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RESEARCH ARTICLE

Adding a Susceptibility-Weighted Angiogram Sequence In MRI Brain For Epilepsy- Does It Help?

Dr. Khawaja Bilal Waheed[1*], Dr. Ali Al Orf[2], Dr. Faisal Al Zahrani[3], Dr. Nawaf Nasser Al Jubair[4], Dr. Muhammad Zia Ulhassan[5], Zechariah Jebakumar Arulanatham[6]

[1,2,3,4,5] Radiology Department, King Fahad Military Medical Complex (KFMMC) Dhahran
[6]Vice Deanship of Post-graduate and Research (VDPR), Prince Sultan Military College of Health Science (PSMCHS) Dhahran, Kingdom of Saudi Arabia

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***Corresponding Author:**

Dr. Khawaja Bilal Waheed,
Consultant General Radiologist,
docbil@hotmail.com

ABSTRACT

To determine the usefulness of incorporating a 'Susceptibility Weighted Angiogram' (SWAN) sequence in magnetic resonance imaging (MRI) brain imaging for patients with epilepsy. A retrospective observational study was conducted in our radiology department in a Hospital in Dhahran from Jan. 2019 -2024. All patients who had brain MRIs for epilepsy work-up with added SWAN sequence were included. Patients with known brain tumors, post-injury, and post-operative were excluded. A venous angioma (or malformation) was documented when a tuft of parenchymal veins drained into a larger (transcortical or subependymal) collector vein, appeared as a low signal structure on SWAN image, and enhanced on contrast-enhanced sequence. Consensus reporting was made by two experienced neuroradiologists. The usefulness of the SWAN sequence in the detection of venous malformation was considered if the detected abnormality corresponded to an epileptiform focus on the electroencephalogram (EEG). This observation was compared with incidentally detected venous malformations that were seen in epileptic patients with normal EEGs (control group). Chi-square and Fisher's Exact test were used to determine an association. Out of 114 patients, 65 were females (57%) and 49 males (43%), with a mean age of 31.4 (range, 15-50 years). In 23 (20.53%) SWAN-detected venous angiomas, 8 corresponded to epileptiform foci on respective abnormal EEGs compared to none of the 3 incidentally detected venous angiomas in the control group with normal EEGs (P-value, 0.001). Adding a SWAN sequence in routine brain MRI for epilepsy patients can help to detect vascular malformations/ venous angiomas that may cause focal seizure activity in these patients detected by EEGs.

INTRODUCTION

Epilepsy can occur in both pediatric and adult age groups [1,2]. The condition can be due to abnormal or excessive neural activity in the brain, leading to periods of unusual behavior, sensations, and sometimes unconsciousness. Genetics, previous brain insults (hypoxic-ischemic, trauma), high fever, excessive fatigue, poisoning, alcohol, brain tumors, vascular malformations, certain brain conditions (stroke, Alzheimer's disease), infections, and developmental disorders are common causes. Once an epileptic seizure is seen or documented, clinical assessment, laboratory, neurophysiology (EEG), and neuroimaging (CT, MRI) are required to investigate the cause of such a problem [1-3]. MRI is preferred because it provides exquisite details of the brain parenchyma and is sensitive in identifying abnormalities [4,5].

Developmental venous anomalies (DVAs) can be associated with seizures and are a common cause of lesional epilepsy [6], e.g., cavernous angiomas can trigger epilepsy by irritating surrounding brain tissue probably because of repeated hemorrhages, while venous angiomas when complicated (associated with thrombosis leading to adjacent infarction) [7]. Susceptibility-weighted imaging (SWI) is a sequence that accentuates the paramagnetic properties of blood products [1,3]. Using

paramagnetic deoxyhemoglobin (deoxy-Hb) in the cerebral veins as an intrinsic contrast agent, SWI can demonstrate normal cerebral veins and cerebral venous abnormality without contrast administration [3,4]. Therefore, we aim to evaluate the significance of adding a SWAN (susceptibility-weighted angiogram) sequence in brain MRI for the detection of such lesions contributing to seizure activity in epileptic patients.

METHOD

This retrospective record-based cross-sectional study was performed in the radiology department at our hospital from Jan. 2019 to Jan. 2024. All patients (N=114) who underwent brain MRIs for epilepsy with added SWAN sequences were included. Already-known brain tumor patients, patients with traumatic brain injuries, and post-operative cases were excluded. The research protocol was approved by the Hospital Research and Ethics Committee. The study was conducted by the Helsinki Declaration. Clinical information was obtained from patients' medical records via the Hospital Information System (HIS), while MR imaging findings were reviewed through RIS/ PACS (Radiology Information System/ Picture Archiving and Communication System). All clinical and radiological data were kept strictly confidential.

All MRI brain studies were performed on a 1.5 T machine (GE Machine). Brain MRI imaging included T1W (T1-Weighted) axial and sagittal Fast Spin Echo (FSE) sequences, T2WI (T2-Weighted Imaging), FLAIR (Fluid Attenuation and Inversion Recovery), DWI (Diffusion Weighted Imaging)/ ADC (Apparent Diffusion Coefficient) and SWAN sequence [TE (time to echo), 50 ms; TR (time to repeat), minimum; flip angle, 15 degrees; matrix, 320 x 192; FOV (field of view), 24 cm; section thickness, 2 mm; bandwidth, 41.67 kHz, flow compensated; number of slices, 40; acquisition time, 4 minutes]. Contrast-enhanced T1W images were also acquired if needed.

The presence of a blooming artifact (i.e., susceptivity artifact caused by the presence of a paramagnetic substance, seen as an area focal hypointensity/ black area), when seen as a linear or curvilinear structure, was taken as a vascular structure containing blood within. Either contrast-enhanced (axial, sagittal, and coronal) T1W imaging or cerebral angiographies were performed where those structures were seen opacified with contrast. Two experienced neuroradiologists interpreted the brain MRIs, blinded to clinical information and final diagnoses, and consensus reporting was made. Any vascular malformation suspected on the SWAN sequence was confirmed in subsequent contrast-enhanced studies or cerebral angiography. Significance was considered if SWAN-detected venous malformation corresponded to an epileptiform focus on EEG. High-frequency discharges and focal sharp waves acquired on EEGs were considered epileptiform foci. Findings were compared with incidentally detected venous angiomas in normal brain MRIs (control group). In cases of detection of venous angioma in normal or asymptomatic consecutive patients (for whom MRI brain imaging was requested for non-specific causes other than seizures or epilepsy-like headaches) during the same study period by the SWAN imaging, EEGs were acquired to document any abnormal findings. The chi-square and Fisher's exact test were used to determine association.

RESULTS

Out of 114 patients, 65 were females (57%) and 49 males (43%), with a mean age of 31.4 (range, 15-50 years) [Table 1].

Table 1. Demographic, imaging, and electrophysiologic characteristics of study population

	Frequency	Percentage
Gender		
Male	49	43.0
Female	65	57.0
SWAN detected anomaly		
Not Present	80	70.2
Present	34	29.8
Epileptiform Focus		

Corresponded	8	7.0
Found other Abnormality	3	2.6
Not Correspond	3	2.6
Not Found	100	87.7
EEG		
Normal	49	43.0
Abnormal	65	57.0

Out of 23 (20.53%) SWAN-detected venous angiomas [Fig.1], 8 corresponded to epileptiform foci on respective abnormal EEGs compared to none of the 3 incidentally detected venous angiomas in the control group with normal EEGs (P-value, 0.0005) [Table 2].

Table 2. SWAN-detected and electrophysiologic findings in the study population

		EEG			P – Value
		Normal	**Abnormal**	**Total**	
SWAN detected anomaly	Not Present	46 (93.9)	34 (52.3)	80	0.0000008 (Using Fisher's Exact Test)
	Present	3 (6.1)	31 (47.7)	34	
EPILEPTIFORM FOCUS	Corresponded	0	8 (12.3)	8	0.001 (Using Fisher's Exact Test)
	Found other abnormality	0	3 (4.6)	3	
	Did not Correspond	3 (6.1)	0	3	
	Not Found	46 (93.9)	54 (83.1)	100	
Total		49	65	114	

Most of these venous anomalies (6/8) had adjacent subtle white matter high signal signifying a possible sequel of complication within the venous angioma (infarct-related to like thrombosis). Five of these with abnormal EEGs were seen in the right parietal, 2 in the right frontal, and one in the left frontal region.

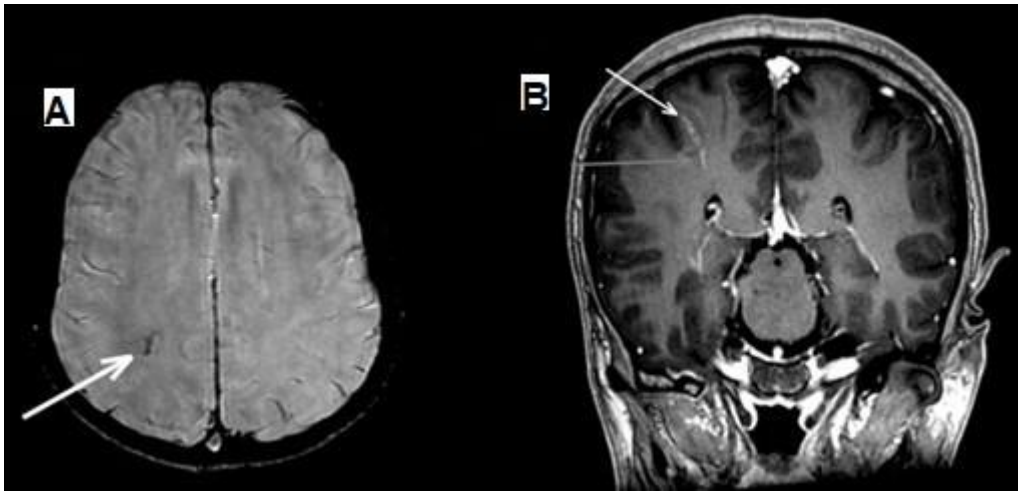

Fig. 1. Selected MR brain images of a patient showing (A) axial SWAN image and (B) contrast-enhanced axial T1W image. The vascular malformation (in this case a venous angioma) is seen as a linear structure reaching the subcortical parietal lobe.

DISCUSSION

Susceptibility-weighted angiogram (SWAN), also called imaging susceptibility-weighted imaging (SWI), is a blood-oxygen-level dependent (BOLD) venographic imaging (T2* weighted angiography)

that is very sensitive to slow flow venous blood vessel, hemorrhage/ blood products or microbleed, and iron/ met-hemoglobin [8-10]. It is a gradient-echo sequence that uses tissue magnetic susceptibility differences to generate a unique contrast [8]. Short TE provides a time-of-flight effect allowing high-resolution visualization of cerebral vessels [8,9]. No prior studies are available to document the detection of venous angiomas as a cause of epileptiform focus.

Developmental venous anomalies/ DVAs (also known as venous angiomas) are usually incidental findings [10]. However, patients can present with intracranial hemorrhage/bleeding (1-5%). An association has also been described with ischemic stroke and epilepsy. A venous angioma is an intertwined vascular formation that undergoes expansion, provoking the appearance and progression of the inflammatory process in the tissue structures of the brain [11]. Magnetic resonance imaging shows a tangle of blood vessels (may look like the spokes of a wheel) with a prominent cortical draining vein (giving a caput medusae sign) [8]. Although digital subtraction angiography remains the gold standard in evaluation of arteriovenous malformations, however, SWI/ SWAN imaging offers improved sensitivity in detecting low-flow vascular malformations that were invisible on routine gradient-recalled echo (GRE) sequences. Also, SWI/ SWAN imaging has been found to be helpful in differentiating nidus from hemorrhage and calcifications [12]. Developmental venous anomalies when isolated require no treatment, and complication rate is extremely low (about 0.15% per annum) mainly from spontaneous thrombosis of collecting vein, leading to venous infarction and hemorrhage [6]. If part of a mixed vascular malformation (i.e., associated with a cavernoma), then treatment is predicated on the other component.

More recently, SWI/ SWAN imaging has been used in patients with trauma, stroke, vascular malformations, (hemorrhagic) brain metastases, multiple sclerosis, certain developmental disorders, dementias and in functional MRIs [13-20]. In multiple sclerosis, it is observed that white matter lesions tend to develop around small veins (giving a so-called central vein sign) [14]. Also, in cases of polymicrogyria (a developmental cortical abnormality), abnormalities of cortical veins have been demonstrated by this imaging [19]. We strongly feel that SWI/ SWAN imaging needs to be incorporated as a regular sequence in routine brain MRI for the epilepsy work-up to detect small venous malformations that can sometimes be a cause of focal seizures particularly when an epileptic focus is suspected on electroencephalogram (EEG).

Limitations to our study include a retrospective small sample size and a single-center study. Not every patient who was found to have venous angioma in the brain underwent routine angiography possibly because of the smaller size and relatively less severity of symptoms. Larger prospective studies are needed to incorporate subgroups of epilepsy in both pediatric and adult age groups presenting with seizures while evaluating the role of SWI/ SWAN imaging in the detection of such vascular malformations and simultaneously correlating these findings with the clinical and EEG patterns.

CONCLUSION

Adding a gradient SWAN sequence in routine brain MRI for epilepsy patients can help to detect vascular malformation venous angiomas that may cause focal seizure activity in these patients particularly if gets complicated.

AUTHORS' CONTRIBUTION

KBW conceived the idea, and design, and contributed to the manuscript writing

AO made critical appraisal and provided managerial support

FZ made critical appraisal and participated in data analysis

NJ performed critical appraisal and data analysis

MZH helped in the drafting of the article and did the literature review

ZJK did statistical analysis

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