Section: Neurology

Original Research Article

ASSESSMENT OF CEREBRAL VENOUS SINUS THROMBOSIS USING SUSCEPTIBILITY-WEIGHTED IMAGING: DIAGNOSTIC PERFORMANCE COMPARED TO MR VENOGRAPHY

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ABSTRACT

Background: Cerebral venous sinus thrombosis (CVT) primarily affects the younger population, and unfortunately, it is associated with higher mortality rates. It is frequently underdiagnosed, as clinical manifestations are not specific and include a wide range of symptoms such as headache, seizures, focal neurological deficits and altered mental status. Therefore, high clinical suspicion is required to avoid misdiagnosis and imaging is fundamental in accurately detecting CVT. **Objective:** To evaluate the sensitivity, specificity and diagnostic accuracy of. susceptibility-weighted imaging in detection of Cerebral venous sinus thrombosis across different sinuses. **Materials and Methods:** A cross-sectional study was conducted from june 2022 to june 2024 in a tertiary care hospital in Andhra pradesh, India. A total of 78 patients with clinical suspicion of CVT underwent MRI brain with routine sequences along with SWI and MRV. Of these 60 patients who had CVT on MRI were included in the study. Sensitivity, diagnostic accuracy, PPV, NPV and specificity of SWI in detecting CVT was calculated considering MRV as gold standard. **Result:** Out of the 60 subjects, 60% were females and 40% were males, with a mean age of 34.05 years (range: 18–68 years). The most common clinical presentation was headache (55%), followed by seizures (20%) and loss of consciousness (13.33%). Superior sagittal sinus was the most frequently involved sinus, detected in 51.67% of patients on MRV and 50% on SWI. Other common sinuses included the right and left transverse sinuses (25% and 23.33%, respectively), and sigmoid sinuses (11.67% right, 13.33% left). Jugular vein involvement was rare (<5%). SWI demonstrated high diagnostic accuracy, particularly for superior sagittal sinus thrombosis (sensitivity: 96.77%, specificity: 100%, accuracy: 98.33%). Similarly, high accuracy was observed for transverse and sigmoid sinus thrombosis. Sensitivity was lower for detecting straight sinus (44.44%) and right jugular vein thrombosis (50%), although specificity remained high across all sites. **Conclusion:** SWI demonstrates excellent diagnostic accuracy in detecting cerebral venous sinus thrombosis, particularly in the superior sagittal, transverse, and sigmoid sinuses. Although sensitivity is lower for straight sinus and jugular vein thrombosis, SWI remains a valuable non-contrast imaging tool that can complement MRV in the diagnosis of CVT.

INTRODUCTION

Cerebral imaging plays a crucial role in the identification of cerebral venous sinus thrombosis (CVT) and its associated complications in brain tissue. Non-invasive imaging techniques such as CT and MRI have completely replaced digital subtraction angiography, which was previously used to guide specialized endovascular treatment for severe forms of blood clotting. Although imaging CVT has been perceived as challenging due to limited knowledge about its anatomical features and

variable results from CT and MRI, these challenges can be overcome with proper caution.[1] Over the past few decades, various MRI sequences and MRV (Magnetic Resonance Venography) techniques have been employed to accurately diagnose CVT. These methods detect signal changes caused by alterations in blood flow and the presence of degraded hemoglobin products in thrombosed veins.[2-4]

MR venography (MRV) brain is gold standard for the diagnosis of CVT.[5]Susceptibility-weighted imaging (SWI) is a new MRI sequence with high-spatial resolution, three-dimensional, gradient-echo (GRE) magnetic resonance (MR) technique used to improve diagnosis of cerebrovascular diseases because of its ability to demonstrate micro bleeds, and conspicuity of the veins due to their higher sensitivity to magnetic susceptibility differences.[6]Recent studies have emphasized the potential of SWI to improve diagnostic accuracy by identifying magnetic signals caused by degraded blood products like deoxyhemoglobin, especially in cases of acute intraparenchymalhemorrhage. However, the current regional evidence is insufficient to make clinical recommendations. Consequently, further investigation is needed to assess the diagnostic accuracy of SWI compared to MRV in the diagnosis of CVT.[7,8] In this study we compared the diagnostic performance of SWI with that of MRV brain in detecting CVT

Aim: To evaluate the diagnostic utility of susceptibility weighted imaging (SWI) compared to magnetic resonance venography (MRV) in identifying cases of cerebral venous sinus thrombosis.

Objective: To evaluate the sensitivity, specificity, and diagnostic accuracy of susceptibility-weighted imaging in the detection of Cerebral venous sinus thrombosis across different sinuses.

MATERIALS AND METHODS

This is a cross sectional study conducted in a tertiary hospital in Andhra Pradesh, India from june 2022 to june 2024.

Study population: A total of 78 patients with clinical suspicion of CVT underwent MRI brain with routine sequences along with SWI and MRV. Of these 60 patients who had CVT on MRI were included in the study. MRI brain images were obtained using 1.5T MR scanner. All the patients underwent T1, T2, FLAIR, diffusion weighted, SWI and MRV sequences. Thrombus on MRV was seen as loss of high flow signal in the sinus in cases of complete occlusion of the sinus and frayed or patchy flow signal in the cases of non-occlusive thrombus. On SWI sequence the thrombosed sinus showed blooming. Data was collected using a proforma that included various parameters, including age, sex, clinical presentation and MRI brain findings on each sequence. The data collected was entered in Excel 2023 and analysis was done by excel and Epi info version 7.2.5 software.

Inclusion Criteria: Patients with clinical suspicion of CVT confirmed on MRI

Exclusion Criteria

- Patients who have not given consent for the study.
- Noncooperative patients.
- Patients with pacemakers, claustrophobia
- Patients with chronic symptoms (more than one month) and previous history of CVT.

RESULTS

Out of the 60 subjects, 60% were females and 40% were males. Age range was between 18 to 68 years. Mean age was 34.05 years.

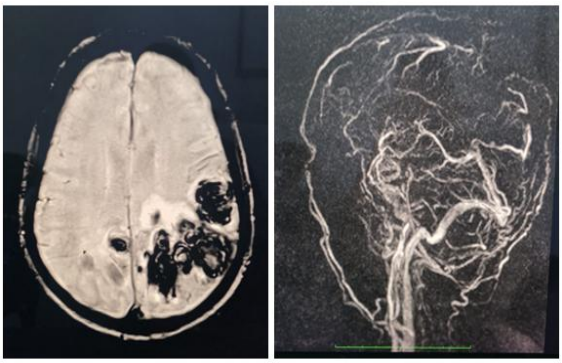

Figure 1: A case of superior saggital sinus thrombosis with hemorrhagic venous infarct showing blooming in superior saggital sinus and in bilateral parietal lobes (L>R) on SWI. MRV shows abscence of flow related signal in superior saggital sinus

Table1: Showing clinical features

Clinical features	Frequency	Percentage
HEADACHE	33	55.00%
LOSS OF CONSCIOUSNESS	8	13.33%
RAISED INTRACRANIAL PRESSURE	6	10.00%
SEIZURES	12	20.00%
VERTIGO	1	1.67%
Total	60	100.00%

SWI detected superior sagittal sinus thrombosis in 30 (50%) patients, straight sinus thrombosis in 5 (8.33%) patients, right transverse sinus thrombosis in 15 (25%) patients, left transverse sinus thrombosis in 14 (23.33%) patients, right sigmoid sinus thrombosis in 7 (11.67%) patients, left sigmoid sinus thrombosis in 8 (13.33%) patients,

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right jugular vein thrombosis in 1 (1.67%) patient and left jugular vein thrombosis in 3 (5%) patients.

MRV detected superior sagittal sinus thrombosis in 31 (51.67%) patients, straight sinus thrombosis in 5 (8.33%) patients, right transverse sinus thrombosis in 15 (25%) patients, left transverse sinus thrombosis in 14 (23.33%) patients, right sigmoid sinus thrombosis in 6 (10%) patients, left sigmoid sinus thrombosis in 6 (10%) patients, right jugular vein thrombosis in 2 (3.33%) patients and left jugular vein thrombosis in 3 (5%) patients. Hemorrhagic venous infarct was seen in 22 cases. Superficial cortical vein thrombosis was seen in 14 cases, which was detected only by SWI, while MRV was inconclusive in detecting cortical vein thrombosis.

Table 2: Showing diagnostic accuracy of SWI in detecting Superior saggital sinus thrombosis

Statistic	Value	95% CI
Sensitivity	96.77%	83.30% to 99.92%
Specificity	100.00%	88.06% to 100.00%
Disease prevalence	51.67%	38.39% to 64.77%
Positive Predictive Value	100.00%	88.43% to 100.00%
Negative Predictive Value	96.67%	80.83% to 99.50%
Accuracy	98.33%	91.06% to 99.96%

Table 3: Diagnostic accuracy of SWI in detecting straight sinus thrombosis

Statistic	Value	95% CI
Sensitivity	44.44%	13.70% to 78.80%
Specificity	98.18%	90.28% to 99.95%
Disease prevalence	14.06%	6.64% to 25.02%
Positive Predictive Value	80.00%	33.43% to 96.96%
Negative Predictive Value	91.53%	85.74% to 95.10%
Accuracy	90.62%	80.70% to 96.48%

Table 4: Diagnostic accuracy of SWI in detecting right transverse sinus thrombosis

Statistic	Value	95% CI
Sensitivity	93.33%	68.05% to 99.83%
Specificity	97.78%	88.23% to 99.94%
Disease prevalence	25.00%	14.72% to 37.86%
Positive Predictive Value	93.33%	66.74% to 98.99%
Negative Predictive Value	97.78%	86.88% to 99.66%
Accuracy	96.67%	88.47% to 99.59%

Table 5: Diagnostic accuracy of SWI in detecting left transverse sinus thrombosis

Statistic	Value	95% CI
Sensitivity	93.33%	68.05% to 99.83%
Specificity	97.78%	88.23% to 99.94%
Disease prevalence	25.00%	14.72% to 37.86%
Positive Predictive Value	93.33%	66.74% to 98.99%
Negative Predictive Value	97.78%	86.88% to 99.66%
Accuracy	96.67%	88.47% to 99.59%

Table 6: Diagnostic accuracy of SWI in detecting right sigmoid sinus thrombosis

Statistic	Value	95% CI
Sensitivity	83.33%	35.88% to 99.58%
Specificity	96.30%	87.25% to 99.55%
Disease prevalence	10.00%	3.76% to 20.51%
Positive Predictive Value	71.43%	37.99% to 91.07%
Negative Predictive Value	98.11%	89.67% to 99.68%
Accuracy	95.00%	86.08% to 98.96%

Table 7: Diagnostic accuracy of SWI in detecting left sigmoid sinus thrombosis

Statistic	Value	95% CI
Sensitivity	100.00%	59.04% to 100.00%
Specificity	98.11%	89.93% to 99.95%
Disease prevalence	11.67%	4.82% to 22.57%
Positive Predictive Value	87.50%	50.11% to 97.99%
Negative Predictive Value	100.00%	93.15% to 100.00%
Accuracy	98.33%	91.06% to 99.96%

Table 8: Diagnostic accuracy of SWI in detecting Right jugular vein thrombosis

Statistic	Value	95% CI
Sensitivity	50.00%	1.26% to 98.74%
Specificity	100.00%	93.84% to 100.00%
Disease prevalence	3.33%	0.41% to 11.53%

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Positive Predictive Value	100.00%	2.50% to 100.00%
Negative Predictive Value	98.31%	93.55% to 99.57%
Accuracy	98.33%	91.06% to 99.96%

Table 9: Diagnostic accuracy of SWI in detecting left jugular vein thrombosis

Statistic	Value	95% CI
Sensitivity	100.00%	29.24% to 100.00%
Specificity	98.25%	90.61% to 99.96%
Disease prevalence	5.00%	1.04% to 13.92%
Positive Predictive Value	75.00%	30.07% to 95.44%
Negative Predictive Value	100.00%	93.62% to 100.00%
Accuracy	98.33%	91.06% to 99.96%

DISCUSSION

30% cases of stroke in India occur in young and CVT accounts for 10 to 20% cases.[9] CVT is one of the few causes of cerebral hemorrhage that call for anticoagulation therapy. Since anticoagulation is contraindicated in most cases of cerebral bleeding, diagnostic certainty is important, making the radiologist's task more difficult.[10] Two dimensional (2D) time of flight and 3D phase contrast MR venography are nonenhanced venography techniques that show the absence of normal signal intensity of the sinus in CVT. These are key methods when contrast agents are contraindicated, such as during pregnancy or in patients with severe renal failure.[11] The 2D time of flight sequence is based on the inflow effect, and it is performed with sections that are perpendicular to the direction of the blood flow. This sequence is highly susceptible to flow artifacts and is dependent on the acquisition plane. A sinus parallel to the acquisition plane may have an artifactual signal intensity loss that mimics CVT. Furthermore, stationary tissue with short T1 (eg, fat or methemoglobin) may be mistaken for flowing blood. Another disadvantage of this technique is its reduced sensitivity for small vessels with slow flow.[11,12,13-15] On the other hand, 3D phase contrast MR venography is based on the dephasing of moving spins submitted to a bipolar gradient in gradient echo acquisitions. 3D phase contrast MR venography has better sensitivity to slow flow than does 2D time of flight MRV and is insensitive to short T1 tissue. However, with this technique, long acquisition times are required and aliasing artifacts can occur. 14 SWI is a considerably sensitive MR sequence for the detection of intravascular deoxygenated blood as well as extravascular blood products. It has been reported that SWI is valuable regarding the detection of intravascular thrombus.[16]

Our study evaluated the diagnostic accuracy of susceptibility-weighted imaging (SWI) in detecting CVT in varous sinuses, using MRV as the reference standard. The results demonstrate that SWI has excellent diagnostic accuracy for detecting thrombosis in major dural venous sinuses, particularly the superior sagittal sinus, transverse, and sigmoid sinuses.

The most common clinical presentation in our cohort was headache (55%), followed by seizures (20%) and loss of consciousness (13.33%), consistent with existing literature that identifies headache as the most frequent symptom in CVST.[17,18] The age range was wide (18–68 years), with a mean age of 34.05 years, and a female predominance (60%), which aligns with the known epidemiological trends of CVT affecting young to middle-aged women, often linked to prothrombotic conditions, hormonal factors, or pregnancy.[19]

Superior sagittal sinus was the most frequently involved venous structure in this study, detected in 51.67% of patients on MRV and 50% on SWI. This finding is in agreement with prior studies, which report that superior sagittal sinus as the most commonly thrombosed site in CVST due to its anatomical length, high flow dynamics, and extensive cortical drainage.[20,21] The next most commonly involved sinuses in our cohort were the right and left transverse sinuses, seen in 25% and 23.33% of patients, respectively. Involvement of the jugular veins was rare, occurring in less than 5% of patients.

SWI showed very high sensitivity (96.77%) and specificity (100%) for detecting superior sagittal sinus thrombosis, with an overall accuracy of 98.33%. Similar high accuracy was observed for the transverse and sigmoid sinuses (sensitivity and specificity > 90%). These findings are consistent with previously published studies demonstrating that SWI is highly effective in detecting venous thrombi due to its ability to visualize paramagnetic deoxyhemoglobin and iron-containing blood products, which accumulate in thrombosed vein.[22,23]

Notably, SWI underperformed in detecting straight sinus thrombosis, with a sensitivity of only 44.44% despite a high specificity of 98.18%. This may be attributed to the deep anatomical location and orientation of the straight sinus, which could pose challenges in signal visualization on SWI, especially when thrombi are isointense or in early stages.[24]

In the case of jugular vein thrombosis, SWI showed varied sensitivity, 100% for the left jugular vein but only 50% for the right. However, the prevalence of jugular vein thrombosis in our study population was low (3.33%–5%), which may limit the reliability of these estimates and contribute to wide confidence intervals.

The high positive predictive value (PPV) and negative predictive value (NPV) of SWI for most

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venous segments suggest it can serve as a reliable adjunct to MRV in certain clinical settings. SWI may be particularly valuable in resource-limited environments or in patients who cannot tolerate contrast agents required for CT venography or contrast-enhanced MRV.

Furthermore, SWI provides additional benefits, including its ability to detect associated parenchymal changes such as hemorrhagic infarcts or cortical vein involvement, which are often missed on MRV alone.[25]

Limitations

This study has some limitations. The sample size, although adequate for preliminary analysis, was relatively small (n = 60), which may affect the generalizability of the findings. The study was conducted at a single center, and inter-observer variability in SWI interpretation was not assessed. Additionally, SWI may have limitations in early thrombus detection and in cases where the thrombus lacks paramagnetic components, leading to false negatives, as seen with the straight sinus.

CONCLUSION

In conclusion, SWI demonstrates excellent diagnostic accuracy for detecting CVT, particularly in the superior sagittal, transverse, and sigmoid sinuses. The superior sagittal sinus was the most frequently involved site in this study, consistent with previous literature. While SWI performance is slightly reduced in detecting thrombosis of the straight sinus and jugular veins, it remains a highly valuable, non-contrast, and widely accessible imaging modality that can complement MRV in the evaluation of CVST. Further multi-center studies with larger cohorts are recommended to validate these findings and explore its role in clinical practice guidelines.

REFERENCES

1. Ulivi L., Squitieri M., Cohen H., Cowley P., Werring D.J. Cerebral venous thrombosis: A practical guide. Pract. Neurol. 2020; 20:356–367. doi: 10.1136/practneurol-2019-002415.
2. Hayman LA, Taber KH, Ford JJ, Bryan RN. Mechanisms of MR signal alteration by acute intracerebral blood: old concepts and new theories. AJNR Am J Neuroradiol. 1991;12(5):899-907.
3. Bradley WG, Jr. MR appearance of hemorrhage in the brain. Radiology. 1993;189(1):15-26.
4. Linfante I, Llinas RH, Caplan LR, Warach S. MRI features of intracerebral hemorrhage within 2 hours from symptom onset. Stroke. 1999;30(11):2263-7
5. Lafitte F, Boukobza M, Guichard JP, Hoeffel C, Reizine D, Ille O, et al. MRI and MRA for diagnosis and follow-up of Cerebral Venous Thrombosis (CVT). ClinRadiol 1997; 52(9): 672-9.
6. 4. Yu-Kun Tsui, Fong Y. Tsai, Anton N. Hasso, Fred Greensite, Binh V. Nguyen. Susceptibility-weighted imaging for differential diagnosis of cerebral vascular pathology: A pictorial review. Journal of the Neurological Sciences Volume 287, Issues 1–2, 15 December 2009,Pages 7-16
7. Dmytriw A.A., Song J.S.A., Yu E., Poon C.S. Cerebral venous thrombosis: State of the art diagnosis and management. Neuroradiology. 2018;60:669–685. doi: 10.1007/s00234-018-2032-2.
8. Vymazal J, Brooks RA, Baumgarner C, Tran V, Katz D, Bulte JW, et al. The relation between brain iron and NMR relaxation times: an in vitro study. MagnReson Med. 1996;35(1):56-61
9. Prakash C, Banl BC. Cerebral venous thrombosis. J Indian AcadClin Med. 2000;5:55–61
10. Canedo-Antelo M., Baleato-González S., Mosqueira A.J., Casas-Martínez J., Oleaga L., Vilanova J.C., Luna-Alcalá A., García-Figueiras R. Radiologic clues to cerebral venous thrombosis. RadioGraphics. 2019; 39:1611–1628. doi: 10.1148/rg.2019190015.
11. Dmytriw AA, Song JSA, Yu E, Poon CS. Cerebral venous thrombosis: state of the art diagnosis and management. Neuroradiology 2018;60(7):669–685.
12. Leach JL, Fortuna RB, Jones BV, Gaskill-Shipley MF. Imaging of cerebral venous thrombosis: current techniques, spectrum of findings, and diagnostic pitfalls. RadioGraphics 2006;26(Suppl 1):S19–S41; discussion S42–S43.
13. Farb RI, Scott JN, Willinsky RA, Montanera WJ, Wright GA, terBrugge KG. Intracranial venous system: gadolinium-enhanced three-dimensional MR venography with auto-triggered elliptic centric-ordered sequence—initial experience. Radiology 2003;226(1):203–209.
14. Liauw L, van Buchem MA, Spilt A, et al. MR angiography of the intracranial venous system. Radiology 2000;214(3):678–682.
15. Ayanzen RH, Bird CR, Keller PJ, McCully FJ, Theobald MR, Heiserman JE. Cerebral MR venography: normal anatomy and potential diagnostic pitfalls. AJNR Am J Neuroradiol 2000;21(1):74–78.
16. Lee S, Cho SB, Choi DS, et al. Susceptibility vessel sign for the detection of hyperacute MCA occlusion: evaluation with susceptibility-weighted MR imaging. InvestigMagnReson Imaging 2016; 20:105-113
17. Saposnik G, et al. "Diagnosis and management of cerebral venous thrombosis: a statement for healthcare professionals." Stroke. 2011.
18. Ferro JM, et al. "Cerebral venous thrombosis: an update." Lancet Neurology. 2007.
19. Coutinho JM, et al. "Cerebral venous thrombosis in women." Stroke. 2009.
20. Einhäupl K, et al. "Cerebral venous and sinus thrombosis: advances in diagnosis and treatment." Lancet Neurol. 2010.
21. Bousser MG, Ferro JM. "Cerebral venous thrombosis: an update." Lancet Neurol. 2007.
22. Sehgal V, et al. "Clinical applications of susceptibility weighted imaging in neuroimaging." J MagnReson Imaging. 2005.
23. Mittal S, et al. "Susceptibility-weighted imaging: technical aspects and clinical applications." AJNR Am J Neuroradiol. 2009.
24. Leach JL, et al. "Susceptibility-weighted imaging: a valuable alternative to conventional GRE sequences in routine brain imaging." AJR. 2010.
25. Chen W, et al. "Susceptibility-weighted imaging of intracranial hemorrhage and calcification in children." J Neuroradiol. 2014.

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