

The Investigation of the Diagnostic Values of the T2WI Sequence in Cerebral Venous Sinuses Thrombosis in Comparison With 3D MRV

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Abstract- Cerebral venous sinus thrombosis is an important pathology with various clinical symptoms. Early detection of thrombosis is very important for the improvement of the prognosis. The aim of this study was to calculate the diagnostic value of T2-weighted sequences of magnetic resonance imaging (MRI) in detecting subacute thrombosis. All patients that were suspected of having subacute cerebral venous sinus thrombosis and were referred to the emergency center of Kashani hospital (between September 2018 and September 2019) were entered into the study. Magnetic resonance venography (MRV) and T2-weighted MRI were accomplished for each patient. The sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) of MRI using MRV as the reference method were calculated. A total of 630 patients were entered into the study. A positive subacute venous sinus thrombosis was detected in the MRV of 53 patients; consequently, the sensitivity of 60%, the specificity of 80%, the PPV of 21%, and the NPV of 96% were calculated. MRI was highly specific for detecting the subacute thrombosis of superior sagittal sinus, transverse sinuses, sigmoid sinuses, and straight sinus (specificity>94%). A substantial agreement was detected between MRI and MRV in distinguishing thrombosis of superior sagittal sinus, transverse sinuses, sigmoid sinuses, and straight sinus ($\kappa>0.6$). T2-weighted MRI is a specific method in detecting cerebral venous sinus thrombosis. In a patient with signs of thrombosis in the T2-weighted sequence, additional workups are highly suggested to rule out the pathology.

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Introduction

Cerebral venous sinus thrombosis is more likely to happen in young adults and children. The estimated annual incidence is three to four individuals per one million populations. The sinus thrombosis can cause various symptoms, including severe headaches, seizures, and blindness. The symptoms may happen by localized edema of the brain or venous infarction due to the occlusion of cerebral veins; another mechanism is intracranial hypertension secondary to occlusion of venous sinuses (1,2).

Although venous sinus thrombosis is not common, early diagnosis and prompt intervention is very important and can reduce the mortality and morbidity (3). Contrast-enhanced magnetic resonance venography (MRV) is a standard technique for diagnosing sinus thrombosis (4);

however, the most sensitive method for detection of thrombosis is MRV in combination with magnetic resonance imaging (MRI) sequences (5).

MRI features of thrombosis depend on the age of the thrombosis; in subacute phases, increased signal intensity is visualized in T2-weighted images (6). Although MRI can be useful in early detection of thrombosis, the routine use of MRI can lead to many false-positive and false-negative results, which can lead to patients' anxiety or unnecessary contrast media or radiation exposure (7).

Although T2-weighted MRI is routinely used in patients with suspected cerebral venous thrombosis, a few pieces of literature are reporting the diagnostic value of T2-weighted images in patients with subacute cerebral venous thrombosis. Therefore, in this study, we aimed to evaluate the sensitivity, specificity, negative predictive value, and positive predictive value of T2-weighted

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images using MRV as the reference standard method.

Materials and Methods

This was a cross-sectional study accomplished between September 2018 and September 2019 at the Kashani Hospital in Isfahan University of Medical Sciences, Isfahan, Iran. All patients with suspicious subacute cerebral venous thrombosis who were referred from the emergency department to the radiology center of Kashani hospital were included in the study. The cerebral venous thrombosis was considered subacute if the symptoms were present for 1-4 weeks. Patients with contraindications to MRI and those with a lack of data were excluded from the study.

The study protocol was approved by the ethical board of the Radiology Department, Isfahan University of Medical Sciences, Isfahan, Iran. The aim of the study was explained to all the patients, and each patient signed written consent. Demographic data, including gender and age, were detected; MRI and MRV images were obtained. Two expert radiologists who were blinded to the patients' clinical symptoms and the report of the other radiologist reviewed all MRI sequences simultaneously.

T2-weighted images

All patients underwent T2 weighted images with a 1.5 T MRI (Ingenia Philips). Patients with a present cerebral venous thrombosis were considered as positive MRI, and those with no evidence of thrombosis were considered as negative MRI. The absence of a flow void and the presence of altered signal intensity in the sinus were considered as the signs of thrombosis.

Patients with positive MRI were examined for the presence of thrombosis in any of the following locations: superior sagittal sinus, inferior sagittal sinus, left transverse sinus, right transverse sinus, left sigmoid sinus, right sigmoid sinus, left internal jugular vein, right internal jugular vein, the vein of Galen, internal cerebral veins, straight sinus, and cortical veins. Other parameters, including the presence of infarction or parenchymal changes related to the thrombosis, were examined.

MRV

MRV images were obtained using a three-dimensional time-of-flight (TOF) MRV (TR/TE: 20 Ms, TE: 5.5, Slices: 80, Slice thickness: 2 mm, matrix size: 232*220, the field of view: 20 cm, acquisition time: 7.5 min). MRVs were performed using the sagittal plane from ear to ear without contrast administration. The absence of a signal at TOF MRV was considered a positive cerebral

venous thrombosis.

Statistical analysis

Statistical analyses were performed using SPSS software, version 21 (SPSS Inc., Chicago, IL, USA). A *Chi-square* test was applied for analyzing categorical variables. $P < 0.05$ was considered as a statistical significance. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. The agreement between MRI and MRV was evaluated using kappa value.

Results

A total of 630 patients were entered into the study. Subacute thrombosis was detected in 53 patients using MRV. Of 53 patients, 25 (47%) were male, and 28 (53%) were female. The patients with thrombosis were aged from 5 to 78 years old with a mean \pm SD of 38.3 ± 15.5 years.

In MRV scans, a total of 101 thrombosed venous sinuses were detected. A single venous site was involved in 20 patients, two in 18 patients, and three in 12 patients. The other two patients had 4 and 5 venous sinus thrombosis. The most common sites for thrombosis were right transverse sinus (21.8%), right sigmoid sinus (19.8%), and left transverse sinus (19.8%), respectively (Table 1 and Figure 1). Using T2WI, 149 patients (23.7%) with thrombosis and 191 involved thrombosed venous sinuses were detected. The left transverse sinus (67.8%) and right transverse sinus (24.8%) were the most common sites of thrombosis in MRI images (Table 1).

No thrombosis was detected in the left internal jugular vein, right internal jugular vein, the vein of Galen, and cortical veins using MRV and MRI. Low signal intensity was detected in twenty-two (41.5%) patients. However, the thrombosis in 15 (28.3%) and 16 (30.2%) patients were visualized as intermediate and high signal intensity, respectively.

Of a total of 53 patients, parenchymal infarction was detected among 16 (30.2%) of the patients. Infarctions were more likely located in the parietal lobe (9 cases), frontal lobe (5 cases), midbrain (2 cases), and parietotemporal lobe (3 cases). Other infarction sites were the internal capsule, temporo-occipital lobes, occipital lobe, frontoparietal lobes, genu of the corpus callosum, basal ganglia, thalamus, and temporoparietooccipital lobe. The diagnostic values of MRI for detection of thrombosis were 60.4% for sensitivity, 79.7% for specificity, 21.5% for positive predictive value (PPV), and 95.7% for negative predictive value (NPV) (Table 2).

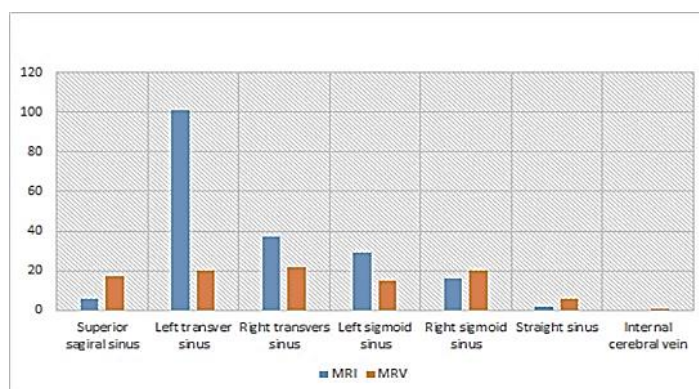


Figure 1. The frequency of cerebral venous sinus thrombosis in MRI and MRV

Table 1. Frequency of cerebral venous sinus thrombosis in MRI and MRV and the agreement between MRI and MRV in detecting thrombosis

	MRV (total=101)	MRI (total=191)	Agreement (k)
Superior sagittal sinus	17 (16.8%)	6 (3.15%)	0.8
Left transvers sinus	20 (19.8%)	101 (52.9%)	0.7
Right transvers sinus	22 (21.8%)	37 (19.3%)	0.7
Left sigmoid sinus	15 (14.8%)	29 (15.1%)	0.7
Right sigmoid sinus	20 (19.8%)	16 (8.3%)	0.7
Straight sinus	6 (5.9%)	2 (1%)	0.5
Internal cerebral vein	1 (1%)	0 (0%)	-

Table 2. Overall diagnostic value of MRI in detecting cerebral venous sinus thrombosis

MRI	MRV		Total
	True positive	True negative	
Test positive	32 (60.3%)	117 (20.3%)	149
Test negative	21 (39.7%)	459 (79.7%)	480
Total	53	576	630

A substantial agreement was detected among MRI and MRV in detecting involvement of superior sagittal sinus, left and right transverse sinuses, and left and right sigmoid sinuses ($P < 0.001$, $k > 0.6$) (Table 1). MRI was

significantly specific for diagnosing superior sagittal sinus, left and right transverse sinuses, right and left sigmoid sinuses, and straight sinus (Table 3).

Table 3. Diagnostic value of MRI in detecting cerebral venous sinus thrombosis at each site separately

	TP	TN	FP	FN	Sensitivity	Specificity	NPV	PPV
Superior sagittal sinus	13	36	0	4	76.5%	100%	90%	100%
Left transvers sinus	15	31	2	5	75%	93.9%	86.1%	88.2%
Right transvers sinus	16	30	1	6	72.7%	96.8%	83.3%	94.1%
Left sigmoid sinus	10	37	1	5	66.7%	97.3%	88%	90.9%
Right sigmoid sinus	14	33	0	6	70%	100%	84.6%	100%
Straight sinus	2	47	0	4	33.3%	100%	92.1%	100%

TP: true positive; TN; true negative; FP: false positive; FN: false negative; NPV: negative predictive value; PPV: positive predictive value

Among 117 patients with false-positive MRI results, left-sided sinus hypoplasia was detected in 91 (77.1%)

patients. Hypoplasia of right-sided sinuses was detected in 26 (22%) participants.

Of 117 patients, 5 (4.2%) were left-handed and 74 (62.7%) were right-handed. The information for the other 38 participants was missing. No association was detected between the side of the dominant hand and the side of sinus hypoplasia ($P>0.05$).

Discussion

In this study, we detected the diagnostic value of T2WI in distinguishing subacute cerebral venous thrombosis. We found a sensitivity of 60%, the specificity of 80%, NPV of 96%, and a PPV of 21%. Additionally, we found a substantial agreement between MRI and MRV in detecting thrombosis of superior sagittal sinus, transverse sinuses, and sigmoid sinuses. MRI was demonstrated as a highly specific method in detecting superior sagittal sinus, transverse sinuses, sigmoid sinuses, and straight sinus thrombosis.

In our study, the most common locations for thrombosis were transverse sinuses and sigmoid sinuses. The same anatomic distribution was reported by Soleau *et al.*, (8), detecting transverse and sigmoid sinuses thrombosis in as many as 90% of the patients. Moreover, Walecki *et al.*, reported thrombosis mostly located in the transverse sinuses and sigmoid sinuses. In their report, thrombosis in the internal jugular vein, superior sagittal sinus, deep cerebral veins, straight sinus, and cortical veins were less frequently observed (9).

In a study by Altinkaya *et al.*, (10), the T2WI MRI was diagnostic for 60% of cases with subacute superior sagittal sinus thrombosis. However, it had no diagnostic value for detecting acute or chronic thrombosis. In the present study, we found MRI as a valuable diagnostic tool for detecting subacute superior sagittal sinus thrombosis. Moreover, the calculated sensitivity (76.5%) in detecting superior sagittal sinus thrombosis was higher than the one reported by Altinkaya *et al.*, (10).

In the present study, we found a high NPV and PPV in detecting thrombosis of superior sagittal sinus, transverse sinus, sigmoid sinus, and straight sinus. It can be suggested that in a patient with susceptible cerebral venous thrombosis, the absence of thrombosis signs in T2WI is highly suggestive for no thrombosis. However, due to a high probability of an available thrombosis in patients with MRI suggesting signs of venous sinus thrombosis, additional workups are highly recommended.

In a study on 65 patients with suspected cerebral venous sinus thrombosis, the combination of all sequences of MRI was reported as a sensitive method for detecting thrombosis (sensitivity of >99%). However, among different sequences of MRI, T1-weighted gradient

echo (GRE) imaging had a statistically significant higher sensitivity than other sequences. Moreover, compared with other MRI sequences, the T2-weighted sequence had the highest specificity (11). The results of the present study are consistent with the report of Sedigh *et al.*, (11). We detected a specificity of 80% for T2-weighted MRI and a specificity of more than 93% in distinguishing superior sagittal sinus, transverse sinuses, sigmoid sinuses, and straight sinus thrombosis. The usefulness of T2-weighted sequences as a screening method for cerebral venous sinus thrombosis detection was reported by Selim *et al.*, (12). They recommended adding this sequence to routine MRI protocols for screening thrombosis (12).

In the present study, all the patients were in the subacute phase of the thrombosis, and variable signal intensities were reported. The hyperintense signal of subacute thrombosis in T2WI was related to the presence of extracellular methemoglobin in late subacute stages. However, the thrombosis in the early subacute stage visualized as hypointense signal intensity on T2WI because of the intracellular methemoglobin (10,13,14). The thrombosis in the sub-acute stage is easier to be detected than the other stages because of the differences between the signal intensity of the sinus and normal flow state. MRI better identifies focal brain abnormalities, including focal edema and hemorrhage that may occur with edema. Parenchymal changes may occur in areas directly drained by occluded venous sinus or areas not closely related to venous occlusion (15).

Although some studies reported contrast-enhanced 3D GRE T1-weighted MRI or T2-weighted GRE MRI as the most sensitive method for evaluating cerebral venous thrombosis (10,16), there are not enough studies in the literature on the diagnostic value of T2-weighted MRI for detection of thrombosis. We found the T2-weighted MRI as a specific MRI sequence in detecting subacute cerebral venous sinus thrombosis. However, there are some limitations. We just included patients with sub-acute thrombosis in the study. The results of the study cannot be generalized to the other types of thrombosis; thus, more studies are needed on the diagnostic accuracy of T2-weighted in acute and chronic sinus venous thrombosis detection.

In conclusion, T2-weighted MRI is suggested as a specific method in detecting cerebral venous thrombosis. Specificity more than 93% were detected for the T2-weighted MRI in distinguishing thrombosis of superior sagittal sinus, transverse sinuses, sigmoid sinuses, and straight sinus. Also, T2-weighted MRI was able to detect the thrombosis of superior sagittal sinus, transverse

sinuses, and right sigmoid sinus with a sensitivity of more than 70%. The application of this method with other imaging modalities can lead to the early detection of thrombosis and the reduction of the morbidity and mortality caused by the pathology.

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