INJ INTERNATIONAL NEUROUROLOGY JOURNAL

Susceptibility Weighted Imaging: Enhancing Neuroimaging Diagnostics through a Spectrum of Clinical Cases

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Abstract

Susceptibility Weighted Imaging (SWI) represents a relatively novel magnetic resonance imaging (MRI) technique that has shown great promise in enhancing the sensitivity to paramagnetic substances and microhaemorrhages. This case series explores the application of SWI in various clinical scenarios to delineate its diagnostic utility and potential impact on patient care. Case series- we report a series of 5 cases who underwent SWI as part of their MRI examination. Cases encompass a diverse range of clinical indications, including neuroimaging for vascular abnormalities, traumatic brain injury, and neurodegenerative disorders. SWI sequences were evaluated for their ability to provide high-resolution images, highlighting susceptibility effects associated with paramagnetic substances. Conclusion- Susceptibility Weighted Imaging emerges as a valuable adjunct to conventional MRI, offering enhanced sensitivity to paramagnetic substances and microhaemorrhages. This case series underscores the diagnostic utility of SWI in diverse clinical scenarios and provides compelling evidence for its integration into routine neuroimaging protocols.

Keywords: Susceptibility Weighted Imaging, MRI, microhaemorrhages, neuroimaging, vascular abnormalities, diagnostic utility

Introduction

A relatively new magnetic resonance imaging (MRI) modality is susceptibility weighted imaging (SWI). This three-dimensional, high-resolution gradient-echo magnetic resonance sequence was created by combining phase and magnitude pictures. In contrast to standard T1 and T2, the paramagnetic characteristics of blood products such deoxyhaemoglobin, intracellular methaemoglobin, and hemosiderin are utilized to create a novel contrast.The use of SWI aids in the detection of extravascular blood products, air, iron, and calcium, as well as intravascular venous deoxygenated blood. For a number of years, SWI has been utilized as an MR venographic technique (2-4).

- Recent applications include characterisation of arterial venous malformations(AVMs), multiple sclerosis, trauma, tumours and functional brain imaging.
- Halefoglu et al. have documented the significance of SWI in the following conditions: trauma, acute stroke-like episodes, low-flow vascular malformations, cerebral microbleeds, intracranial calcifications, neurodegenerative illnesses, and brain malignancies (2).
- Tong et al have demonstrated its role in paediatric neuroimaging including Neurocutaneous syndromes such as SWS(5).

Case presentation

Case 1- A 12 year oldboycame with history of recurrent seizures since childhood. MRI was taken

Findings-

FIGURE 1A,B,C. **-Multiple radially arranged dilated medullary veins seen converging trans parenchymally on left side and communicating with deep venous system. Contrast MRI showed**

enhancing serpiginous pial vessels filling the sulci. In view of leptomeningeal angiomatosis a diagnosis of Sturge Weber Syndrome was made

Advantages Of Swi

Gives precise anatomic information about these collateral veins, including tiny veins that are frequently relatively modest even on gadolinium-enhanced MR imaging and that are not visible on MR venography. In order to better characterize calcification, aberrant periventricular and trans medullary veins, cortical gyriform hypo intensities, and gray-white matter abnormalities, SWI is reported to be more effective than post-gadolinium-enhanced T1WI.

STURGE WEBER SYNDROME / Encephalotrigeminal angiomatosis

It is a triad of unilateral leptomeningeal venous angiomatosis, glaucoma and cutaneous port wine stain. According to Juhasz et al.'s investigation, SWI can identify deep trans medullary veins and cortical anomalies in young children (6). In children with SWS, transmedullary venous collaterals are persistent in the white matter next to damaged cortex and can be identified early by SWI. The deep venous system, which includes the basal veins and the great vein of Galen, drains the periventricular white matter, whereas the cerebral cortex and underlying white matter are drained by superficial veins. Anastomotic veins passing through the centrum semiovale connect these two systems. These medullary veins, which are frequently swollen in Sturge Weber Syndrome, are assumed to be emptying blood from the cortex into the deep (galenic) venous system due to inadequate superficial venous drainage.

Case2- A 45 year old male met with RTA and had poor GCS. CT showed no haemorrhage.

Findings

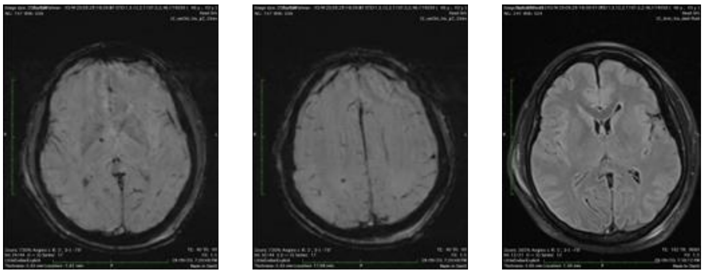

***FIG 2A,B,C*-SWI sequence shows focal areas of blooming in splenium of corpus callosum, right internal capsule and right frontal parasagittal white matter suggestive of microhaemorrhages**

In the setting of trauma, a diagnosis of DIFFUSE AXONAL INJURY WAS MADE. The conspicuity of these microbleeds in SWI is much more than conventional MR sequences. In individuals with severe traumatic brain injury (TBI), diffuse axonal damage (DAI) is a form of primary neuronal injury that is commonly followed by tissue rip hemorrhage..

Role Of Swi In Traumatic Brain Injury

To forecast the result, it's critical to identify diffuse axonal injury with precision. Prognostically significant microhaemorrhages in the brainstem are also identified by susceptibility-weighted imaging, which may not be picked up by traditional MRI(9). A major predictor of the long-term outcome in DAI patients is brain stem involvement (7). Epidural and subdural hematomas are also readily visible on SWI sequences, if masking artifacts are not brought on by air-bone contacts (7).

Case 3- A 5 year old presented with new onset seizure.

FINDINGS

ISSN:2093-4777 | E-ISSN:2093-6931
DOI: 10.5123/inj.2023.4.in171
Vol. 27 Iss. 4 (2023)

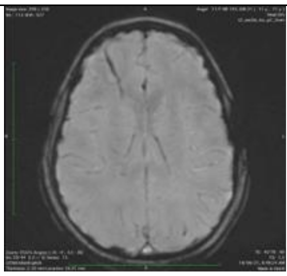

***FIG 3* – MRI showed a tangle of blood vessels with a single prominent cortical draining vein towards the frontal horn of right lateral ventricle with medusa head appearance - DEVELOPMENTAL VENOUS ANOMALY**

DEVELOPMENTAL VENOUS ANOMALY

The most prevalent kind of cerebral vascular malformations (≤ 60%) are frequently unintentionally found during standard MRI exams. A DVA is made up of radially oriented venous structures that converge at a centrally located venous trunk that drains the parenchyma of the normal brain. Because of the risk of venous infarction, neurosurgical intervention is generally contraindicated for these asymptomatic lesions that do not frequently bleed. They are, nevertheless, strongly linked to other vascular malformations, particularly cerebral cavernous malformations (8).Due to the low intensity of the dark veins on miniIP images, SWI contrast enhanced images more effectively than T1W images in displaying the collector (head of Medusa) and deep medullary veins (snake hair of Medusa).

OTHER CNS VASCULAR MALFORMATIONS

High flow, or true AVM, is picked up by traditional MRI.Low-flow vascular malformations: primarily composed of slow-flowing small vessels, cerebral cavernous hemangioma, developmental venous anomalies (DVAs), and capillary telangiectasias (CaTe) are undetectable on fast spin echo (FSE) MRI/MR angiography (1).The sensitivity of SWI is increased when magnitude and phase information is included, making it possible to identify low-flow vascular malformations that are invisible on GE sequences. A single layer of endothelium encircling abnormally enlarged capillary cavities without brain parenchyma intervening is known as a cerebral cavernous malformation, or CCM. Depending on whether there is calcification and bleeding within the lesions, the MRI results for CCMs can vary. They exhibit a heterogenous signal intensity that is "popcorn-like," with a central reticulated core encircled by a peripheral rim of hemosiderin.

Case 4- A 55 year old severe headache and dizziness.

FINDINGS:

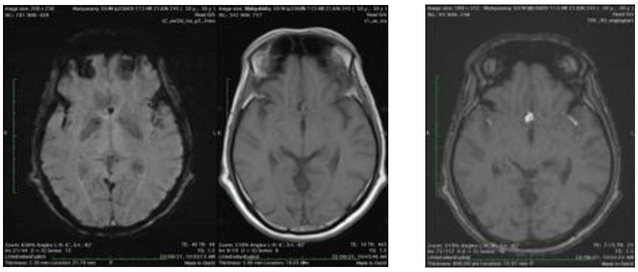

***FIG 4A,B,C*-T1W images are unremarkable without any evidence of subarachnoid haemorrhages. SWI shows hypointense subarachnoid haemorrhage in both sylvian fissures and cerebral sulci undetected in conventional MR sequences. There is also a globular hypo intensity in the interhemispheric fissure with MR angiogram confirming it to be an ACA-ACOM saccular aneurysm**

ADVANTAGES OF SWI:

Capability to identify subacute and chronic subarachnoid hemorrhages, which can occasionally be overlooked by CT and FLAIR, and to detect acute subarachnoid hemorrhages(10). When a person has an ischemic stroke, SWI can help distinguish between two types of strokes: hemorrhagic and bland. A. hemorrhages within the infarct region.B. Compared to CT and 2D GE T2* weighted sequences, SWI is more sensitive in detecting hemorrhage within the acute infarct regions.

Discussion-

ISSN:2093-4777 | E-ISSN:2093-6931
DOI: 10.5123/inj.2023.4.in171
Vol. 27 Iss. 4 (2023)

Haacke et al., Reichenbach et al., and Sehgal et al. have expanded on the fundamentals of SWI. In other words, it takes advantage of the local field heterogeneity that results from a homogeneous magnetic field disturbance (5).A variety of paramagnetic, ferromagnetic, and diamagnetic materials can result in these disruptions. Gradient echo images experience overall signal loss due to spins processing at different rates when they encounter field heterogeneity. Signal loss results from a phase difference between areas with deoxygenated blood and the surrounding tissues caused by the susceptibility difference between oxygenated and deoxygenated hemoglobin. A three-dimensional gradient echo sequence with high resolution is used by SWI to obtain both phase and magnitude images.

The smaller veins and other sources of susceptibility artifacts, such as calcium and iron, become more noticeable when the MR phase image is multiplied by the magnitude images. Minimal intensity projection is then used to illustrate these artifacts (2).To improve the phase differences between the surrounding tissues and susceptibility artifacts, a mask is made. Then, a minimal intensity projection is made to make it easier to distinguish between veins and focal lesions by multiplying the mask and magnitude images.

Material and methods

MRI was the imaging modality used. Routine T1W,T2W and FLAIR imaging was done. In addition to these conventional MR sequences SWI***(FIGURE 5)***was done. 1.5 T Siemens Magnetom Amira parameters used in our Institute

	SWI
Field strength	**1.5T**
Slice thickness	**1.3mm**
TR	**28ms**
TE	**20ms**
Flip angle (degrees)	**15 degrees**
Acquisition matrix	**256x256**
FOV	**230mm**

FIG 5

Review Of Literature-

VARIOUS CLINICAL APPLICATIONS OF SUSCEPTIBILITY WEIGHTED IMAGING

1) Cerebral amyloid angiopathy,Traumatic Brain injury, Stroke, Low flow AVMs, Microbleeds, Neurodegenerative disorder. (Halefoglue et al).
2) Traumatic and bleeding disorder related haemorrhage,CVT, Sturge Weber Syndrome, Infarcts, Hypoxic/anoxic injury, Brain death,Tumors.(Tong et al (Paediatric)).
3) Traumatic Brain Injury,Brain death, Vascular malformation, Neurocutaneous syndromes – Sturge Weber Syndrome,Haemorrhage, stroke, CVT, Hemiplegic migraine,Tumours, Infections, Neurometabolic diseases. (Verschuuren et al (Paediatric)).

Newer applications of SWI-

Recently, a sophisticated postprocessing technique called Quantitative Susceptibility Mapping (QSM) was developed. It measures the local tissue magnetic susceptibility from the major magnetic field distribution, which

DOI: 10.5123/inj.2023.4.in171
ISSN:2093-4777 | E-ISSN:2093-6931
Vol. 27 Iss. 4 (2023)

is reflected in the phase images of SWI, by numerically solving the inverse source-effect problem. In the context of numerous significant neurologic disorders, iron mapping can be extremely important. He et al. assessed 44 early Parkinson disease patients and found higher values when comparing the susceptibility values of the substantia nigra and red nucleus contralateral to the most affected limb to those of a healthy control group. By measuring the iron content and iron deposition pattern in the brain, QSM provides a much more accurate assessment of many neurodegenerative disorders.

Conclusion

With its many applications in neuroradiology practice, SWI is a unique imaging guide that should be incorporated into standard protocols.As suggested, it is commonly used to identify large-scale hemorrhages as well as microbleeds.It can also help in characterization of cerebral microvasculature and detection low-flow vascular malformations like developmental venous anomaly(DVA) and Cerebral cavernous malformations(CCM). It can also be used as a problem solving tool in the treatment of stroke patients by detecting haemorrhagic transformation.

Acknowledgment

The authors acknowledge the patient as a great source of learning.

Declaration of patient consen

The writers certify that they have secured the necessary patient permission.

Competing interests

The writers say they have no competing interests, either financial or non-financial.

Financial support and sponsorship

The authors state that sponsorship was secured for this study and that they do not receive any funding.

Reference-

1. Reichenbach JR, Venkatesan R, Schillinger DJ et al (1997) Small vessels in the human brain. MR venography with deoxyhemoglobin
2. as an intrinsic contrast agent. Radiology 204:272–277
3. Halefoglu, A. M., &Yousem, D. M. (2018). Susceptibility weighted imaging: Clinical applications and future directions. World journal
4. of radiology, 10(4), 30–45. https://doi.org/10.4329/wjr.v10.i4.30
5. 3. Reichenbach JR, Essig M, Haacke EM, Lee BC, Przetak C, Kaiser WA, Schad LR. High resolution venography of the brain using
6. magnetic resonance imaging. MAGMA 1998; 6: 62–69
7. 4. Baudendistel KT, Reichenbach JR, Metzner R, Schröder J, Schad LR. Comparison of functional venography and EPI-BOLD-fMRI at
8. 1.5T. MagnReson Imaging 1998; 16: 989–991.
9. 5. Sehgal V, Delproposto Z, Haacke EM, Tong KA, Wycliffe N, Kido DK, Xu Y, Neelavalli J, Haddar D, Reichenbach JR. Clinical applications of neuroimaging with susceptibility-weighted imaging. J MagnReson Imaging. 2005;22:439–450. [PubMed] [Google Scholar]
10. 6. Multimodality Imaging of Cortical and White Matter Abnormalities in Sturge-Weber Syndrome.
11. C. Juhász, E.M. Haacke, J. Hu, Y. Xuan, M. Makki, M.E. Behen, M. Maqbool, O. Muzik, D.C. Chugani, H.T. Chugani. American Journal of Neuroradiology May 2007, 28 (5) 900-906;
12. 7. He N, Ling H, Ding B, Huang J, Zhang Y, Zhang Z, Liu C, Chen K, Yan F. Region-specific disturbed iron distribution in early idiopathic Parkinson's disease measured by quantitative susceptibility mapping. Hum Brain Mapp. 2015;36:4407–4420. [PMC free
13. article] [PubMed] [Google Scholar].
14. 8. Susceptibility-Weighted Imaging of the Pediatric Brain Sylvia Verschuuren, Andrea Poretti, Sarah Buerki, Maarten H. Lequin, and Thierry A. G. M. Huisman American Journal of Roentgenology 2012 198:5, W440-W449
15. 9. Thomas, B., Somasundaram, S., Thamburaj, K. et al. Clinical applications of susceptibility weighted MR imaging of the brain – a pictorial review. Neuroradiology 50, 105–116 (2008). https://doi.org/10.1007/s00234-007-0316-z

16. 10.10. Thomas B, Somasundaram S, Thamburaj K, Kesavadas C, Gupta AK, Bodhey NK, Kapilamoorthy TR. Clinical applications of susceptibility weighted MR imaging of the brain - a pictorial review. Neuroradiology. 2008;50:105–116