Original Article

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SWI Sequence -as a Promising Tool in the Evaluation and Treatment of Acute Stroke

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Abstract

Background: There are many recent advances in the magnetic resonance imaging technique that have improved the assessment and evaluation of acute stroke. The susceptibility of tissue is based on its components like hemosiderin, calcium, deoxygenated blood, and ferritin (1). Thrombosed vessels, old hemorrhages, and even tiny minute hemorrhages can easily be detected in SWI sequence. The aim of this study is to depict the importance of SWI sequence in detecting the tissue susceptibility differences which ultimately helps in the assessment and management of both ischemic and hemorrhagic strokes. **Subjects and Methods:** This hospital-based prospective study was conducted upon 150 patients, over two years from July 2019 to August 2021 at the department of Radio-Diagnosis, Narayana Medical College. The patients who came with complaints of weakness of limbs, headache, vomiting, deviation of the mouth, etc, were subjected to MRI brain study including SWI sequence. **Results:** Among the 150 studied population, 138(92%) cases had findings and 12(8%) cases are normal. In 138 cases, 99 (71.7%) cases had ischemic infarction, 30 (21.7%) cases had an intraparenchymal hemorrhage and 9(6.6%) cases had venous sinus thrombosis. In 99 cases of ischemic infarction, 38 (38.3%) cases had no hemorrhagic transformation, 35 (35.3%) cases had shown susceptibility sign and 26(26.4%) cases had an early hemorrhagic transformation. **Conclusion:** Detection of early hemorrhagic transformation within acute infarcts is necessary to prevent the patient from the catastrophic condition due to thrombolytic treatment (2). As SWI sequence detects the early hemorrhagic transformation, it plays a crucial role in planning the management of the patient. It also detects the cause of infarct by detecting the susceptibility sign. Therefore, it is necessary to include the SWI sequence in the routine MRI brain stroke protocol for assessing the patients presented with complaints of stroke.

Keywords: Acute stroke, MRI-SWI sequence, hemorrhagic transformation, thrombosis in vessels

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Introduction

MRI Brain has been a primary modality of choice in the evaluation and assessment of treatment in stroke cases. It also gives information about the necessity of doing an intervention in needful patients and thus aids in guiding treatment.[1]

The areas of recent ischemia, vessel occlusion, and hemorrhage are easily diagnosed with susceptibility-weighted imaging sequence. MRI gives information regarding the region of the core infarct (ischemic core) and penumbra (salvageable tissue) i.e., tissue with maintained perfusion due to collaterals. Detection of microbleeds, petechial hemorrhages in the area of ischemia is difficult with conventional MRI sequences.[2]

In the newer advances, Susceptibility Weighted Imaging (SWI) has emerged as a promising tool in enhancing the contrast in Magnetic Resonance Imaging sequences. The conjoined information from both conventional MR sequences and SWI sequence provides valuable information regarding the status of the patient. The susceptibility-weighted imaging is defined as a high resolution, three-dimensional GE (Gradient Echo) sequence, based on a fully velocity corrected technique.[3,4] It uses both magnitude and phase images separately or in the combination of both magnitude and phase images. This sequence highlights the

paramagnetic properties of blood products. Therefore, this sequence is very sensitive in the detection of abnormalities in blood both intravascular and extravascular compartments based on oxygenation properties of blood. The ability to detect early hemorrhage in patients with acute stroke has made SWI a powerful technique. Based on this information, appropriate treatment can be given avoiding the use of thrombolytic drugs and thus minimizing the chances of development of a large hematoma. Approximately 20-40% of all stroke patients, early hemorrhagic transformation was seen within the first week of onset.[5]

In the evaluation of acute stroke, another important sign is the "Susceptibility Sign".[6] There will be a hypointense signal (blooming artifact) noted in the arteries due to thrombus and the diameter of that vessel is comparatively increased to that of the contralateral vessel. SWI along with DWI plays a crucial role in identifying the involved vascular territory. This is in correlation of "Dense MCA sign" On CT Imaging.[7]

SWI also gives information on tissue perfusion. There will be asymmetrical prominent cortical veins in the ischemic area because of increased amounts of deoxyhemoglobin. It is most commonly seen in patients with severe intracranial stenosis or occlusion. Usually, it represents either a penumbra or poor collateralization of the arterial supply.[8,9]

There is another important condition called, Cerebral venous sinus thrombosis (CVST),[10] which can result in the death of the patient if not diagnosed early. In these cases, early commencement of thrombolytic and anticoagulant treatment is necessary.[11,12] It is important to demonstrate the venous stasis and collateral flow. The Susceptibility Weighted Imaging demonstrates a prominent hypointense signal in the involved thrombosed venous sinuses (blooming artifact) that is complementary to the loss of flow void in conventional sequences.[3] Therefore, the SWI along with conventional sequences plays a crucial role in detecting CVST.

Objectives of the study:

1. To study the role of SWI in assessing and identifying hemorrhagic foci in patients with acute ischaemic stroke and CVST.
2. To know the sensitivity of SWI in identifying the Susceptibility sign in acute stroke patients and know the status of arteries.

Subjects and Methods

It is a two-year Hospital-based prospective study from July 2019 to August 2021 conducted at Narayana Medical College and Hospital after taking informed consent.

The study included 150 patients aged between 20-75 years, irrespective of sex, referred to the Radiology department.

Patients having pacemakers, metallic implants, a history of claustrophobia, and causes of hemorrhage other than acute ischemic stroke-like cerebral amyloid angiopathy were considered as the exclusion criteria of the present study.

The study was conducted on a 3.0 Tesla GE MRI scanner (DISCOVERY MR 750w). The commonly performed sequences in our department include: FSPGR(T1WI), Axial T2 PROPE, Fluid attenuated inversion recovery Sequence (FLAIR), Diffusion-weighted imaging (DWI) including Apparent diffusion coefficient (ADC), SWAN images (SWI), and Filtered Phase images. Foci of blooming in the infarct area on SWI were considered as hemorrhages. Positive 'Susceptibility sign' indicates when the diameter of a hypointense vessel is greater than the diameter of the contralateral vessel on SWI images.

Results

Among the 150 studied population, 138(92%) cases had findings and 12(8%) cases are normal. In 138 cases, 99(71.7%) cases had ischemic infarction, 30 (21.7%) cases had an intraparenchymal hemorrhage and 9(6.6%) cases had venous sinus thrombosis. In 99 cases of ischemic infarction, 38 (38.3%) cases had no hemorrhagic transformation, 35(35.3%) cases had shown susceptibility sign and 26 (26.4 %) cases had an early hemorrhagic transformation.

Table 1: The study population (n=150) was divided into five groups according to the findings.

Group	Number of patients	Findings
1	12	Normal
2	38	Infarction without hemorrhagic transformation
3	35	Infarction with susceptibility sign
4	26	Infarction with early hemorrhagic transformation
5	9	Venous sinus thrombosis
6	30	Intraparenchymal hemorrhage
Total	150	

The age group of the study population is within 20 to 75 years. The peak incidence of neurological deficits is between 50-70 years. Males are more common affected than females. In our study population of 150 patients, 98 (65.3%) were males and remaining 52 (34.7%) were females. Venous sinus thrombosis was mostly encountered in the young adult age group.

In this study out of 150 patients, 52 (34.7%) patients had only hypertension, 28(18.6%) patients had only diabetes and 44 (29.3%) patients had both diabetes and hypertension.

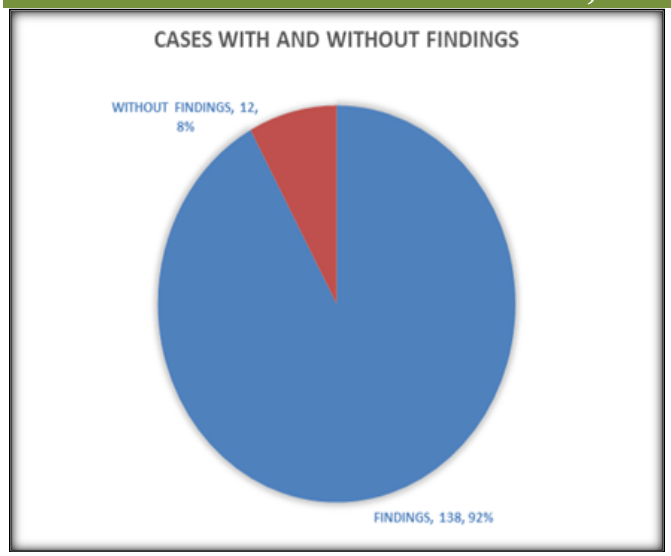

Figure 1: Percentage Distribution of Study Population With And Without Findings

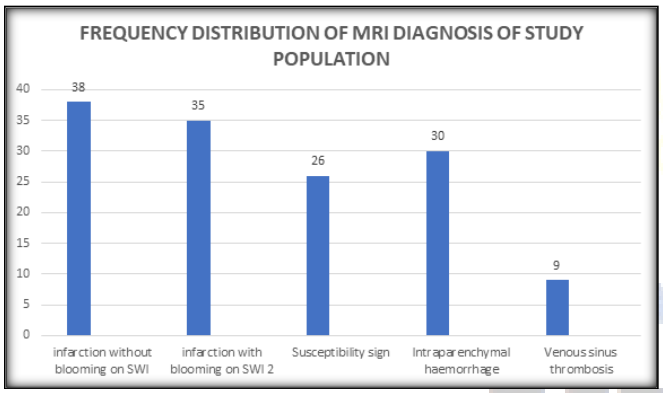

Figure 2: Showing Mri Diagnosis Among the Study Population

Representative Cases

1. A 72 years old male patient present with complaints of right upper and lower limb weakness for 1 day. He was advised MRI Brain. [Figure 3]
2. A 45years old female patient came with the chief complaints of weakness of right upper and lower limbs, deviation of mouth to the left side, and 2 episodes of seizures for 1 day. MRI Brain was done with including SWI sequence. [Figure 4]
3. A 59 years old male patient came with the chief complaints of right upper and lower limb weakness for 2 days. MRI brain was done. [Figure 5]
4. A 50year old male patient presented with chief complaints of left upper and lower limb weakness for 1 day. He was known hypertensive. He was advised MRI brain. [Figure 6]
5. A 24years male patient presented with chief complaints of vomiting for 4 days, 1 episode of seizure with LOC for 4 min, and involuntary micturition. H/o irritable behaviour for 1 day. He was advised MRI brain. [Figure 7]

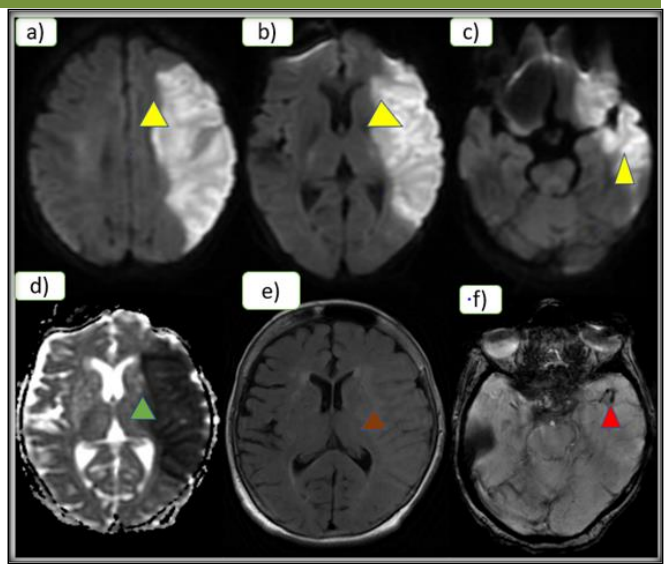

Figure 3: (a-f)- Showing Acute infarct in MCA territory with susceptibility sign in left MCA. Fig 3a-3d demonstrating true diffusion restriction (Yellow arrow heads) in left fronto-temporo-parietal lobes and left lentiform nucleus. Fig 3e, demonstrating the FLAIR hyperintensity (brown arrow head) in the involved region. Fig 3f, demonstrating the susceptibility sign (Red arrow head) with thrombus in the M1 and M2 segment of left MCA.

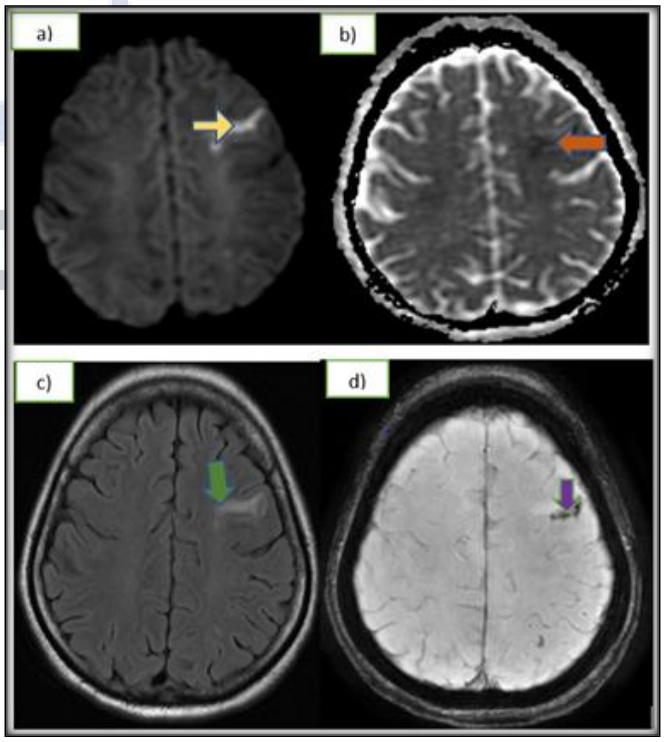

Figure 4: (a-d)- Acute Infarct with early hemorrhagic transformation in cortical and subcortical region of left frontal lobe. There is diffusion restriction (yellow arrow) with corresponding decrease in the ADC values (red arrow) noted in Fig a) and B). FLAIR image(c), showing hyperintense signal (Green arrow) and foci of blooming (purple arrow) on SWAN(d) in the involved region

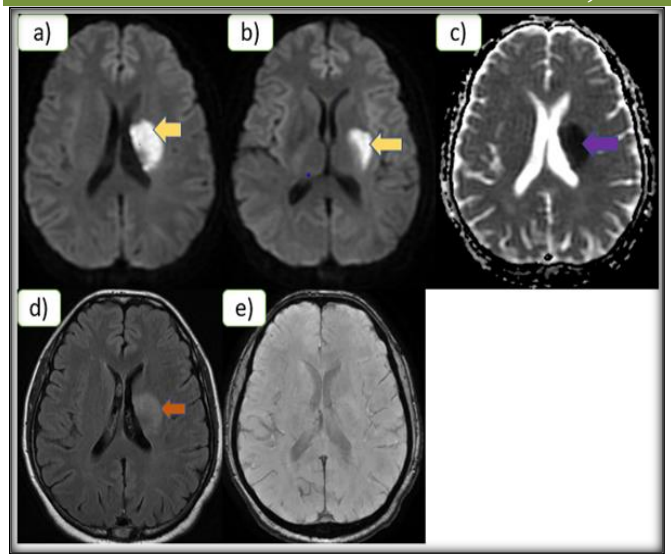

Figure 5: (a-e) showing Acute infarct in left corona radiata and left basal ganglia. Fig a-c, showing an area of diffusion restriction (yellow arrows) with corresponding low ADC values (purple arrow) in the involved region. Fig d- FLAIR hyperintensity (brown arrow) in the affected region. Fig e – SWI showing no significant findings.

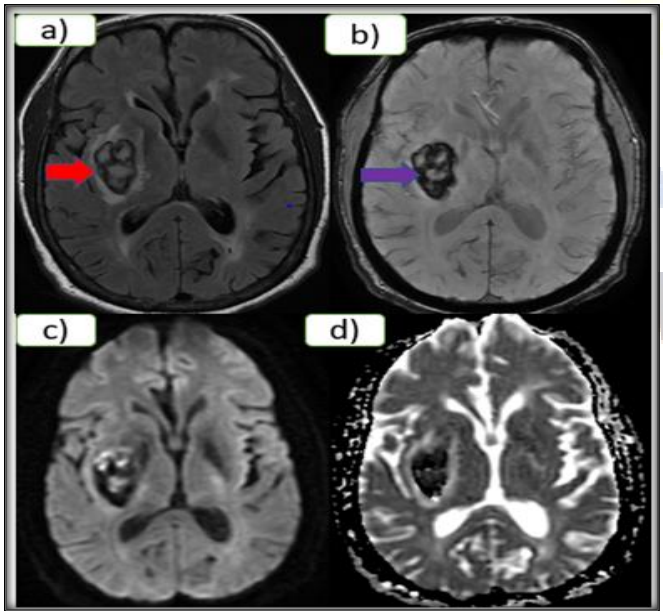

Figure 6: (a-d) showing Acute Intraparenchymal hemorrhage in the region of the right capsulo-ganglionic region with adjacent vasogenic edema. a)There is a well-defined heterogenous FLAIR hyperintense lesion (red arrow) noted in capsule-ganglionic region. Fig b) showing blooming (purple arrow) on SWAN in the affected region. Fig c &d- the lesion is not showing any true diffusion restriction

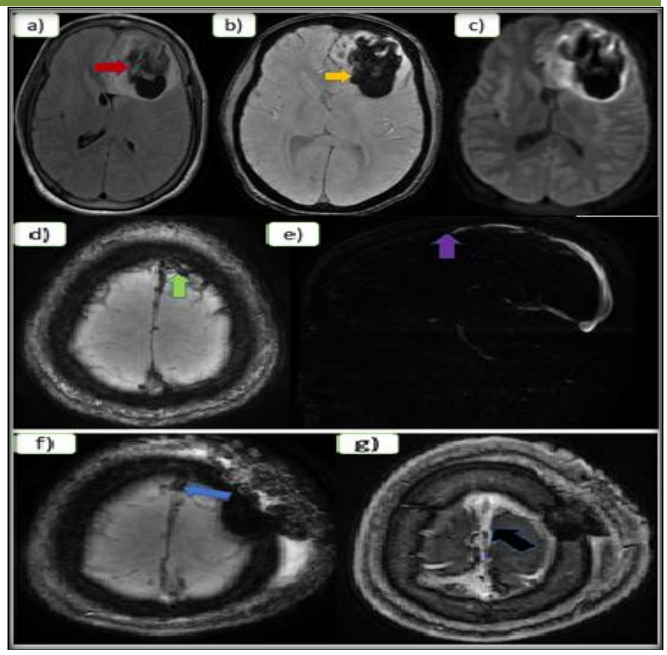

Figure 7: (a-g) showing an intraparenchymal hemorrhage in the left frontal lobe secondary to superior sagittal sinus thrombosis. Fig a)- FLAIR image demonstrating heterogeneously hypo to isointense lesion (Red arrow) in the left frontal lobe with surrounding edema. b & d – SWAN images showing blooming in the affected region (yellow arrow) and in the superior sagittal sinus (green arrow) in its anterior aspect. Fig c – DWI image showing no true diffusion restriction. e- MRV TOF image demonstrating thrombosis (purple arrow) in the anterior half of superior sagittal sinus. Fig f & g – Postoperative mages showing mild reduced thrombosis (blue and black arrow) in the superior sagittal sinus.

Discussion

The susceptibility of any tissue changes based on surrounding tissue susceptibility that contains paramagnetic substances like de-oxyhemoglobin, meth-hemoglobin, ferritin, hemosiderin, and calcification. To determine these different tissue susceptibilities, the Susceptibility-weighted imaging (SWI) sequence is an important sequence along with conventional sequences in MR Imaging.

Patients presenting symptoms with weakness of limbs, vomiting, deviation of the mouth, etc, and clinical examination of that patient can suggest the diagnosis of stroke which can either be ischemic or hemorrhagic. To confirm the diagnosis of stroke, brain imaging studies are much needed which detects the ischemia, hemorrhage with high accuracy and direct the physicians towards proper management.

The main cause of acute ischemic infarct is Thromboembolism or arteriosclerotic stenosis.[3] Hemorrhages may or may not be seen in the ischemic areas. Anticoagulant and thrombolytic treatment in patients with the early hemorrhagic transformation of the ischemic infarct is contraindicated as there is a possibility of deterioration of the patient's condition due to the formation of a large hematoma. Therefore, SWI sequence plays important role in

the accurate diagnosis and management of acute stroke patients with early hemorrhagic transformation.

In the current study, out of 99 patients, early detection of hemorrhagic transformation in infarct was confirmed by SWI in 26 patients (26.4%) and the intraparenchymal hematoma was found in 30 cases (21.7%). Most of the patients presented with the intraparenchymal hematoma are already hypertensive or denovo hypertension.

According to the study conducted by Wycliffe et al.[13] and Santhosh et al,[2] SWI sequence is the most important study in the evaluation of acute stroke patients. Even traces of hemorrhagic foci can easily be detected on the SWI sequence as blooming artifacts. Therefore, this sequence is found to be a sensitive sequence for both diagnostic and therapeutic purposes in cases of acute stroke. Their study results are comparable to our study in which it proved that SWI is a sensitive sequence in detecting early hemorrhagic transformation in acute infarct and hence it should be included in routine brain stroke profile protocol to avoid the catastrophic condition resulting from thrombolytic therapy.

The presence of intra-arterial thrombus and increase in the diameter of the affected vessel is called the susceptibility sign and, in our study, among 99 cases having arterial infarction, susceptibility sign was seen in 35 cases. The hypointense signal in the SWI images is due to severe T2 shortening of high concentrations of deoxyhemoglobin within the clot. Evaluation of intracranial internal carotid arteries was found to be difficult because of the artifacts from the base of the skull and adjacent paranasal sinuses. This is the limitation of SWI sequence in the detection of ICA thrombus. In the cases of ICA thrombosis, angiography is found to be useful.

Among the study population of 150 cases, venous sinus thrombosis was found in 9 cases in which there is a hypointense signal along the affected venous sinus and there will be associated intracranial hemorrhage in most of the cases. Sinus thrombosis was confirmed by complementary MRV. This is comparable to the study done by Thomas et al.[14] in which he implied that SWI in conjugation with conventional spin echo sequences, sinus thrombosis can easily be detected. On conventional MR sequences, the diagnosis of CVST is highly challenging unless there is high clinical suspicion [(10)]. On conventional images (T1, T2, and FLAIR sequences), there will be loss of flow void in the involved sinus and this is considered to be the direct sign of CVST. Cerebral hemorrhage, infarction, and edema are most commonly associated with cerebral venous sinus thrombosis. On computed tomography imaging, Triangle sign or empty delta sign is seen in cases of venous sinus thrombosis.[15] In these cases, thrombolytic treatment should be started as early as possible to decrease the mortality of the patients. Therefore, SWI has an important role in the early diagnosis of CVST by demonstrating hypointense signal (blooming artifacts) in the involved venous sinuses and collateral slow flow.

In many cases, we see micro bleeds in the brain parenchyma and most common causes for these micro-bleeds include hypertension, cerebral amyloid angiopathy, or any other causes of small-vessel vasculopathy. These, micro-bleeds appear as tiny foci of blooming on susceptibility weighted imaging.[16,17]

In SWI sequence, hemorrhagic foci, calcifications, and hemosiderin will appear as hypointense signal. To differentiate these different materials, filter phase imaging plays an important role. Bleed appears hypointense in both SWI and Filter phase images and calcification appear as hypointense foci on SWI and hyperintense foci on Filter phase images. Thus, helps in proper management of patients with stroke.

Conclusion

Susceptibility-weighted imaging is a fast acquisition technique and is independent of contrast. It helps in early detection of hemorrhagic transformation within acute infarction and of venous thrombosis which alerts the physicians and surgeons about the early use of thrombolytic treatment in infarcts with susceptibility sign and venous thrombosis as well as devasting complications of use of thrombolytics in cases of hemorrhagic transformation in acute infarction. Hence, the SWI sequence should be included in the routine protocol of the MRI brain imaging.

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