (36%), Female: 16 (64%)
Socioeconomic status (BG Prasad)	Class I: 3 (12%), Class II: 4 (16%), Class III: 7 (28%), Class IV: 8 (38%); Class V: 3 (12%)
Mode of presentation	Acute: 10 (40%), Subacute: 11 (44%), Chronic: 4 (16%)
Risk factors identified	Dehydration: 16 (64%), Infection: 14 (56%), Pregnancy: 8 (50%*), Hyperhomocysteinemia 8 (32%), Low Vitamin B12 levels 7 (28%)

***n=16**

Table 1 summarizes the baseline demographic and clinical characteristics of the 25 CVST patients studied. The cohort was predominantly female (64%), with a mean age of 28 years. Most patients belonged to lower socioeconomic classes (Class III–V). The majority presented in the subacute phase (44%), and common risk factors included dehydration (64%), infection (56%), and among females, pregnancy (50%). Hyperhomocysteinemia (32%) and low vitamin B12 levels (28%) were also notable biochemical risk factors.

Table 2: Radiological Distribution of Venous Sinus Involvement

Site of Thrombosis	n (%)
Superior sagittal sinus	12 (48%)
Sigmoid and/or transverse sinus	7 (28%)
Cavernous sinus	1 (4%)
Multiple sinuses	5 (20%)

Table 2 details the radiological distribution of venous sinus involvement. The superior sagittal sinus was the most commonly thrombosed site (48%), followed by the sigmoid and/or transverse sinuses (28%). Multiple sinus involvement was observed in 20% of cases, while cavernous sinus thrombosis was rare (4%). This indicates a predilection for the superior sagittal and lateral sinuses in this patient population.

Table 3: Laboratory Profile: Vitamin B12 and Homocysteine Levels

Parameter	Mean ± SD
Serum Vitamin B12 (pmol/L)	370.0 ± 354.5
Serum Homocysteine (µmol/L)	13.7 ± 28.4
Hemoglobin (g/dL)	8.6 ± 1.6

Table 3 presents the laboratory profile, showing mean serum vitamin B12 levels of 370.0 ± 354.5 pmol/L and homocysteine levels of 13.7 ± 28.4 µmol/L, with considerable variability. The mean hemoglobin level was 8.6 ± 1.6 g/dL, suggesting a high prevalence of anemia among these CVST patients

Table 4: Statistical Association Between Biochemical Abnormalities and CVST Presentation

Variable	χ^2 value	p-value
Low Vitamin B12 vs. Seizures	2.14	0.043*
Low Vitamin B12 vs. Focal deficit	4.02	0.031*
High Homocysteine vs. Seizures	5.12	0.018*
High Homocysteine vs. Focal deficit	6.24	0.009*

***p < 0.05 considered statistically significant.**

Table 4 shows statistically significant associations between biochemical abnormalities and clinical features of CVST. Low vitamin B12 was significantly associated with seizures ($p = 0.043$) and focal deficits ($p = 0.031$), as was high homocysteine with seizures ($p = 0.018$) and focal deficits ($p = 0.009$). This suggests that these metabolic disturbances may contribute to more severe neurological manifestations in CVST.

Table 5 correlates the site of thrombosis with clinical outcomes. Sagittal sinus involvement was associated with the highest number of deaths (4) and a mean hospital stay of 4.75 days. Multiple sinus thrombosis had the longest mean stay (5.6 days) and 3 deaths. No deaths occurred with cavernous sinus thrombosis. This indicates that sagittal and multiple sinus involvement may predict worse outcomes.

Table 5: Cortical venous sinus involvement, deaths, and duration of stay

Sinuses	Deaths	Mean duration of stay
Sagittal	4	4.75 days
Sigmoid/transverse	3	1 day
Cavernous	0	0
Multiple sinuses	3	5.6 days

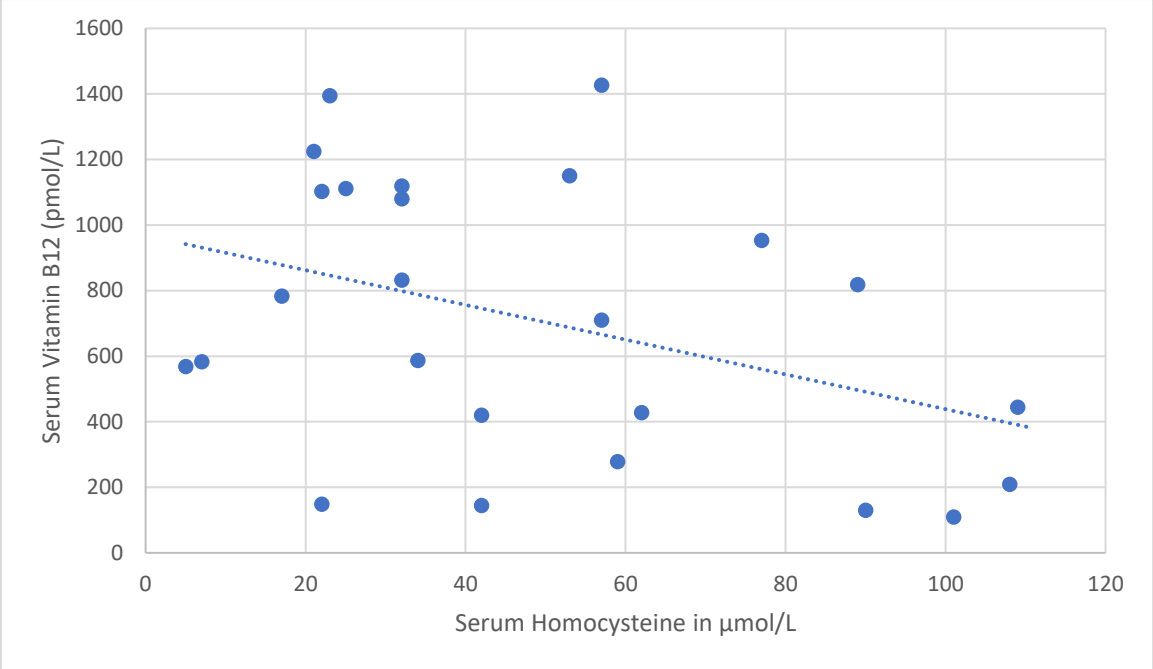

Figure 1: Correlation of Serum Vitamin B12 with Serum Homocystiene

The correlation analysis between serum homocysteine and serum vitamin B12 levels in 25 patients with CVST showed a moderate, statistically significant inverse relationship (Pearson's r = −0.3975, 95% CI: −0.6850 to −0.0028, $R^2 = 0.1580$, p = 0.0491). [Figure 1].

DISCUSSION

Cerebral Venous Sinus Thrombosis (CVST) is a rare but serious neurovascular disorder, accounting for approximately 0.5%-1% of all strokes, with a predilection for young and middle-aged adults, particularly women. [21] Historically, its etiology in developing countries has been strongly linked to pregnancy, multiparity, dehydration, and local or systemic infections. [22, 23] Our hospital-based study, which analyzed 25 patients with radiologically confirmed CVST, reinforces this demographic profile, demonstrating a mean age of 28 years with a clear female predominance (64%). The majority of our patients belonged to lower socioeconomic strata (Classes III-V of the BG Prasad scale), a factor often correlated with nutritional deficiencies that may play a critical role in disease pathogenesis.

The clinical presentation of CVST is notoriously diverse. In our cohort, the subacute mode of presentation was most common (44%), aligning with the often-insidious onset of the disease. The identified risk factors were consistent with established literature, with dehydration (64%) and infection (56%) being the most prevalent. Among the female patients, the peripartum period was a significant risk factor, present in 50% of the women studied. However, our findings introduce a crucial, modifiable dimension to the risk profile of CVST: metabolic abnormalities. A substantial proportion of our patients exhibited hyperhomocysteinemia (32%) and low vitamin B12 levels (28%), suggesting that these biochemical factors are important contributors to the hypercoagulable state in our population.

The radiological distribution of thrombosis in our study, with the superior sagittal sinus (48%) being most frequently involved, followed by the sigmoid/transverse sinuses (28%), is consistent with reports from other Indian and international cohorts. [24, 25] This pattern underlines the predilection for the superficial venous system. Multiple sinus involvement was observed in 20% of cases, a finding often associated with more severe clinical courses.

The core insight from our investigation lies in the significant association between biochemical abnormalities and clinical severity. Our laboratory profile revealed a mean homocysteine level of 13.7 ± 28.4 µmol/L and a mean vitamin B12 level of 370.0 ± 354.5 pmol/L, with considerable standard deviations indicating a wide range of values within the cohort. Crucially, statistical analysis demonstrated that low vitamin B12 levels were significantly associated with seizures (p=0.043) and focal neurological deficits (p=0.031). Similarly, high homocysteine levels showed an even stronger association with seizures (p=0.018) and focal deficits (p=0.009). This compellingly suggests that these metabolic disturbances are not merely incidental findings but are intrinsically linked to a more severe neurological presentation of CVST, potentially exacerbating neuronal injury and thrombogenesis.

This relationship is further strengthened by the observed moderate, statistically significant inverse correlation between serum vitamin B12 and homocysteine levels (Pearson's r = -0.3975, p=0.0491). This inverse correlation is well-established in biochemistry; vitamin B12 is an essential cofactor in the metabolic pathway that remethylates homocysteine to methionine. A deficiency in B12 thus leads to an accumulation of homocysteine, a sulfur-containing amino acid known to promote endothelial dysfunction, oxidative stress, and a prothrombotic state. [26, 27] Our findings are supported by previous research. Martinelli et al. in a case-control study found that hyperhomocysteinemia was associated with a 4-fold increased risk of CVT. [13] Similarly, Cantu et al. reported that high plasma homocysteine and low folate levels were associated with an increased risk of CVST. [18]

The outcomes in our study, stratified by sinus involvement, provide additional clinical context. Sagittal sinus thrombosis was associated with the highest number of deaths (4) and a mean hospital stay of 4.75 days, while multiple sinus involvement had the longest mean stay (5.6 days) and 3 deaths. This aligns with the understanding that more extensive thrombosis often correlates with worse prognosis due to larger venous infarcts and higher intracranial pressure. The overall mortality in our study was 16%, which is comparable to rates reported in other modern series, and lower than historical cohorts, likely reflecting improvements in diagnostic awareness, imaging, and management. [28]

The implications of our findings are significant for clinical practice, particularly in the Indian context where nutritional deficiencies are prevalent. While traditional risk factors like infection and dehydration remain critical to address, our study underscores the imperative to screen all CVST patients, especially those presenting with severe symptoms like seizures or focal deficits, for vitamin B12 deficiency and hyperhomocysteinemia. This is not merely an academic exercise but has direct therapeutic consequences. As demonstrated in case reports and smaller studies, supplementation with vitamin B12, folic acid, and pyridoxine can effectively lower homocysteine levels. [29] Therefore, in addition to standard anticoagulation, targeted metabolic therapy could represent a vital adjuvant strategy to mitigate the risk of severe presentation and potentially improve long-term outcomes. This approach is supported by Nagaraja et al., who highlighted that low folate levels contribute significantly to hyperhomocysteinemia in Indian women with puerperal CVST. [30]

Our study must be interpreted in the context of its limitations. The sample size, though consistent with many single-center CVST studies, is modest. Furthermore, due to resource constraints, we were unable to evaluate genetic prothrombotic factors (such as Factor V Leiden or Prothrombin G20210A mutations) or other uncommon hematological conditions that might interact with the metabolic factors we identified. The possibility of such gene-environment interactions, as suggested by the work of Cantu et al. on MTHFR mutations, warrants

further investigation in larger, multi-center studies. [18]

CONCLUSION

Based on the findings of this hospital-based survey, it can be concluded that vitamin B12 deficiency and hyperhomocysteinemia are significant, interrelated metabolic risk factors associated with more severe clinical presentations of Central Venous Sinus Thrombosis (CVST). The study identified a high prevalence of these biochemical abnormalities within the cohort, and statistically significant associations were found between low vitamin B12 levels and neurological sequelae such as seizures and focal deficits, as well as between high homocysteine levels and the same severe manifestations. Furthermore, a moderate inverse correlation between serum vitamin B12 and homocysteine levels suggests a potential pathophysiological link. These insights highlight the importance of screening for and managing vitamin B12 deficiency and hyperhomocysteinemia in CVST patients, as addressing these metabolic factors could potentially influence disease severity and clinical outcomes.

Declaration by Authors

Ethical Approval: Approved
Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Nilam Ramjibhai Gabani, Prashant Vinodbhai Chotalia, Nirav Rohit Kumar Shah, Mayur Babubhai Kachchhi. Correlation of vitamin B12 and homocysteine with clinical presentation of central venous sinus thrombosis: insights from hospital based survey. *Int. J. Sci. Healthc. Res.* 2025; 10(4): 131-139. DOI: *https://doi.org/10.52403/ijshr.20250419*

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