ORIGINAL ARTICLE

Diagnostic Accuracy of Non-Contrast Computed Tomography for Acute Cerebral Venous Sinus Thrombosis using Magnetic Resonance Venography as the Reference Standard

Aatiqa Anwar[1*], Nasreen Naz[2], Sohail Ahmed Khan[2], Binish Rasheed[3], Nida Rafiq[4], Sameera Salman[5]

[1]*FCPS Trainee, Dow Institute of Radiology, DUHS-Karachi, Sindh-Pakistan*
[2]*Professor, Dow Institute of Radiology, DUHS-Karachi, Sindh-Pakistan*
[3]*Associate Professor, Dow Institute of Radiology, DUHS-Karachi, Sindh-Pakistan*
[4]*Assistant Professor, Dow Institute of Radiology, DUHS-Karachi, Sindh-Pakistan*
[5]*Senior Instructor, Dow Institute of Radiology, DUHS-Karachi, Sindh-Pakistan*
Correspondence: *draatiqashaikh@gmail.com*
doi: 10.22442/jlumhs.2026.01488

ABSTRACT
OBJECTIVE: To evaluate the diagnostic accuracy of non-contrast computed tomography (CT) in detecting acute cerebral venous sinus thrombosis (CVST), using magnetic resonance venography (MRV) as the reference standard.
METHODOLOGY: This cross-sectional descriptive study was conducted at the Dow Institute of Radiology, Dow University of Health Sciences, Karachi, from June to December 2025. 208 patients aged 18–60 years of either gender presenting with acute neurological or visual symptoms suggestive of CVST, or referred with clinical suspicion of CVST, were enrolled using non-probability consecutive sampling. All patients underwent non-contrast CT of the brain followed by contrast-enhanced MRV. Sinus attenuation was measured in Hounsfield units (HU) by placing regions of interest in the most hyperdense portion of the affected sinus, and values >70 HU were considered positive. The HU-to-hematocrit (HU/HCT) ratio was also calculated, with values >1.64 considered positive. MRV findings served as the reference standard.
RESULTS: Among 208 patients, the mean age was 39.8±12.0 years, and 51.4% were male. MRV identified CVST in 30 patients (14.4%). The transverse sinus was the most commonly involved sinus (36.7%). Non-contrast CT demonstrated a sensitivity of 90.0% (95% CI: –), specificity of 74.7% (95% CI: –), positive predictive value of 37.5%, negative predictive value of 97.8%, and an overall diagnostic accuracy of 76.9%.
CONCLUSION: Non-contrast CT demonstrated high sensitivity and excellent negative predictive value for detecting acute CVST. These findings support its role as an initial screening modality, particularly in emergency departments and resource-limited settings; however, confirmatory MRV remains necessary because of its moderate specificity.

KEYWORDS: Cerebral venous sinus thrombosis, computed tomography, magnetic resonance venography, diagnostic accuracy, sensitivity, specificity.

INTRODUCTION

Cerebral venous sinus thrombosis (CVST) is an uncommon form of venous thromboembolism characterized by thrombosis of the intracranial venous sinuses and cerebral veins. Its reported annual incidence is approximately 13 per million population, although rates vary across geographic regions. Despite its relatively low frequency, CVST is an important cause of stroke, accounting for approximately 0.5–1% of all stroke cases. It predominantly affects young adults, with a mean age of around 35 years, and is associated with significant morbidity and mortality, particularly when diagnosis and treatment are delayed. In Pakistan, the prevalence of CVST has been reported to be approximately 11.0% [1–5].

The pathogenesis of CVST is multifactorial and can be explained by Virchow's triad of hypercoagulability, venous stasis, and endothelial injury. Common risk factors include pregnancy, puerperium, oral contraceptive use, chronic inflammatory disorders, malignancy, inherited thrombophilia, and certain iatrogenic causes. The clinical presentation is often variable and nonspecific, ranging from isolated headache and visual disturbances to seizures, focal neurological deficits, altered consciousness, and signs of raised intracranial pressure. This heterogeneity frequently contributes to diagnostic delays and increases the risk of adverse neurological outcomes [6].

Imaging plays a central role in the diagnosis of CVST. Non-contrast computed tomography (CT) is usually the first imaging modality performed in emergency settings because it is rapid, widely available, and cost-effective. Acute thrombus within the dural venous sinuses may appear hyperattenuating on CT; however, visual assessment alone can be subjective. Quantitative assessment using Hounsfield unit (HU) measurements and the HU-to-hematocrit (HU/HCT) ratio has been proposed to improve diagnostic accuracy by accounting for variations in blood attenuation with hematocrit. These objective measures may help reduce false-positive findings in polycythemia and false-negative findings in anemia[7,8].

Magnetic resonance venography (MRV) is widely accepted as the reference standard for non-invasive evaluation of CVST because of its superior ability to demonstrate venous sinus occlusion and altered venous flow. However, its limited availability, higher cost, and longer acquisition time may restrict its use in emergency and resource-limited settings. Consequently, establishing the diagnostic performance of non-contrast CT is clinically important.

Therefore, this study was conducted to determine the diagnostic accuracy of non-contrast CT in detecting acute CVST using MRV as the reference standard. The findings may assist clinicians in early identification of CVST and support the evidence-based use of imaging resources, particularly in settings where immediate access to MRV is limited.

METHODOLOGY

This cross-sectional descriptive study was conducted at the Dow Institute of Radiology, Dow International Medical College, Dow University of Health Sciences (DUHS), Ojha Campus, Karachi, over six months from June to December 2025. Ethical approval was obtained from the Institutional Review Board of Dow International Medical College, DUHS (IRB Letter No. IRB-3906/DUHS/Approval/2025/200 dated: 22/05/2026) and the College of Physicians and Surgeons Pakistan (CPSP). Written informed consent was obtained from all participants before enrollment.

A total of 208 patients were recruited through non-probability consecutive sampling. The sample size was calculated using the diagnostic test sample size calculator, based on the study by **Shayganfar A et al.** [9], which reported a sensitivity of 94.3%, specificity of 54.2%, and a disease prevalence of 11.06%. The calculation was performed at a 95% confidence level with an acceptable precision of 10%.

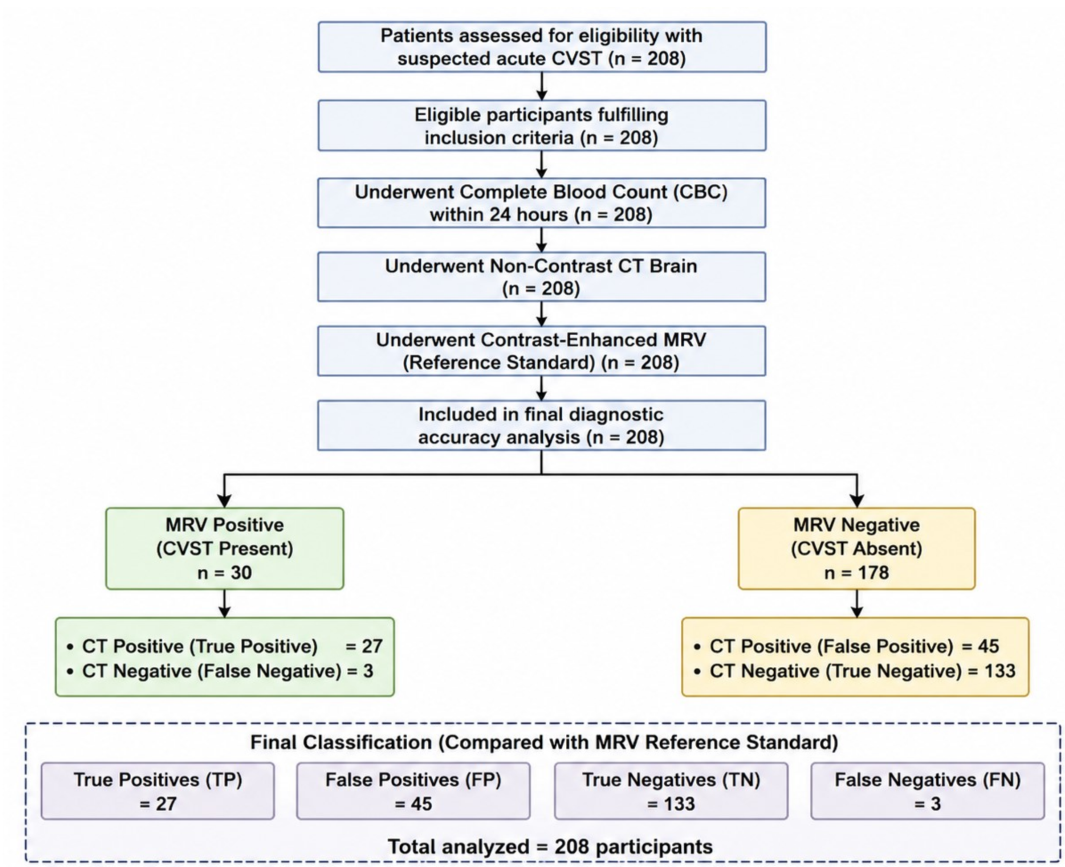
Eligible participants included patients aged 18–60 years of either gender presenting with acute neurological or visual symptoms suggestive of cerebral venous sinus thrombosis (CVST), including headache, loss of consciousness, seizures, or blurring of vision, with symptom duration of less than five days. Patients were required to have undergone a Complete Blood Count (CBC) within 24 hours of both non-contrast CT and MRV examinations. Patients with brain tumors, impaired renal function, pregnancy, or those unwilling to participate were excluded from the study.

All CT and MRV examinations were reviewed by a single consultant radiologist with fellowship training in neuroimaging and more than five years of post-fellowship experience. The radiologist interpreted CT images independently and was blinded to the MRV findings.

Each participant underwent a non-contrast CT scan of the brain using a 128-slice multidetector CT scanner (Toshiba or GE Healthcare) according to the departmental imaging protocol. Axial images were acquired with a slice thickness of 3 mm using standard brain and bone window settings. Multiplanar reconstructions and maximum-intensity projection (MIP) images were generated to optimize visualization of the cerebral venous sinuses. Attenuation values of the dural venous sinuses were measured in Hounsfield units (HU) by placing regions of interest (ROI) over the most hyperattenuating portion of the sinus while avoiding adjacent bone structures and minimizing partial volume effects. Hemoglobin and hematocrit values obtained from the Complete Blood Count were recorded, and the HU-to-hematocrit (HU/HCT) ratio was calculated. A CT examination was considered positive for acute CVST when sinus attenuation exceeded 70 HU and/or the HU/HCT ratio was greater than 1.64.

Magnetic resonance venography (MRV) was performed on the same day using a 1.5-Tesla MRI system (Siemens or GE Healthcare) and served as the reference standard. The MRI protocol included axial T1-weighted, T2-weighted, FLAIR, diffusion-weighted imaging (DWI) with apparent diffusion coefficient (ADC) maps, and susceptibility-weighted imaging (SWI) sequences. Post-contrast T1-weighted images were acquired in axial, coronal, and sagittal planes. MR venography was performed using three-dimensional time-of-flight (3D-TOF) and contrast-enhanced techniques with isotropic voxel thickness of approximately 1–1.2 mm. Multiplanar reformations and maximum-intensity-projection images were reviewed for evaluation of the cerebral venous sinuses. The presence or absence of venous sinus thrombosis was recorded based on MRV findings.

Demographic characteristics, presenting symptoms, duration of symptoms, laboratory parameters, CT findings, and MRV findings were recorded using a structured data collection proforma. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Quantitative variables, including age, duration of symptoms, hemoglobin level, and hematocrit level, were expressed as mean ± standard deviation, while qualitative variables were presented as frequencies and percentages. A 2 × 2 contingency table was constructed to determine the sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy, and corresponding 95% confidence intervals of non-contrast CT, using MRV as the reference standard. Stratified analysis was performed according to age, gender, catchment area, duration of symptoms, and presenting symptoms to evaluate the diagnostic performance of non-contrast CT across different subgroups.



: Cerebral Venous Sinus Thrombosis; CT: Computed Tomography; MRV: Magnetic Resonance Venography; Complete Blood Count.

Figure 1: STARD Flow Diagram of Participant Recruitment and Analysis

RESULTS

Table I presents the demographic and clinical characteristics of the study population. Among the 208 participants, 107 (51.4%) were males, and 101 (48.6%) were females. Most participants were aged ≤45 years (61.5%). Magnetic resonance venography (MRV) identified acute cerebral venous sinus thrombosis (CVST) in 30 (14.4%) patients, whereas non-contrast CT was positive in 72 (34.6%) patients. Headache was the most frequently reported presenting symptom, followed by blurring of vision.

Table I: Demographic and Clinical Characteristics of the Study Participants (n = 208)

Variable	Category	Frequency	Percentage (%)
Gender	Male	107	51.4
	Female	101	48.6
Age group	≤ 45 years	128	61.5
	> 45 years	80	38.5
Catchment area	Urban	112	53.8
	Rural	96	46.2
Headache	Yes	100	48.1
	No	108	51.9
Loss of consciousness	Yes	39	18.8
	No	169	81.3
Seizures	Yes	29	13.9
	No	179	86.1
Blurring of vision	Yes	73	35.1
	No	135	64.9
Duration of symptoms	Up to 2 days	130	62.5
	3-5 days	78	37.5
MRV findings	Positive	30	14.4
	Negative	178	85.6
CT findings	Positive	72	34.6
	Negative	136	65.4

Table II shows the distribution of venous sinus involvement among patients diagnosed with acute CVST on MRV. The transverse sinus was the most commonly involved sinus, accounting for 36.7% of cases, followed by the superior sagittal sinus (33.3%). Cortical vein thrombosis was the least frequent finding, observed in 3.3% of patients.

Table II: Distribution of Cerebral Venous Sinus Involvement Among Patients Diagnosed with Acute CVST on MRV (n = 30)

Sinus Involved	Frequency (n)	Percentage (%)
Transverse sinus	11	36.7
Superior sagittal sinus	10	33.3
Sigmoid sinus	4	13.3
Straight sinus	2	6.7
Multiple sinus involvement	2	6.7
Cortical veins	1	3.3
Total	30	100.0

Table III compares the findings of non-contrast CT with MRV, the reference standard, using a 2 × 2 contingency table. Non-contrast CT correctly identified 27 true-positive and 133 true-negative cases. However, 45 false-positive and 3 false-negative cases were observed. These findings indicate that non-contrast CT demonstrated a high ability to detect patients with CVST while maintaining a low false-negative rate.

Table III: Comparison of Non-Contrast CT Findings with MRV Findings (Reference Standard) in the Diagnosis of Acute CVST (n = 208)

Non-Contrast CT Findings	MRV Positive	MRV Negative	Total
CT Positive	27 (True Positive)	45 (False Positive)	72
CT Negative	3 (False Negative)	133 (True Negative)	136

Table IV summarizes the diagnostic performance of non-contrast CT in detecting acute CVST using MRV as the reference standard. Non-contrast CT demonstrated a sensitivity of 90.0%, specificity of 74.7%, positive predictive value of 37.5%, negative predictive value of 97.8%, and an overall diagnostic accuracy of 76.9%. Corresponding 95% confidence intervals for sensitivity and specificity are presented in the table.

Table IV: Diagnostic Performance of Non-Contrast CT for Detection of Acute CVST Using MRV as the Reference Standard (n = 208)

Parameter	Value (%)	95% Confidence Interval
Sensitivity	90.0	74.4 – 96.5
Specificity	74.7	67.9 – 80.5
Positive Predictive Value (PPV)	37.5	27.2 – 49.0
Negative Predictive Value (NPV)	97.8	93.7 – 99.2
Diagnostic Accuracy	76.9	70.7 – 82.1

Table V presents a stratified analysis of the diagnostic performance of non-contrast CT by demographic and clinical characteristics. Sensitivity remained high across most age, gender, and symptom subgroups, while negative predictive values were consistently high. These findings suggest that a negative CT examination may be useful in excluding acute CVST across different patient categories; however, confirmatory MRV remains important because of the moderate specificity observed in the overall analysis.

Table V: Stratified Diagnostic Performance of Non-Contrast CT According to Demographic and Clinical Characteristics

Variable	Category	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Age Group	≤45 years	94.4	75.5	38.6	98.8	78.1
	>45 years	83.3	73.5	35.7	96.2	76.3
Gender	Female	87.5	81.2	46.7	97.2	79.2
	Male	92.9	68.8	31.0	98.5	75.7
Catchment Area	Rural	85.7	74.4	36.4	96.8	76.0
	Urban	93.8	75.0	38.5	98.6	78.6
Duration of Symptoms	Up to 2 days	87.5	74.6	32.6	97.7	76.2
	3–5 days	92.9	75.0	44.8	98.0	78.2
Headache	Yes	84.6	79.3	37.9	97.2	77.0
	No	94.1	70.3	37.2	98.5	76.9
Loss of Consciousness	Yes	66.7	66.7	26.7	91.7	66.7
	No	95.8	76.6	40.4	99.1	79.9
Seizures	Yes	100.0	64.0	30.8	100.0	69.0
	No	88.5	76.5	39.0	97.5	78.2
Blurring of Vision	Yes	91.7	78.7	45.8	98.0	82.2
	No	88.9	72.6	33.3	97.7	75.6

DISCUSSION

The present study demonstrated that non-contrast CT has high sensitivity (90.0%) for detecting acute cerebral venous sinus thrombosis (CVST), indicating a strong ability to identify patients with MRV-confirmed disease. The excellent negative predictive value (97.8%) suggests that a negative CT examination may be useful in excluding CVST, particularly in emergency settings where rapid clinical decision-making is required. However, the moderate specificity (74.7%) observed in this study indicates that positive CT findings should be interpreted cautiously and confirmed using venographic imaging. These findings are consistent with those reported by **Shayganfar A et al.** [9] who demonstrated high diagnostic performance of non-contrast CT using objective parameters such as Hounsfield unit (HU) measurements and the HU-to-hematocrit (HU/HCT) ratio. Their study reported a sensitivity of 92% and specificity of 100% using an attenuation threshold of 70 HU and an HU/HCT ratio cut-off of 1.64.

Recent studies have further supported the use of quantitative CT parameters in the evaluation of suspected acute CVST. Tanveer et al. reported a sensitivity of 91.01%, specificity of 52.17%, and diagnostic accuracy of 86.57% for the HU/HCT ratio, highlighting its potential utility in emergency settings[10]. Similarly, **Ratnaparkhi S et al.** [11] observed significantly higher sinus attenuation values and HU/HCT ratios among patients with CVST compared with controls, suggesting that quantitative measurements may improve differentiation between thrombotic and non-thrombotic sinus hyperdensity. Comparable findings have been reported by **Amran M et al.**[12], **Maghbooli A et al.**[13], **and Abdrabou A et al.**[14] all of whom demonstrated the diagnostic value of objective CT-based measurements in the assessment of acute CVST.

The findings of the present study are consistent with these reports and support the role of non-contrast CT as an initial screening modality in patients with suspected acute CVST. The relatively low positive predictive value and moderate specificity observed in this study may be attributed to false-positive sinus hyperdensity caused by elevated hematocrit levels, dehydration, polycythemia, partial-volume effects, or anatomical variations of the dural venous sinuses. Previous studies have similarly shown that visual assessment alone may be less reliable than quantitative HU-based analysis, particularly in subtle or early cases of thrombosis[15,16].

Several investigators have emphasized the importance of venographic imaging for definitive diagnosis. **Nethikoppula AK et al.**[17] **and Musuku NK et al.**[18] reported that venography-based techniques provide superior anatomical confirmation when CT findings are equivocal. Furthermore, a recent systematic review by **Räty S et al.** [19] demonstrated high diagnostic accuracy for both CT venography and MR venography in the evaluation of cerebral venous thrombosis. Current recommendations by **Saposnik G et al.** [20] also support the use of CT venography or MR venography for confirmation of suspected CVST. Therefore, while non-contrast CT may facilitate earlier diagnosis and assist in the initial evaluation of patients with suspected CVST, confirmatory venographic imaging remains necessary, particularly in cases with positive or indeterminate CT findings.

CONCLUSION

Non-contrast CT demonstrated high sensitivity (90.0%) and excellent negative predictive value (97.8%) for detecting acute cerebral venous sinus thrombosis when compared with MRV as the reference standard. These findings support its role as an initial screening modality, particularly in emergency departments and resource-limited settings, where rapid diagnosis is essential. However, because of its moderate specificity and low positive predictive value, positive or equivocal CT findings should be confirmed with MRV.

STUDY LIMITATIONS

This study has several limitations. First, its cross-sectional design precluded assessment of temporal changes in imaging findings and long-term clinical outcomes. Second, the study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other healthcare settings. Third, despite the use of objective parameters such as HU thresholds and the HU/HCT ratio, false-positive CT findings may still occur due to factors including elevated hematocrit levels, dehydration, and anatomical variations. Fourth, all imaging examinations were interpreted by a single experienced neuroradiologist; therefore, interobserver agreement could not be assessed. The absence of interobserver variability analysis limits the reproducibility and external validity of the findings. Finally, the relatively low prevalence of MRV-confirmed CVST in the study population may have influenced predictive values, particularly the positive predictive value. Despite these limitations, the study provides evidence supporting the use of non-contrast CT as an initial screening modality for suspected acute CVST, while emphasizing the continued importance of MRV as the reference standard for diagnostic confirmation.

Ethical Permission: Dow University of Health Sciences, Karachi, Pakistan, IRB approval letter No. IRB-3906/DUHS/Approval/2025/200.
Conflict of interest: There is no conflict of interest between the authors.
Financial Disclosure / Grant Approval: No funding agency was involved in this research.
Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Anwar A:	Conceptualization, data collection, data analysis, manuscript drafting
Naz N:	Study design, supervision, critical revision of manuscript
Khan SA:	Methodology development, data interpretation, final manuscript review
Rasheed B:	Data analysis, statistical input, manuscript editing
Rafiq N:	Literature review, data validation, manuscript proofreading
Salman S:	Data collection support, manuscript formatting. Literature review

REFERENCES

1. Nguyen VN, Demetriou AN, Dallas J, Mack WJ. Cerebral venous sinus thrombosis. Neurosurg Clin N Am. 2024; 35(3): 343-353.
2. Mahadevan JJ, Psaltis PJ, Thrift AG, Kleinig TJ. Incidence of thrombocytopenia-associated cerebral venous sinus thrombosis: a population-based study. BMJ Neurol Open. 2024; 6(1): e000605.
3. Lutsey PL, Zakai NA. Epidemiology and prevention of venous thromboembolism. Nat Rev Cardiol. 2023 Apr; 20(4): 248-262. doi: 10.1038/s41569-022-00787-6.
4. Mubarak F. In-hospital imaging prevalence and patterns of neurological involvement in cerebral venous sinus thrombosis: analysis from Pakistan. J Adv Med Med Res. 2018; 25: 1-9.
5. Bano S, Farooq MU, Nazir S, Aslam A, Tariq A, Javed MA et al. Structural imaging characteristics, clinical features and risk factors of cerebral venous sinus thrombosis: a prospective cross-sectional analysis from a tertiary care hospital in Pakistan. Diagnostics (Basel). 2021; 11(6): 958.
6. Tadi P, Behgam B, Baruffi S. Cerebral venous thrombosis. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020.
7. Naseer H, Panhwer U, Shaikh A, Ahmed R, Mansoor MA, Anwar S. Cerebral venous sinus thrombosis: case series across various age groups, presentations, and imaging characteristics. J Liaquat Natl Hosp. 2025; 3(2): 148-151.
8. Kumar NLR, Puttaraj NC, Sanjay P, Kumar P. Utility of Hounsfield unit: hematocrit ratio in diagnosing acute cerebral venous sinus thrombosis on unenhanced computed tomography. Int J Anat Radiol Surg. 2021; 10: R52-R57.
9. Shayganfar A, Azad R, Taki M. Are cerebral veins Hounsfield unit and H: H ratio calculation in unenhanced CT eligible for diagnosis of acute cerebral vein thrombosis? J Res Med Sci. 2019; 24: 83.
10. Tanveer A, Javed K, Arshad MZ, Rubab Y, Tanveer S, Zulqarnain H. Diagnostic accuracy of plain computed tomography in detecting acute cerebral venous sinus thrombosis, keeping magnetic resonance venography as gold standard. Journal of Pakistan Medical Association. 2023; 73(4): 830-833.
11. Ratnaparkhi S, Sharma A, Gupta R, Verma P, Singh V, Kulkarni M et al. Diagnostic utility of Hounsfield unit and hematocrit ratio in acute cerebral venous sinus thrombosis on non-contrast CT. Egypt J Radiol Nucl Med. 2024; 55(1): 102-108.
12. Amran M, El-Husseiny M, Khalaf M, Abdelrahman H, Youssef A, Ibrahim S et al. Role of sinus attenuation and HU-to-HCT ratio in diagnosis of acute cerebral venous sinus thrombosis: ROC-based analysis. Clin Imag. 2025; 92: 45-52.
13. Maghbooli A, Rahmani F, Hosseini S, Karimi N, Jalili M, Ebrahimi H et al. Venous sinus density measurements on non-contrast CT in diagnosis of cerebral venous sinus thrombosis. Neuroradiol J. 2025; 38(2): 121-128.
14. Abdrabou A, Hassan T, El-Morsy A, Abdelmonem A, Ibrahim M, Elsayed M et al. Quantitative non-contrast CT parameters for differentiating cerebral venous sinus thrombosis from normal hyperdense sinuses. Eur J Radiology Open. 2025; 12: 100572.
15. Chiewvit P, Tritrakarn S, Nilanont Y. Accuracy of noncontrast CT brain in detection of cerebral venous sinus thrombosis. Int J Clin Med. 2021; 12: 471-483.

16. Sadik M, Ahmed S, Khan A, Raza H, Malik A, Hussain T et al. Diagnostic performance of visual versus quantitative CT assessment in acute cerebral venous sinus thrombosis. BMC Med Imag. 2022; 22: 145.
17. Nethikoppula AK, Dasaraju VK, Gunna NR, Vangala A, Abhilash HD, Raziq et al. Multidetector computed tomography venography versus magnetic resonance venography in cerebral venous thrombosis: a cross-sectional study. Int J Anatomy Radiol Surg. 2022; 11(4): RO12-RO18.
18. Musuku NK, Srujana P, Kumar AP, Sreedevi TS, Jabez JA. A comparative study of CT venography with MR venography in cerebro-sinovenous thrombosis. J Pharmacol Toxicol Clin Pharmacol. 2024; 31(11): 1408-1424.
19. Räty S, Hiltunen S, Georgiopoulos G, Adamou A, Ajdini E, Virtanen P et al. Diagnostic accuracy of CT and MR venography in acute cerebral venous thrombosis. Acta Neurologica Scandinavica. 2025; 2025: 5712133.
20. Saposnik G, Barinagarrementeria F, Brown RD, Bushnell CD, Cucchiara B, Cushman M et al. Diagnosis and management of cerebral venous thrombosis: updated scientific statement. American Heart Association. 2024.