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MRI Insights into Cerebral Venous Sinus Thrombosis: A Cross-Sectional Study of Diagnostic and Prognostic Indicators

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Abstract
Cerebral Venous Sinus Thrombosis (CVST) is a challenging neurological condition characterized by the formation of a clot in the dural venous sinuses of the brain, which can lead to cerebral edema and hemorrhage. Magnetic Resonance Imaging (MRI) plays a critical role in diagnosing CVST due to its high sensitivity and specificity. This study aims to explore the diagnostic and prognostic indicators of CVST using MRI features. A cross-sectional study was conducted involving 200 patients suspected of CVST based on clinical and neurological presentations. All patients underwent MRI examinations and images were analyzed to identify patterns correlated with clinical outcomes. MRI was instrumental in diagnosing CVST in 184 out of 200 patients, revealing a combination of direct and indirect signs that facilitated a robust diagnosis. The study also identified specific MRI features that are potentially linked with patient prognosis. MRI not only confirms the diagnosis of CVST but also provides valuable prognostic information that can guide treatment decisions. This study highlights the importance of MRI features in the management of CVST and suggests a framework for future research on this condition.

INTRODUCTION

Cerebral Venous Sinus Thrombosis (CVST) represents a unique cerebrovascular disorder where clotting (thrombosis) occurs in the cerebral veins and dural sinuses, obstructing venous drainage and potentially leading to neurological impairment and mortality. Despite its clinical significance, CVST remains an under-recognized condition with variable clinical presentations, ranging from headache to severe neurological deficits like seizures and coma[1].

MRI is pivotal in the diagnosis of CVST, offering detailed images of brain structures and venous flow without exposure to ionizing radiation. The value of MRI lies in its ability to detect both direct signs of thrombosis and indirect signs such as venous infarcts and edema. Recent advancements in MRI technology, including high-resolution venograms and susceptibility-weighted imaging, have improved the sensitivity and specificity of CVST diagnosis[2].

Epidemiological data suggest that CVST accounts for 0.5-1% of all strokes. The condition shows a predilection for young adults and middle-aged individuals, particularly among women, who are at higher risk due to pregnancy, puerperium and hormonal contraception. Other risk factors include genetic thrombophilias, malignancies, infections and inflammatory diseases[3].

Aim and Objectives: To evaluate the efficacy of MRI in diagnosing cerebral venous sinus thrombosis and its role in predicting clinical outcomes.

- To identify MRI features commonly associated with CVST.
- To correlate specific MRI findings with the clinical severity of CVST.
- To examine the prognostic value of MRI in predicting outcomes in CVST patients.

MATERIAL AND METHODS

Source of Data: Data was retrospectively collected from patients suspected of having Cerebral Venous Sinus Thrombosis (CVST).

- **Study Design:** This was a cross-sectional study designed to evaluate the diagnostic and prognostic capabilities of MRI in patients with CVST.
- Study Location: The study was conducted at a tertiary care hospital equipped with advanced MRI facilities.
- **Study Duration:** Data collection occurred from January 2019-July 2020.
- **Sample Size:** The study comprised 200 patients selected based on predefined inclusion criteria.
- **Inclusion Criteria:** Included were patients of any age and sex with clinical symptoms suggestive of CVST and referred for MRI scanning.
- **Exclusion Criteria:** Patients were excluded if they had contraindications to MRI (e.g., metal implants), previous history of CVST, or incomplete medical records.
- **Procedure and Methodology:** All patients underwent a standard MRI protocol, including T1, T2, FLAIR sequences and magnetic resonance venography. Images were analyzed by two experienced neuroradiologists blinded to clinical data.
- **Sample Processing:** Not applicable, as the study involved imaging data without biological sample processing.
- **Statistical Methods:** Descriptive statistics were used to analyze the prevalence of specific MRI findings. Chi-square and logistic regression analyses were conducted to explore correlations between MRI features and patient outcomes.
- **Data Collection:** Data regarding patient demographics, clinical presentation, MRI findings and follow-up outcomes were collected through patient records and follow-up interviews where possible.

RESULTS and DISCUSSION

The table illustrates the high diagnostic capability of MRI in detecting cerebral venous sinus thrombosis (CVST). It shows that 92% (n=184) of the patients exhibited positive MRI findings, associated with an odds ratio of 18.5, indicating a strong likelihood of diagnosing CVST when positive signs are present on MRI. The results are statistically significant with a P-value of less than 0.001. Negative MRI findings occurred in 8% (n=16) of the patients, serving as the referential group in the analysis.

Table details the frequency and significance of various MRI features commonly seen in CVST. Venous sinus filling defects were observed in 75% of cases, with an odds ratio of 3.0, suggesting a strong association with CVST. Cortical vein thrombosis and brain edema were noted in 60% and 50% of cases respectively, with corresponding odds ratios of 2.4 and 1.6, both indicating significant diagnostic indicators. Hemorrhagic venous infarction, present in 40% of cases, had an odds ratio of 1.2, showing a weaker association that was not statistically significant.

Table correlates specific MRI findings with the clinical severity of CVST. Hemorrhagic transformation was significantly associated with greater clinical severity, present in 35% of patients with an odds ratio of 2.5. Extended sinus thrombosis and bilateral involvement were also significantly correlated with

Table 1: Diagnostic Efficacy of MRI in CVST

Feature	n(200)	%	Odds Ratio (OR)	95% CI	P-value
Positive MRI findings	184	92	18.5	9.8-35.2	<0.001
Negative MRI findings	16	8	Referent	-	-

Table 2: Common MRI Features Associated with CVST

MRI Feature	n(200)	%	Odds Ratio (OR)	95% CI	P-value
Venous sinus filling defect	150	75	3.0	1.9-4.7	<0.001
Cortical vein thrombosis	120	60	2.4	1.5-3.8	0.002
Brain edema	100	50	1.6	1.0-2.5	0.045
Hemorrhagic venous infarction	80	40	1.2	0.8-1.9	0.376

Table 3: Correlation of MRI Findings with Clinical Severity in CVST

MRI Feature	n(200)	%	Odds Ratio (OR)	95% CI	P-value
Hemorrhagic transformation	70	35	2.5	1.5-4.2	0.001
Extended sinus thrombosis	50	25	2.1	1.2-3.6	0.009
Bilateral involvement	40	20	1.9	1.1-3.3	0.020

Table 4: Prognostic Value of MRI in Predicting Outcomes in CVST Patients

Outcome	n(200)	%	Odds Ratio (OR)	95% CI	P-value
Complete recovery	120	60	2.0	1.2-3.3	0.007
Partial recovery	50	25	1.5	0.9-2.5	0.112
No improvement or worsening	30	15	0.5	0.3-0.8	0.003

more severe cases, present in 25% and 20% of patients, with odds ratios of 2.1 and 1.9, respectively. These findings are statistically significant and highlight MRI's role in assessing disease severity.

Table valuates the prognostic utility of MRI in predicting clinical outcomes for CVST patients. Sixty percent of the patients achieved complete recovery, with an odds ratio of 2.0, suggesting a positive prognosis when MRI findings are favorable. Partial recovery was seen in 25% of patients and no improvement or worsening was noted in 15% of cases, with respective odds ratios of 1.5 and 0.5. The findings for complete recovery and worsening are statistically significant, indicating that MRI can effectively predict different clinical outcomes in CVST patients.

The diagnostic efficacy of MRI, as illustrated, shows an overwhelming majority of positive findings (92%) with an extremely high odds ratio, underscoring MRI's robustness in detecting CVST. These results align with previous studies that highlighted MRI's superior sensitivity and specificity compared to other imaging modalities like CT scans in diagnosing CVST, primarily due to its ability to visualize the cerebral veins and dural sinuses directly Sarma[4]. This high diagnostic capacity is critical given the potentially life-threatening nature of CVST and the importance of prompt, accurate diagnosis for effective management Liberman[4] .

The MRI features related to CVST identified in the study (venous sinus filling defects, cortical vein thrombosis, brain edema and hemorrhagic venous infarction) show varying degrees of prevalence and association strengths. The high odds ratios for venous sinus filling defects and cortical vein thrombosis are particularly notable and are supported by literature indicating these features as common markers in CVST patients Medeiros[6]. However, hemorrhagic venous infarction shows a lower and non-significant association, which may reflect the variability in patient presentation and the progression stages of CVST at the time of imaging Shabo[7]. This variability necessitates a comprehensive MRI protocol to capture the full spectrum of disease manifestations.

The correlation of specific MRI findings with clinical severity (hemorrhagic transformation, extended sinus thrombosis and bilateral involvement) reveals significant relationships. Hemorrhagic transformation has a particularly strong correlation with severity, suggesting that patients with this feature may require more aggressive treatment and closer monitoring Shabbir[8]. This finding is corroborated by studies that have noted hemorrhagic transformation as an indicator of poor prognosis and higher complication rates Anh[9].

The prognostic implications of MRI findings are critical for guiding treatment decisions. The significant odds ratios for complete recovery and worsening outcomes indicate that certain MRI characteristics can reliably predict patient trajectories, which is invaluable for clinicians in setting realistic expectations and tailoring interventions Chang[10]. This predictive capacity of MRI is a cornerstone in the longitudinal management of CVST, aiding in early intervention and potentially improving long-term outcomes Yang[11].

CONCLUSION

This cross-sectional study has systematically evaluated the efficacy of Magnetic Resonance Imaging (MRI) in diagnosing cerebral venous sinus thrombosis (CVST) and its capability to provide prognostic insights. Our findings confirm that MRI is a highly effective diagnostic tool for CVST,

demonstrating a significant diagnostic capability with a notable 92% of the studied cases showing positive MRI findings. The strength of MRI not only lies in its high sensitivity but also in its ability to detail distinct pathological features associated with CVST, such as venous sinus filling defects, cortical vein thrombosis and brain edema.

Furthermore, this study has highlighted the role of specific MRI features in predicting the clinical severity of the condition. Features like hemorrhagic transformation, extended sinus thrombosis and bilateral involvement have been significantly correlated with increased clinical severity, indicating that MRI can assist in stratifying patient risk and tailoring individual management plans.

The prognostic value of MRI in predicting outcomes in CVST patients was also substantiated, with clear correlations between MRI findings and patient recovery trajectories. Our data suggest that specific MRI markers can be used to predict both positive outcomes, such as complete recovery and adverse outcomes, including no improvement or worsening conditions.

In conclusion, MRI not only stands as a cornerstone in the diagnosis of CVST but also serves as a critical prognostic tool that can influence treatment strategies and predict patient outcomes. These insights underscore the importance of integrating advanced MRI techniques into the routine clinical assessment of patients suspected of having CVST, thereby enhancing the precision of medical interventions and improving patient prognosis. Future studies are encouraged to expand on these findings, possibly incorporating longitudinal data and larger sample sizes to further refine the prognostic models and validate the clinical utility of MRI in diverse patient populations.

Limitations of Study

- **Cross-sectional Design:** The cross-sectional nature of this study limits our ability to establish causal relationships between MRI findings and clinical outcomes. Longitudinal studies would be better suited to observe the progression of CVST over time and to more accurately assess the impact of MRI findings on long-term patient outcomes.
- **Sample Size and Diversity:** Although a sample size of 200 patients provides a good basis for statistical analysis, it may not fully capture the heterogeneity of CVST presentations seen in broader populations. Moreover, the study may lack sufficient power to detect smaller effect sizes or to generalize findings across different ethnicities or demographic groups who might exhibit variability in CVST incidence and presentation.
- **Single-Center Study:** Data being derived from a single tertiary care center may introduce a selection bias, as patients referred to such centers often present with more severe or complicated cases compared to the general population. This might influence the prevalence of certain MRI findings and their apparent correlation with outcomes.
- **Inter-Observer Variability:** Although MRI scans were analyzed by experienced neuroradiologists, inter-observer variability in interpreting complex images could introduce discrepancies in the data. While efforts were made to minimize this through consensus readings, the subjective nature of some MRI interpretations can affect the reproducibility of the results.
- **Technological Variability:** MRI technology and techniques vary widely, including differences in machine strength (e.g., 1.5T vs. 3T) and imaging protocols. This variability can affect the sensitivity and specificity of the findings and the results obtained in this study may not be directly transferable to all clinical settings.
- **Exclusion of Certain Patient Groups:** Patients with contraindications to MRI, such as those with implanted medical devices or severe claustrophobia, were excluded. This could omit a subset of patients who might present differently, potentially skewing the overall understanding of CVST.
- **Use of Statistical Models:** The reliance on odds ratios and confidence intervals provides a measure of association but can be influenced by the prevalence of outcomes within the study sample. This statistical limitation may affect the interpretation of the strength of associations between MRI features and clinical outcomes.

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