ORIGINAL RESEARCH ARTICLE

Diagnostic Performances of Susceptibility weighted imaging Brain for the Detection of Cerebral Venous Thrombosis in Patients Presenting with Headache

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ABSTRACT

Introduction: Magnetic resonance venography (MRV) brain is the gold standard for diagnosing cerebral venous thrombosis (CVT). Susceptibility-weighted imaging (SWI) is a high-spatial resolution, (MR) technique that is exquisitely sensitive to venous blood, hemorrhage and iron storage. Study aimed to know the diagnostic performance of SWI in detecting CVT compared to MRV and to facilitate early diagnosis of CVT where MRV not feasible.

Material and Methods: A prospectively study, included patients presenting with clinical symptoms of CVT who underwent MRI (1.5T) brain with MRV. We determined the sensitivity, specificity, predictive value, accuracy, degree of agreement between SWI and MRV in detecting CVT.

Results: Out of 100 cases, 64 were females. Majority of patients presented with headache (100%) and CVT was diagnosed in 55 cases. Majority of patient had transverse sinus (TS) thrombosis (54%). The overall diagnostic accuracy of SWI sequence was 76.31% and that of MRV was 95.18%. Sensitivity of SWI versus MRV was 63.22% Vs 91.23%; Specificity 92.31% Vs 100%; Positive predictive value 90.95% vs 100%; Negative predictive value 67.25% vs 90.32% respectively. 95% confidence interval was observed for the specificity and positive predictive value of the SWI test. There exists good degree of agreement between both imaging modalities with 98% accuracy to detect cortical vein thrombosis by SWI.

Conclusion: SWI sequence added on the conventional MRI can be used as the first line imaging modality for evaluation of patient with CVT where MRV brain is not feasible. SWI has higher diagnostic performance in detecting isolated cortical vein thrombosis.

Keywords: Venous Thrombosis**,** Gradient Echo Image, Cerebrum

INTRODUCTION

Cerebral venous thrombosis (CVT) accounts for 0.5% of all strokes. CVT includes thrombosis of cerebral cortical veins and dural sinuses.[1] Clinical presentation of CVT is variable that ranges from headache, seizure, focal motor deficit, raised intracranial tension, and coma.[2] Majority of the cases headache is the main presentation. There is a delay in diagnosis of CVT due to varied presentation and risk factors. Therefore a high index of suspicion for CVT is crucial for prompt diagnosis and treatment. Phase contrast MR venography (MRV) brain is the gold standard for the diagnosis of CVT. [3] 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.[4] SWI has been found to provide additional clinically useful information that is often complementary to conventional MR imaging sequences used in the evaluation of various neurologic disorders. Additionally SWI is also useful in detection of isolated cortical vein thrombosis.[5] Assessment of CVT using SWI sequence brain and its comparison with that of MRV is scarce in literature. Here we try to compare diagnostic performance of SWI with that of MRV brain in detecting CVT in patients presenting with headache.

MATERIAL AND METHODS

Study design: It was a prospective study conducted from January 2018 to January 2020. The study included patients presenting with headache in the department of neurology with clinical suspicion of CVT in whom MRI brain

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sequence with SWI and phase contrast MRV brain was done in Radiology department. 100 cases were included in this study. MRI brain images were obtained using 1.5T MR scanner. Imaging sequences included T1-Weighted image, T2 -weighted image, Flair sequence, diffusion weighted sequence, SWI sequence and phase contrast MRV. SWI is an MRI technique that exploits magnetic susceptibility difference between blood, calcium, and iron thus enabling new sources of MR contrast.

MRI protocol: All studies are done on a Magnetom Essenza (Siemens, Germany) using a four channel head coil. No specific preparation was prescribed. Few patients required sedation or anaesthesia support. All patients in the study had DWI, ADC, T1W, T2W, FLAIR and SWI along with 3D-PC MR Venogram. Axial T2 W image reveals hypo intense signal within the sinus mimicking a flow void, while axial gradient echo image (SWI) demonstrates blooming within the sinus and Phase contrast MRV confirms occlusion of the sinus by showing absence of flow voids with in the sinus. All MRI images were reported by one experienced radiologists and a clinical correlation with neurologist. The reviewers were in strong agreement regarding the visualization of thrombosis on various evaluated imaging sequences plus clinical suspicion. Visualization of venous sinus thrombosis was assessed based on the following criteria: Visible (1-1 high signal, 1-2 low signal), Iso signal (insufficient for diagnosis), and not seen.

Data collection: Study was done in three sittings by a senior consultant radiologist with 28years of experience. In the first sitting findings on MRV were recorded separately for each sinus and deep veins. Then other sequences were studied for any parenchymal changes. SWI findings were recorded in a separate sitting. Finally correlation of SW1 and MRV was performed with each other and with the final diagnosis which is based on complete imaging and clinical features Data about the demographic profile, clinical profile and radiological profile was collected using a proforma that included various parameters, including age, sex, clinical presentation (headache, visual symptoms, seizure, focal neurological deficit, raised intracranial tension features), MRI brain finding DW sequence with corresponding ADC sequence, T1, T2, T2 flair, SW1 sequences, phase contrast venogram and parenchymal involvement all were collected. The data collected were entered into SPSS software (version 18, SPSS Inc. IBM).Presence of thrombus in each sinus or cortical vein was entered .Based on presence of thrombus, in each sinus using MRV vs SWI sequence, cases were divided into 3 groups normal, indeterminate, and thrombus positive cases and they were compared . STARD 2015 diagram was used to report flow of participants through the study [Figure1].

Data analysis: Single variable were shown as percentage. P value of < 0.05 was considered significant. All confidence intervals (CI) were set at 95%. Analysis of efficacy of test was calculated using 95% CI of difference in proportions**.** Sensitivity, specificity, positive predictive, negative predictive value and accuracy of the test was calculated using final prevalence of the disease, number of true positive, true negative, false positive and false negative obtained in each diagnostic test. Pearson chi square test was calculated using crosstabulation between SW1 and MRV sequences for individual sinuses. Measurement of agreement of the test was assessed using kappa value. The equation used to calculate kappa is: K = PR (*e),* where Pr (*a)* is the observed agreement among the raters and Pr (*e)* is the hypothetical probability of the raters indicating a chance agreement. The strength of the kappa coefficients is interpreted in the following manner: 0.01-0.20 slight; 0.21-0.40 fair; 0.41-0.60 moderate; 0.61-0.80 substantial; 0.81-1.00 almost perfect.

Ethics statement: All the information necessary for the conduct of the study was collected, with the approval of the Institutional Ethics Committee.

RESULTS

Total of 100 cases were included in the study who presented with headache and suspected CVT and had undergone both MRV and SWI sequences in addition to the routine MRI brain sequences.

Baseline characteristics: Out of 100 cases 64 were females. Age range of study cases were between 18 to 68 years. Mean age was 36 ± 18 years. Baseline characteristics of study sample are shown in table 1. It was observed that out of 100 cases, 55% cases had CVT. [Table 1]

Diagnostic performance of SWI sequence of brain versus MRV brain: Out of 100 cases, clinical features combined with MRV confirmed presence of CVT in 55 cases.
MRV alone confirmed thrombus in 52 cases, normal in 43 cases and indeterminate in 5 cases. Sensitivity of MRV in detecting venous thrombus was 91.2%, specificity was 100%, positive predictive value was 100 %, and negative predictive value of 90.32% and diagnostic accuracy of the test is 95.18% with 95% confidence interval (CI) of 88.95% to 98.46%.
SWI detected thrombosis in 56 cases, normal in 12 cases and was inconclusive or indeterminate in 32% cases. Overall sensitivity of SW1 was 63.22%, specificity 92.31%, positive predictive value 90.95%, negative predictive value of 67.25% and diagnostic accuracy of 76.31%. 95% confidence interval was higher for specificity (63.97% to 99.81%) and positive predictive value (60.28% to 98.52% Sensitivity of SWI in comparison to MRV in case of superior sagittal sinus was

Variables	Number (%)
Total cases	100 (100%)
Males	36 (36%)
Females	64 (64%)
headache	100 (100%)
seizures	28 (28%)
Focal deficit	24 (24%)
Raised ICT (Intracranial tension)	7 (7%)
CVT (Cerebral venous thrombosis)	55 (55%)
Normal venogram	45 (45%)
Susceptible weighted images (SW1) suboptimal	6 (6%)
Cortical vein thrombosis	41(41%)
Parenchymal involvement	25 (25%)

Table 1 Baseline characteristics of the study cases

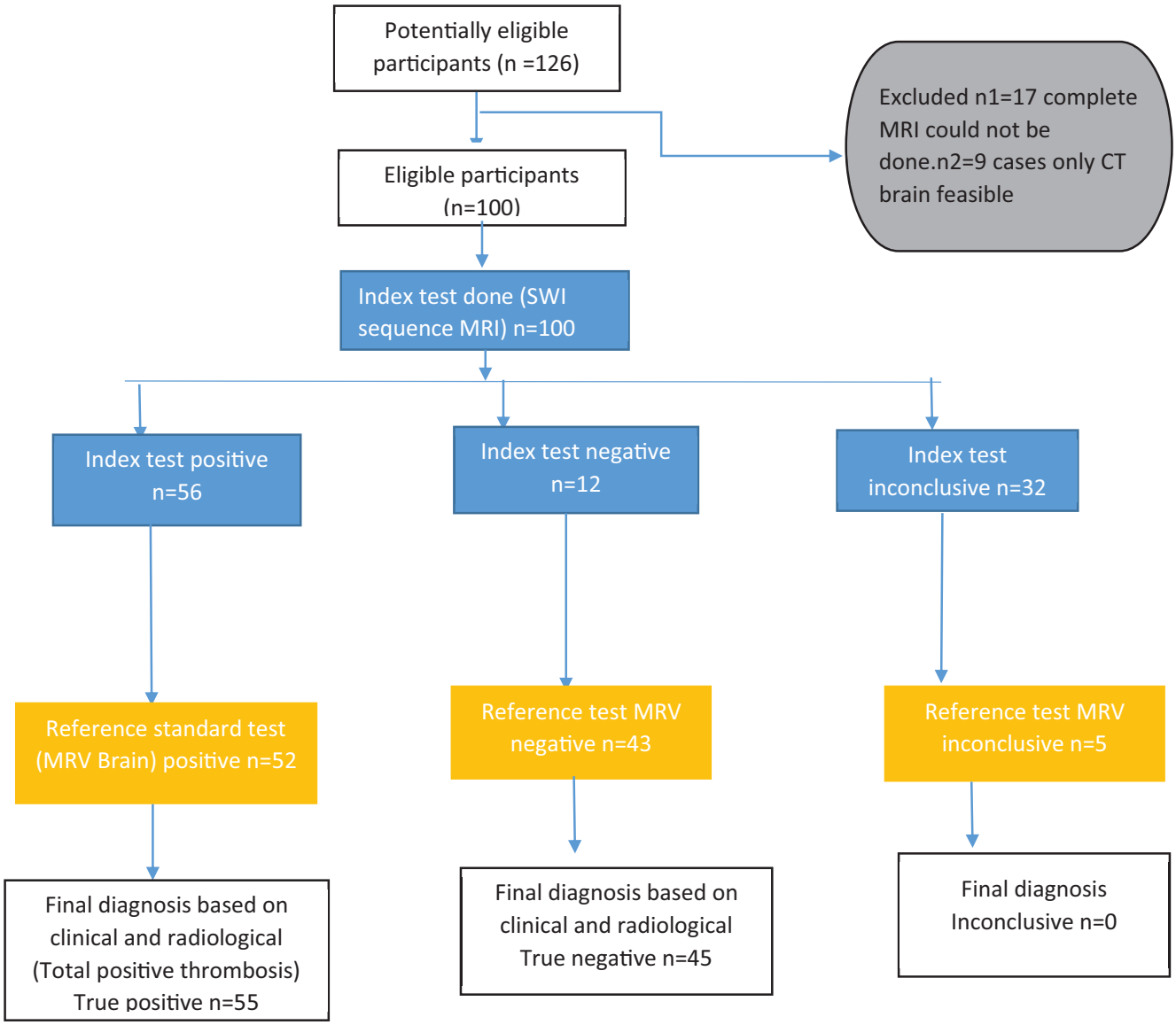

Figure-1: STARD flow chart showing participants and the Index test (Susceptible weighted sequence) compared with reference standard test (MR venogram Brain).

Parameters (MRV Vs SW1)	Percentage of Agreement (concordance)	Chi square score	Degree of freedom(df)	P value
SSS	88	78.27	4	<0.00001
Straight sinus	88	70.21	4	<0.00001
Deep veins	85	32.41	2	<0.00001
Right sigmoid sinus	44	16.53	4	0.002
Left sigmoid sinus	44	25.79	4	0.00003
Right transverse sinus	57	41.35	4	<0.00001
Left transverse sinus	61	47.59	4	<0.00001

Table-2: Summary of the results: agreement among MRV and SW1 MRI methods for the parameters considered. Significance calculated with the chi square score and degree of freedom.

90% and specificity was 96.6%. Similarly sensitivity of SWI in case of straight sinus was 84.2% and specificity was 98.7%. There existed percentage of concordance and discordance between both studies. We found a higher concordance than discordance on comparing SWI from MRV for various sinuses studied [Figure 2]

Figure 3 showed the degree of agreement between MRV and SWI sequence. Degree of agreement was substantial (Kappa value: 0.61-0.80) in case of superior sagittal sinus and straight sinus thrombosis while fair (kappa value: 0.21-0.40) in transverse and deep cerebral vein thrombosis when diagnostic performance of MRV was compared with SW1 sequence in detecting CVT.

Cohen's kappa result be interpreted as follows: values

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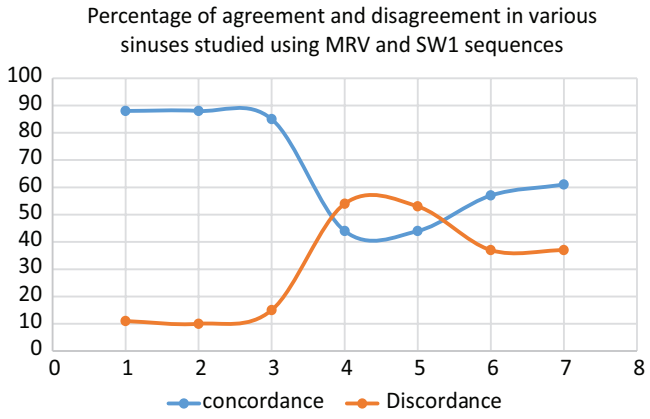
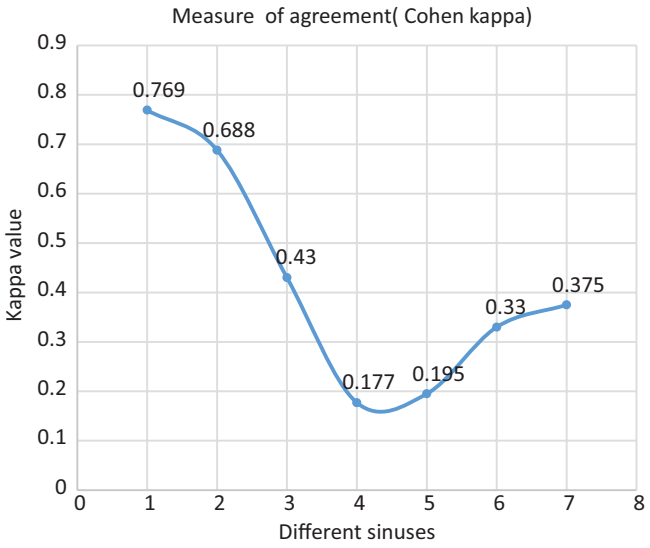


X axis indicates sinuses 1: Superior sagittal sinus, 2: Straight sinus, 3: Deep veins, 4: Right sigmoid sinus, 4: Left sigmoid sinus, 5: right transverse sinus, 6: left transverse sinus. Y axis indicates percentage

Figure-2: Comparing the percentage of concordance and discordance among patients using the 2 techniques (MR venogram and susceptible weighted sequence) in the various sinuses studied.



X axis showing sinuses 1 indicates Superior sagittal sinus, 2 : Straight sinus, 3: Deep veins, 4 : Right sigmoid sinus, 5: left sigmoid sinus, 6: right transverse sinus,7 : left transvers sinus. Cohen kappa value ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

Figure-3: Showing measurement of agreement (Inter rater's variability) between MR venogram and susceptibility weighted sequence in various cerebral sinuses studied.

≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement. Graph showing measurement of agreement (Inter rater's variability) between MR venogram and susceptibility weighted sequence in various cerebral sinuses studied [Figure 3]. Superficial cortical vein thrombosis was observed in 41 cases, which was picked only by SWI, while MRV was inconclusive in detecting cortical vein thrombosis. Comparing clinical findings, SWI, MRV out of 41 cortical vein thrombosis 39 cases were confirmed to have cortical vein thrombosis and 2 were considered normal. Accuracy of SWI in detecting superficial cortical vein thrombosis was 98% (CI: 92.96% to 99.76%), with sensitivity of 100 %(CI: 90.97% to 100%), specificity of 96.72% (CI: 88.65%to 99.60%), positive predictive value of 95.12 %(CI: 83.30% to 98.70%), negative predictive value of 100%.

All cases with definite thrombus on MRV turned out to be positive for CVT irrespective of SW1 features while all cases with definitely normal MRV were classified as negative for CVT irrespective of SW1 features except for one case with superficial cortical thrombosis detected on SW1 sequence. While taking the multiple sinuses involvement MRV was indeterminate in 18 sinuses while SW1 was indeterminate in 163 sinuses (table 2).

Summary of the results: Agreement among MRV and SWI. Various MRI methods for the parameters were considered. There exists higher percentage of agreement between MRV and SWI in case of superior sagittal sinus (SSS), and straight sinus, followed by deep veins, transverse sinus and sigmoid sinus. MRV still remain the gold standard of choice for the diagnosis of CVT in view of significant p value obtained on cross tabulation on individual sinuses as shown in Table 3. While SWI remains the powerful imaging sequence for detecting superficial cortical vein thrombosis, where MRV fails.

DISCUSSION

CVT is a disease usually affecting young to middle aged people with potentially serious consequences. [6] 30% cases of stroke in India occurs in young and CVT accounts for 10 to 20% cases. [7] Challenges in the diagnosis of cerebral vein thrombosis are posed by the variety of risk factors and variable presentation. It is therefore important to have a high suspicion index for this condition to ensure prompt diagnosis and care. Contrast enhanced MRV can magnificently detect thrombosis in sinuses and small veins and demonstrate collaterals and its details.[8] Conventional MRI is not predictable for CVT, often it is difficult to determine whether the signal noted in cerebral vein correlate to flow or thrombosis. Limitations occurs even with MRV also in terms of their ability to visualize slowly flowing blood in small vessels like cortical veins. In comparison SW imaging uses the phase difference between vessel and its surrounding parenchyma by using paramagnetic deoxyhaemoglobin as an intrinsic contrast agent. Thus SW images using both phase and magnitude information facilitates in CVT detection which are otherwise difficult only with conventional MRI images.

We found that SWI detected thrombosis in sinuses, deep veins and even cortical veins. Compared to MRV contrast the efficiency of SWI to detect CVT was superior in terms of cortical vein thrombosis. In cases where MRV did not show cortical vein thrombosis, SW1 sequence picked cortical vein thrombosis. The diagnostic accuracy of SWI in detecting superficial cortical vein thrombosis was 98% while. One drawback with SWI sequence was that higher proportion of cases were indeterminate when compared to MRV (32% Vs

5%). Hence MRV is the gold standard of choice for diagnosis of CVT. Sensitivity and specificity of SW1 in diagnosis superior sagittal and straight sinus thrombosis was similar to MRV. Thus Conventional MRI with SW1 would help to confirm CVT in majority of cases based on clinical history. This would help in reduction of the cost in diagnosing CVT in those cases where MRV not feasible due to financial constraints. Secondly MRV contrast is time consuming and risk of contrast exposure also there.

Present study showed that thrombosis in deep veins were better demonstrated by SW1 (17 cases) when compared to MRV contrast (8 cases).This is similar to previous study that showed role of SWI in detecting Deep vein thrombosis. [5]

Limitations of the study are firstly this was a small sample size study. The Study was related to image interpretation and comparison with clinical data. Advantage of our study was, it being the first study comparing diagnostic accuracy of SWI brain with MRV in CVT cases from Asia. Secondly here we tried to know the diagnostic performance of both sequences by including normal patient who did not have CVT with that of CVT cases. SWI is the powerful imaging sequence to detect isolated superficial cortical vein thrombosis.

CONCLUSION

The study showed that MRV remains the gold standard of diagnosis of CVT. There exists degree of agreement between both tests (MRV and SW1 sequence) with substantial agreement in case of superior sagittal sinus thrombosis and straight sinus thrombosis. SWI is the gold standard for diagnosis of isolated superficial cortical vein thrombosis. Conventional MRI with SWI would help to confirm CVT in majority of cases where MRV is not feasible. However, large scale randomized studies will be required to confirm its efficacy as a diagnostic modality.

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