Comparison Of Susceptibility Weighted Imaging In Closed Head Injury To Conventional MRI

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ABSTRACT:

Introduction: Head injuries are fast becoming a major cause of morbidity and mortality worldwide. Susceptibility Weighted Imaging (SWI) is a new T2 weighted Gradient Echo technique is more sensitive than CT scan and conventional T1W and T2W weighted images of MRI. *Aims and objectives:* To compare the role of conventional MR imaging with SWI in detection and characterisation of diffuse axonal injuries (DAI) in closed head trauma. *Material and methods:* 20 patients of acute closed head injury with suspected DAI referred to the Department of Radiodiagnosis were taken up for MR imaging. Conventional MRI techniques was compared with SWI using students paired T test. *Results:* Majority of the patients were young males in the age group of 21 to 40 years. SWI was the most sensitive MR sequence for detection of shear lesions followed by DWI, FLAIR, T2W and T1W. Paired test applied showed p value < 0.05, which was statistically significant. *Conclusion:* SWI sequence was the most sensitive MR sequence for detection of shear lesions. SWI is an emerging MR imaging tool which is assuming an increasing important role in imaging patients with DAI.

Keywords: Susceptibility Weighted Imaging, diffuse axonal injury, conventional MR imaging

INTRODUCTION:

While modern life has ushered in a new era of automation and industrialisation, it has also made mankind more vulnerable to vehicular accidents. Cranio-cerebral trauma or acute head injury can be considered a byproduct of our fast-paced life style. Head injuries are fast becoming a major cause of morbidity and mortality worldwide[1, 2].

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In India, an estimated 1.5 to 2 million persons have traumatic brain injuries per year and 1 million persons succumb to death. Road traffic accidents are leading cause of traumatic brain injury (60%), followed by falls (20-25%) and violence (10%). Alcohol involvement is present in 15-20% of traumatic head injuries[3]. Since these patients almost invariably belong to productive age group (between 20-50 years) the socioeconomic dimension of such injuries cannot be discounted. Traumatic brain injury is therefore a social and health problem of great magnitude.

Diffuse brain injuries form an important subset and constitute approximately 40% of total severe head injuries and are most prevalent cause of persisting neurodisability in survivors.

Initial radiological workup of such patients is usually a CT scan. However, it has been less beneficial in recognition of non-hemorrhagic lesions such as diffuse axonal injuries[4]. Subsequently it was found that conventional T1W and T2W weighted images of MRI are more sensitive than CT in the detection of non-hemorrhagic lesions. However, it was not sensitive in detecting microbleeds[4].

Susceptibility Weighted Imaging (SWI) is a new T2 weighted Gradient Echo technique that takes advantage of the magnetic susceptibility effects generated due to local in homogeneities in the magnetic field[5]. To date, SWI is not a scanner derived image and remains to be a post processed reconstruction technique. SWI helps image veins of resolution upto less than a millimeter[6].

AIMS AND OBJECTIVES:

To compare the role of conventional MR imaging with SWI in detection and characterisation of diffuse axonal injuries (DAI) in closed head trauma.

MATERIAL AND METHODS:

In this prospective study, 20 patients of acute closed head injury with suspected DAI referred to the Department of Radiodiagnosis, Hassan Institute of Medical Sciences were taken up for MR imaging.

Inclusion criteria for patients:

1. Patients should have clear history of acute closed head injury (skull and dura is intact)
2. Preliminary CT scan is negative for any traumatic injury.
3. Mechanism of trauma is consistent with DAI of brain i.e. acceleration/deceleration rotational strain.

Exclusion criteria

1. Patients should not have any history of intervention of neurosurgical nature prior to imaging.
2. Patient should not have prior neurological disease.
3. Patients with polytrauma, medically unstable patients or brain dead patients.
4. Patients in whom MR imaging is hazardous e.g. presence of aneurysm clips, pacemaker, metallic implants.

Methodology:

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20 such patients were selected & underwent MR imaging in the Department of Radio diagnosis, HIMS, Hassan.

MRI Acquisition: The imaging was done at 1.5 Tesla MR unit (Philips) in the Department of Radiodiagnosis, HIMS.

Image analysis: MR images was reviewed. Shear lesion (DAI) was assumed to be present if hypointense foci are recognized on SWI sequence. Hypointensity due to calcification were excluded by comparing the images with CT scans obtained at the corresponding level. Bilateral symmetric hypointensity of the basal ganglia and dentate nucleus due to physiological deposition of calcium or iron were excluded. Hypointensity due to intracranial veins were excluded by careful assessment of the continuity of the structures.

STATISTICAL ANALYSIS

Measurable data was tested for its normality using kolmogorov-smirnov test. Normally distributed data expressed as mean and SD. Skewed data expressed as median and inter quarentile range. The classified/categorical data expressed as percentages. Conventional MRI techniques was compared with SWI using students paired T test. The degree of association between measurable variables were calculated using Pearson's coefficient of correlation. P value of less than 0.05 was considered as significant in all statistical tests.

RESULTS:

In our study group of 20 patients with closed head injuries, an overwhelming majority of the patients 75 % (n=15) were male while 25 % (n=5) were females.

The age of the patients ranged between 18 years to 60 years with a mean age of 39 years. Maximum number of patients 40 % (n=8) were in the age group of 21-30 years followed by 30% (n =6) in the age group of 11-20

Together the patients in these two groups constituted approximately 70% of the total number of patients. Our study thus showed a distinct vulnerability of young adult males towards this type of injury.

The age and sex distribution of our study group is summarized in table 1 and fig 1, given below.

Table 1: Age and sex distribution

AGE (years)	MALE	FEMALE	TOTAL
0-10	0	0	0
11-20	4	2	6
21-30	6	2	8
31-40	2	1	3
41-50	2	0	2
>50	1	0	1
TOTAL	**15**	**5**	**20**

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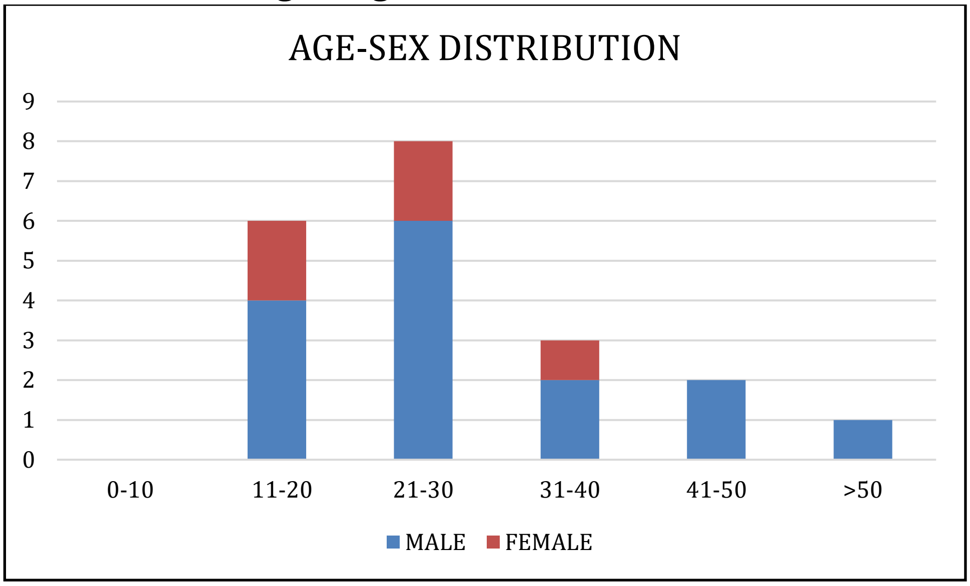
Fig 1: Age and sex distribution



It was found that most of the shear lesions distributed in the region predisposed to diffuse axonal injury. Corticomedullary junction constituted the most common site (37%). (Table 2)

Table 2: Distribution of shear lesions in anatomical location

ANATOMICAL LOCATION	NO. OF SHEAR LESIONS	PERCENTAGE
Corticomedullary junction	35	37%
Central white matter	15	16%
Corpus callosum	12	12%
Brain stem	13	14%
Cerebellum	8	8%
Other locations	12	13%

Fig 2: Distribution of shear lesions in anatomical location

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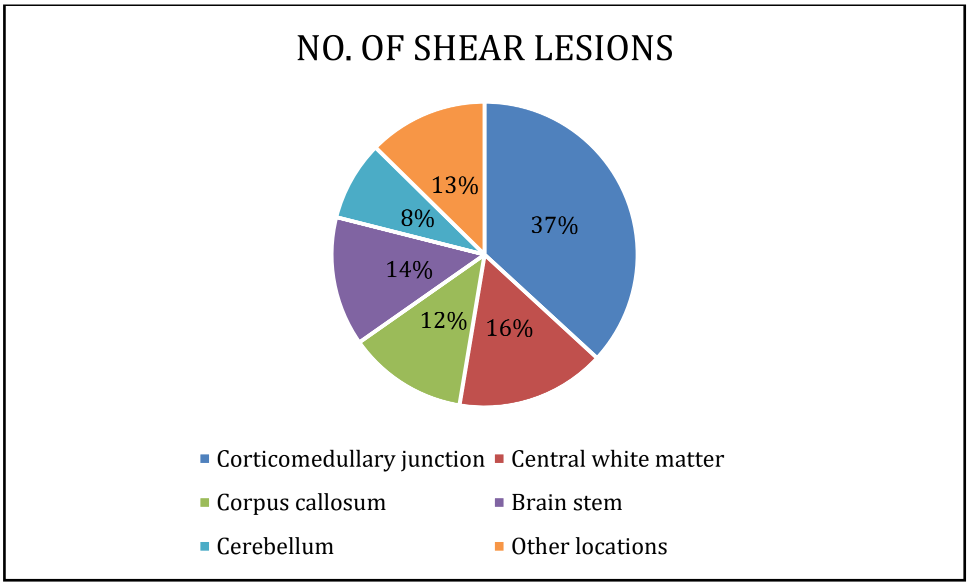

T1W identified lesions in 65% of the patients. Maximum number of lesions identified on T1W was 5 in a single patient with a mean of 1.8. T1W failed to show lesions in 35% of the patients.
T2W identified lesions in 75% of the patients. Maximum number of lesions identified on T2W was 5 in a single patient with a mean of 2.4. T2W failed to show lesions in 25% of the patients.
FLAIR identified lesions in 75% of the patients. Maximum number of lesions identified on FLAIR was 5 in a single patient with a mean of 2.45. FLAIR failed to show lesions in 25% of the patients. However, it was observed that lesions in periventricular region were better identified by FLAIR.
DWI identified lesions in 75% of the patients. Maximum number of lesions identified on DWI was 7 in a single patient with a mean of 2.85. DWI failed to show lesions in 15% of the patients.
SWI identified lesions in 85% of the patients. Maximum number of lesions identified on SWI was 10 in a single patient with a mean of 4.45. SWI failed to show lesions in 15% of the patients. (Fig 3,4,5)
As the distribution of the lesions showed normal distribution, paired T test was applied.
The mean for total number of lesions in SWI for all patients was calculated, which measured 4-5 (4.45). In similar fashion, mean number of lesions for 20 patients identified on T1W was calculated which measured 1.80. Mean difference between these two entities measured 2.650 with 95% confidence interval of 1.491 and 3.809 with p value measuring less than 0.05. Thus, insisting that, there is a significant difference between the ability to identify the number of lesions between these two sequences.
In the similar fashion pairing of SWI was done with T2W, FLAIR and DWI, which also showed similar results, thus insisting that SWI has statistically significant difference with other sequences in its ability to identify the total number of lesions as shown in table no. 3

Table 3: Paired samples statistics

		Mean	N	correlation	P value
Pair 1	SWI	4.40	20	.564	.010
	T1	1.80	20		

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Pair 2	SWI	4.45	20	.783	.000
	T2	2.40	20		
Pair 3	SWI	4.45	20	.829	.000
	FLAIR	2.45	20		
Pair 4	SWI	4.45	20	.768	.000
	DWI	2.85	20		

SWI sequence shows more number of lesions per patient as compared to T1W, T2W, FLAIR and DWI sequences. (Table no. 4)

Table 4: Paired sample statistics

		Mean	Df	95% Confidence Interval of the Difference		P value
				Lower	Upper	
Pair 1	SWI-T1	2.650	19	1.491	3.809	.000
Pair 2	SWI-T2	2.050	19	1.146	2.954	.000
Pair 3	SWI-Flair	2.000	19	1.168	2.832	.000
Pair 4	SWI-DWI	1.600	19	.697	2.503	.001

DISCUSSION:

Traumatic brain injury is one of the leading causes of death worldwide[7] as well as India[3]. DAI is considered one of the most common types of injury in patients with severe closed head injury[8]. DAI is thought to be present in more than 85% of all severe head injuries resulting from motor vehicle accidents[9].

Complete radiological workup of patients with traumatic brain injury is mandatory in guiding correct treatment to prevent or limit secondary injury[2]. Identification and characterisation of trauma induced injury has been the focus of many imaging studies.

CT scan is a baseline imaging option for head trauma. It has contributed significantly in management of these patients with improved survival and reduces morbidity of close trauma patients primarily through early recognition and treatment of extra cerebral hemorrhage[4]. It is however less beneficial in detection of DAI because of less sensitivity for non hemorrhagic traumatic lesions and difficulty in obtaining multiplanar images[10].

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MRI has clear advantages over CT in evaluating closed head trauma patients hemorrhagic as well as non hemorrhagic lesions. The superior soft tissue contrast and multiplanar capability gives MRI a distinct edge over CT in lesion detection as well as localisation and characterisation. In a study by Gentry et al[11], the sensitivity of T1W and T2W MR sequences for non hemorrhagic lesions were found to be significantly higher (67.6% and 93% respectively) as compared to CT (sensitivity of 17.7%). Numerous other studies have also found similar results[8, 12].

T2W images are very sensitive for lesion detection (both hemorrhagic as well non-hemorrhagic). T1W sequence is highly sensitive for hemorrhagic lesions (especially if imaged >3 days after injury). T1W images are however less sensitive for non-hemorrhagic lesions. Brainstem lesions are though better picked up on TIW scans as compared to T2W because of obscuration by phase shift artifacts from vascular/CSF pulsation.

In our study lesions identified by T2W sequence (n=43) were also more than those identified on T1W sequence (n=30).

Inversion recovery sequence like FLAIR (fluid attenuated inversion recovery) involve the use of long TE spin echo acquisition for heavy T2 weighting with reduction of very high signal from CSF. This sequence is therefore particularly useful in identifying lesions abutting the CSF spaces. In our study only coronal FLAIR images were available and they identified 49 shear lesions and had a high sensitivity next to that of DWI of the non SWI sequences studied.

DWI provides image contrast based on differences in diffusion of water molecules within the brain. Diffusion represents random thermal movement of water molecules known as Brownian motion. Multiple disease processes including traumatic brain injury are characterized by changes in the rate and 3D shape of diffusion vector. Diagnostic value of DWI lies in its high sensitivity in detecting early cytotoxic oedema which is the important contributor in traumatic brain injury. Although DWI has already achieved a prominent role in the diagnosis of acute brain infarction[13]. It is also assuming increasingly important role in evaluation of closed head trauma. In our study all patients underwent MRI imaging within 72 hours of trauma. DWI identified 62 lesions which are highest second only to SWI. In our study SWI identified most number of brain shear injuries. Only one previous study (Tong et al[10]) is available in which role of SWI has been studied comprehensively in closed head trauma and we have compared our data with this study.

In our study, we included 20 patients which is more than the patients included by Tong et al which included only 7 patients and hence our study is a larger study and statistically significant[9].

We included patients of wide range of age from 18 years to 60 years. Whereas Tong et al[9]. included only children with mean age of 14 years. Thus, our study also identified the age group and sex which is more vulnerable to road traffic accident.

Tong et al.[10], calculated number of lesions both manually and with computer software. But we did it only manually. However, even the manual calculation in tong et al yielded valid results, thus justifying our manual calculation.

We observed that one of our patients, showed a greater number of lesions in DWI, which was hyper intense on DWI and hypo intense on ADC suggesting its non-haemorrhagic nature. Few lesions in DWI did not correlate with anatomical locations of the lesions identified on SWI which also shows

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similar signal (Hyper intense on DWI and hypo intense on ADC) suggestive of presence of haemorrhagic and non-haemorrhagic lesions together in the same patient. So, we establish the need of both SWI and DWI sequences in head injury patients.

All the 95 shear lesions identified in our study were evaluated for their location and were assigned to five neuroanatomical locations. The most common anatomical location of shear injuries in our study was Corticomedullary junction (37%), followed by cerebral white matter (16%), corpus callosum (12%) and brain stem (14%). Corresponding figures in the study by Heisman et al., are 43%, 24%, 8% and 7% respectively which are in close agreement with our study. Among the lesions showing Corticomedullary distribution, involvement of the frontal lobe (37%) was most common followed by temporal (26%) and parietal lobes (13%). This was similar to the figures stated in radiological literature[14].

CONCLUSION:

In the present study the SWI sequence was the most sensitive MR sequence for detection of shear lesions. To conclude the conventional MRI plays an important role in imaging closed head trauma patients by detection and delineation of shear lesions. SWI sequence is an important adjuvant to conventional MR for detecting hemorrhagic lesions. SWI is an emerging MR imaging tool which is assuming an increasing important role in imaging patients with DAI. The short acquisition time of this sequence makes it highly suitable for evaluating such patients. Furthermore, increased lesion conspicuity allows detection of additional shear lesions missed on conventional MRI.

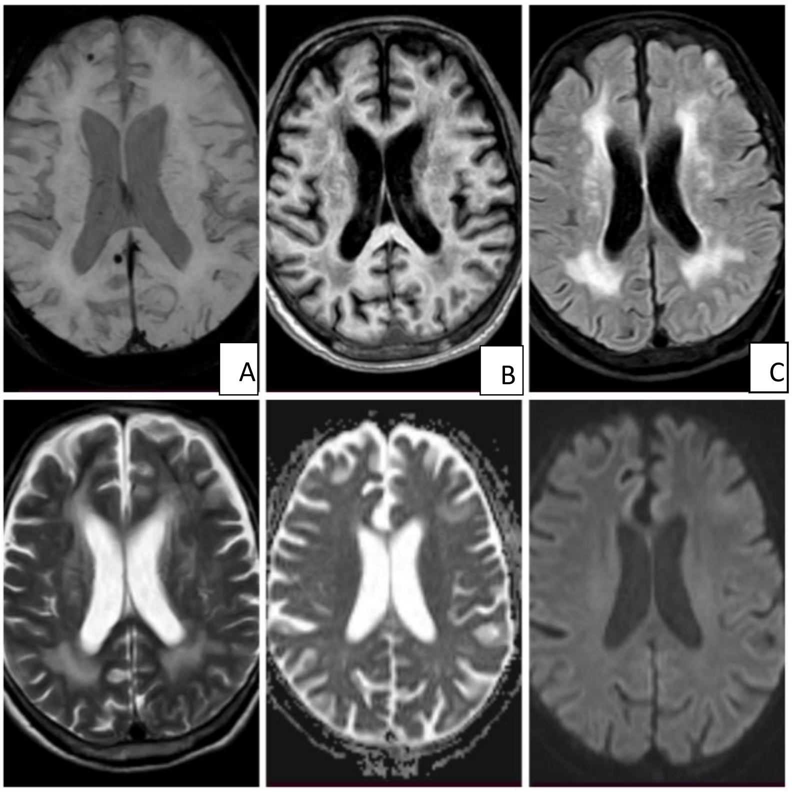

Fig 3: Small focal hemorrhagic lesion in 50-year-old male patient in right frontal and parietal lobe exclusively identified on SWI (A). Lesion not apparent on T1 (B), T2 (D), FLAIR (C), DWI (E/F)

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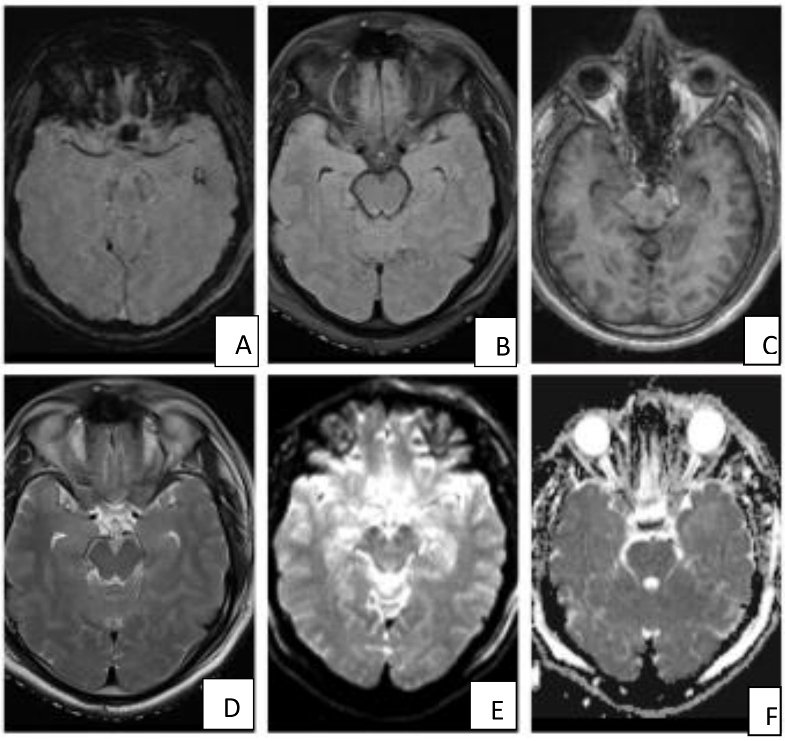

Fig 4: SWI image (A) showing few small focal hemorrhagic lesions in left temporal lobe of a 33-year-old male patient. Subtle hyperintensities in FLAIR image (B). Lesion not apparent on T1 (C), T2 (D), DWI (E/F)

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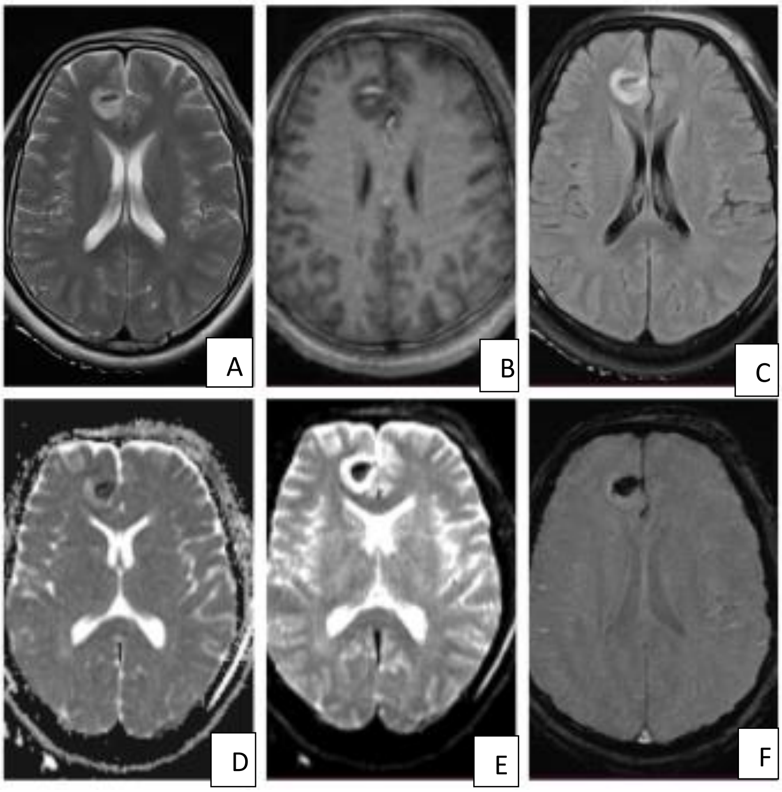

Fig 5: T2 heterogenously hyperintense lesion (A) with punctate hyperintensities suggestive of hemorrhage and surrounding edema in right frontal lobe. Heterogenously hyperintense on T1 (B) and FLAIR (C) with no restricted diffusion (D/E). SWI (F) confirms the diagnosis of hemorrhagic DAI

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