eEdE-72

SWI- PHASE IMAGES: PRACTICAL APPLICATIONS AND PITFALLS

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Disclosures

The authors have no disclosures.

PHYSICAL PRINCIPLES

- Distinguishing between calcification & blood products is not possible on post processed SWI images; both demonstrate signal drop out & blooming.
- FILTERED PHASE images are able to distinguish between them as diamagnetic & paramagnetic compounds affect phase differently, appearing of opposite signal intensity.
- Paramagnetic compounds include deoxyhemoglobin, ferritin & hemosiderin.
- Diamagnetic compounds include bone minerals & dystrophic calcifications.

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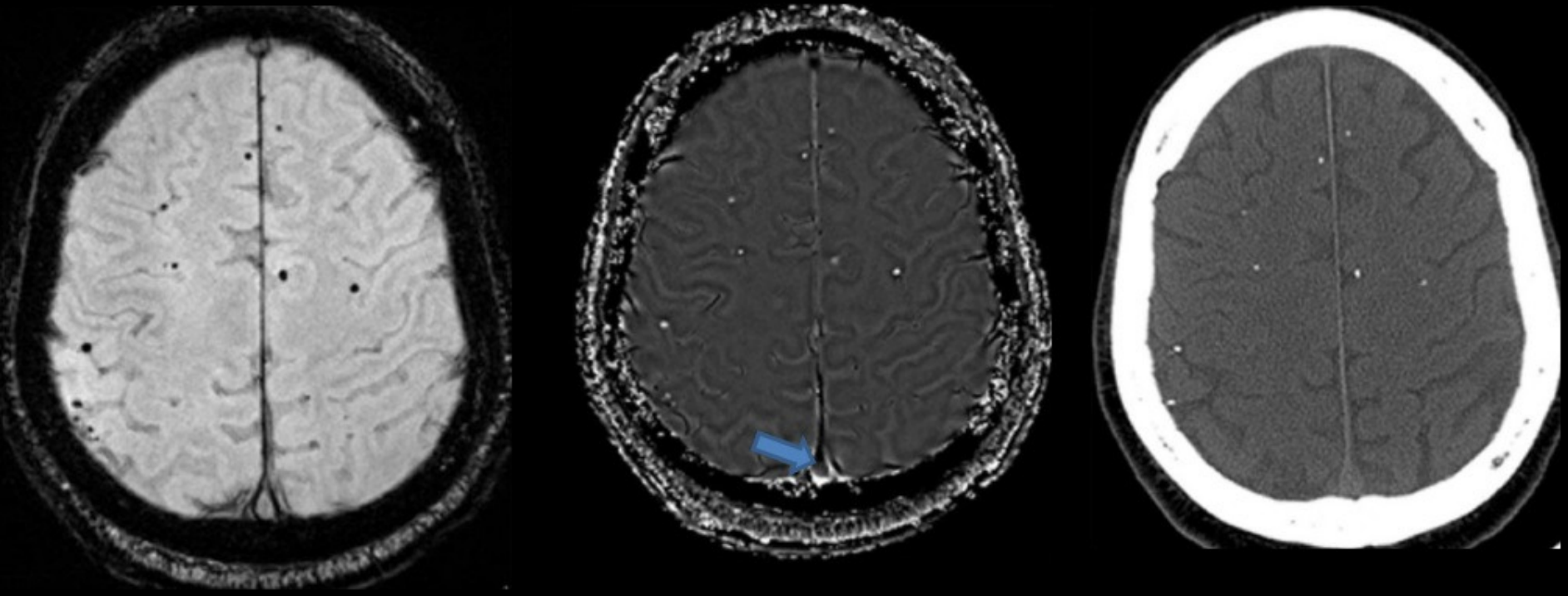

Magnitude Phase CT

Note that calcifications on the phase (center) image have different signal than blood in the sagittal sinus (arrow).

Mittal. S et al. Susceptibility-Weighted Imaging: Technical Aspects and Clinical Applications. AJNR 2009

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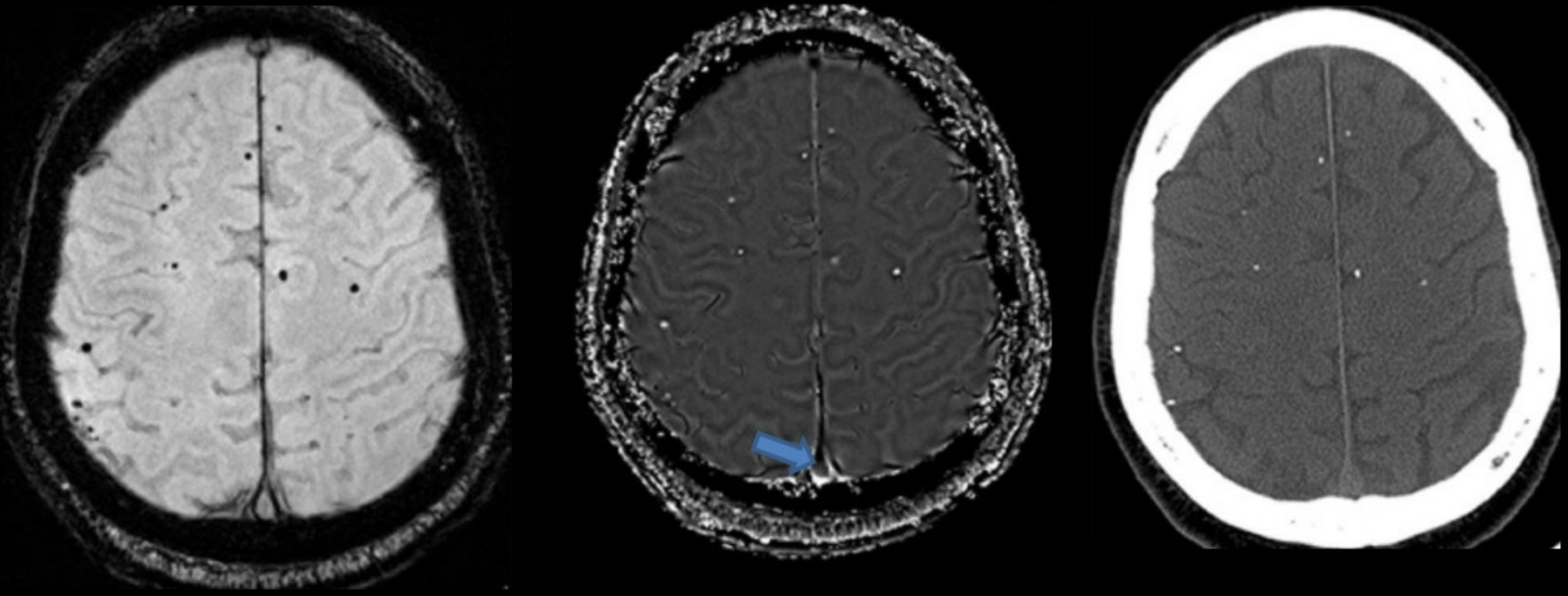

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CLINICAL APPLICATIONS

DIFFERENTIATION BETWEEN MICROBLEED FROM MICROCALCIFICATIONS

- Both calcifications & iron accumulation in chronic hemorrhage are hypointense on T2-WI & show "blooming" in SWI. It is not possible to differentiate between them on conventional MR sequences & CT is usually required.
- SWI - phase represents an average magnetic field of protons in a voxel, which depends on the susceptibility of tissues.
- Calcium is diamagnetic in nature and the phase shift induced by it is opposite to that found with paramagnetic substances like deoxy-Hb, methemoglobin (Met-Hb), hemosiderin & ferritin.

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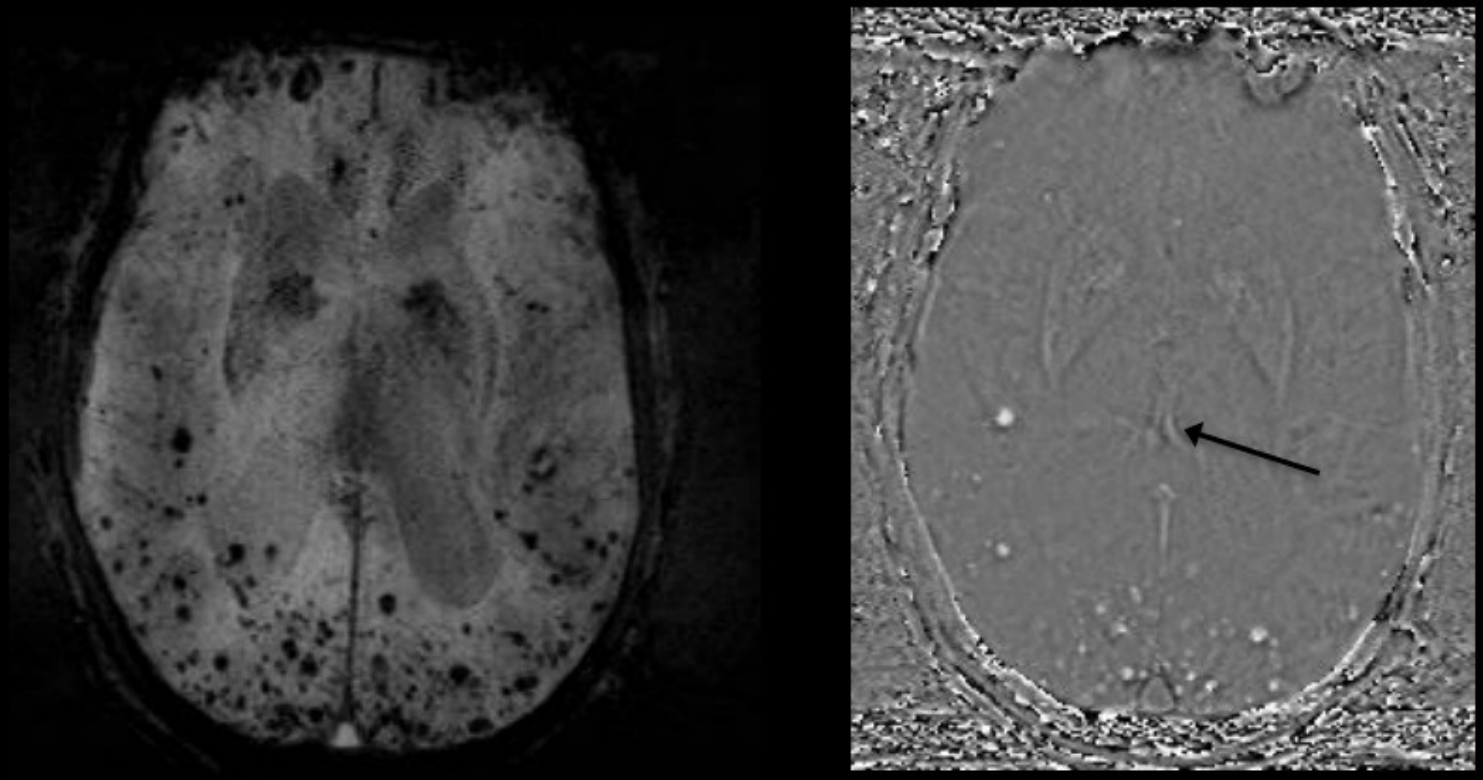
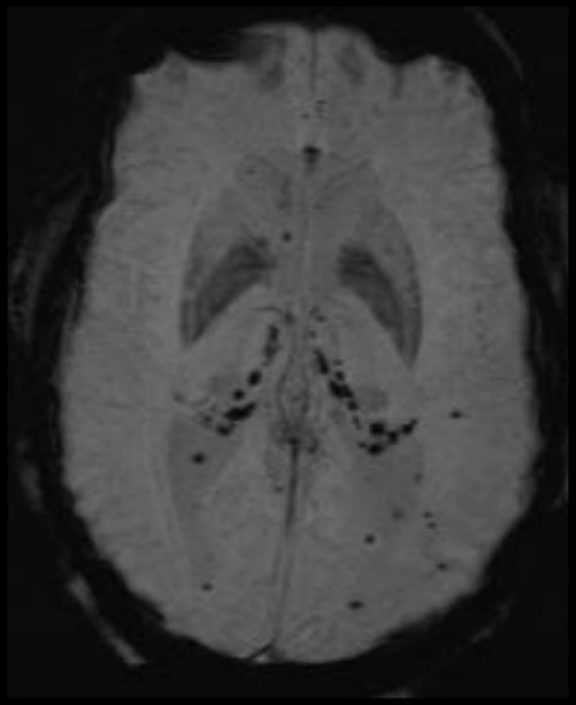
DIFFERENTIATION BETWEEN MICROBLEEDS AND MICROCALCIFICATIONS - **AMYLOID ANGIOPATHY**



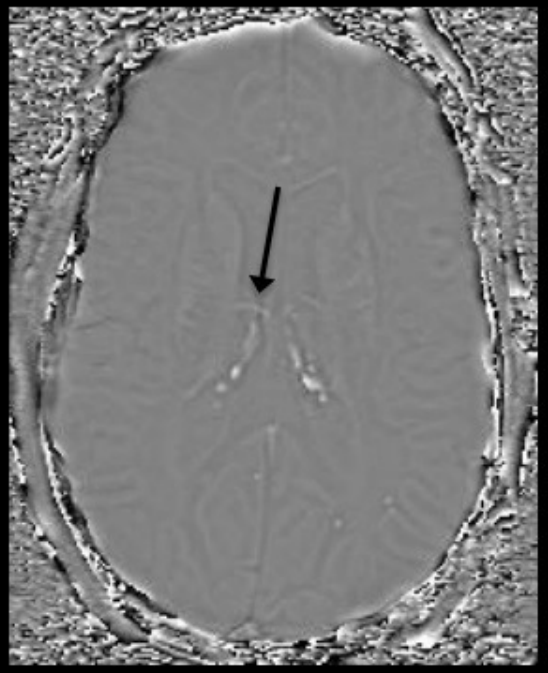
A B.

SWI (A) shows subcortical black spots in parietal/occipital regions. One cannot be sure if they correspond to microhemorrhages or calcifications. In SWI-Phase (B) the spots have similar signal to that of the deep venous structures (black arrow) indicating that they correspond to blood.

DIFFERENTIATION BETWEEN MICROBLEEDS AND MICROCALCIFICATIONS - **POST-RADIOTERAPHY**



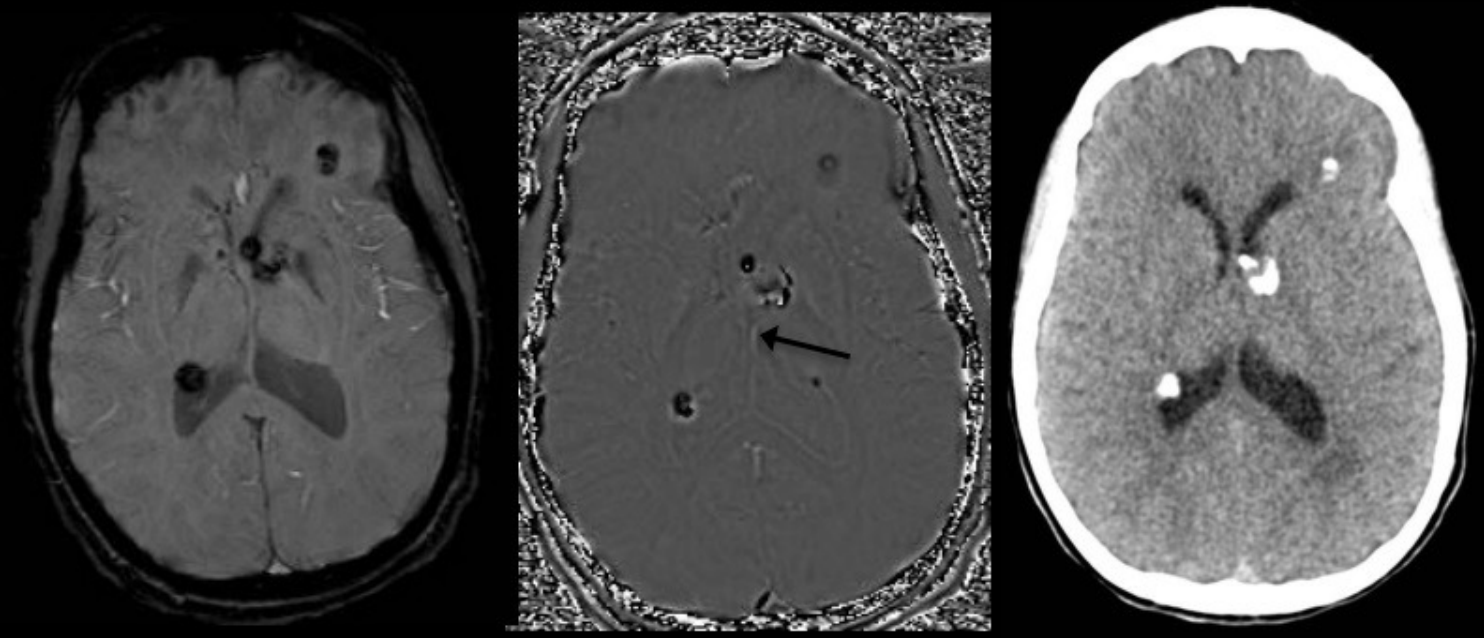
A



B

High grade glioma after radiotherapy.
SWI (A) cannot differentiate if the signal loss in the ventricular system & occipital lobes are due to choroid plexus microcalcifications or microhemorrhages. SWI-Phase (B) shows bright spots similar in signal to blood in the deep venous system (arrow) suggesting microhemorrhages instead of calcifications.

TUBEROUS SCLEROSIS

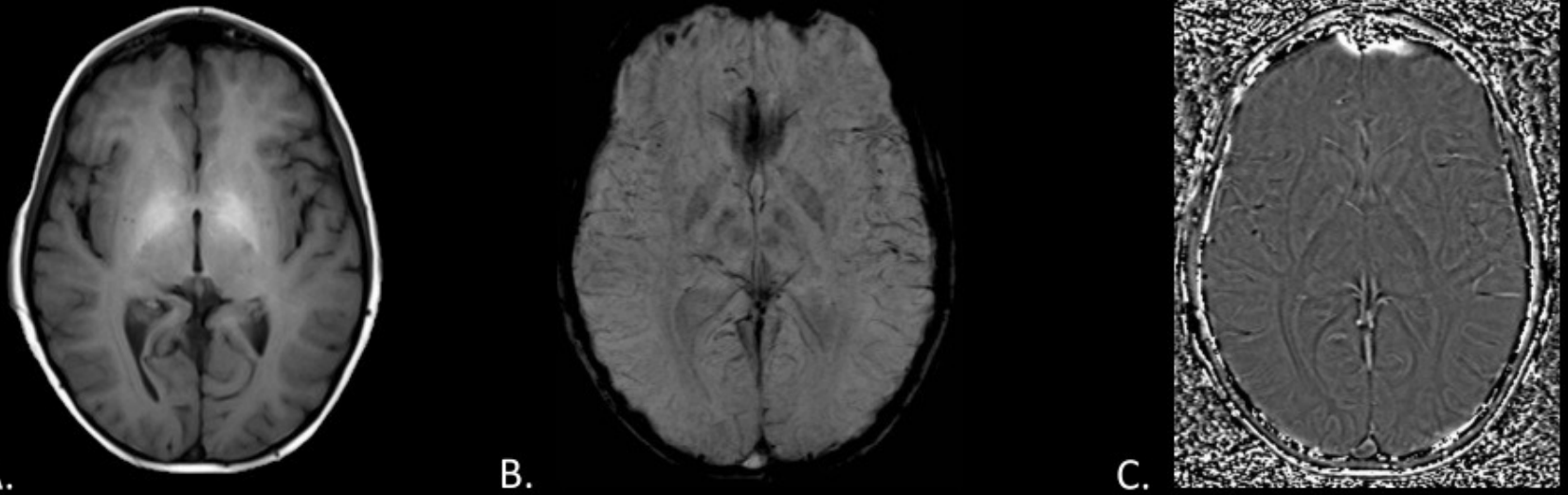


A B C

Patient with tuberous sclerosis.
SWI (A) shows multiple black lesions in the brain & subependymal regions. Phase - SWI (B) shows dark lesions (opposite signal compared to deep veins, arrow), suggesting calcifications. NECT (C) confirms calcifications which are common in patients with this disease.

MANGANESE ACCUMULATION

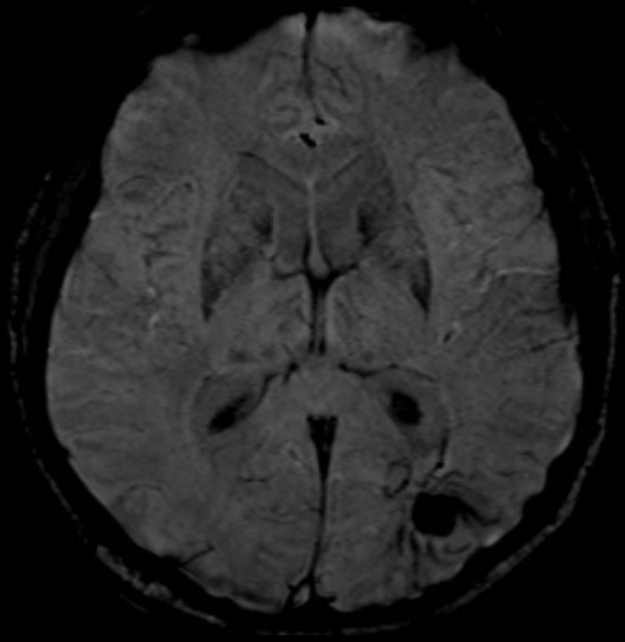
- Manganese is paramagnetic & shortens T1 relaxation time sufficiently to produce pallidal T1 hyperintensity in liver disease. Usually SWI fails to show blooming. Magnetic susceptibility of paramagnetic manganese is much higher than the diamagnetic calcium.
- Association of manganese deposition & T1 hyperintensity is well known but causation is not well established.



Patient with portosystemic shunt.
Axial non-enhenced T1WI (A) demonstrates high signal in the globus pallidi, compatible with manganese accumulation which is also seen on SWI (B). SWI-Phase image (C) shows a bright signal in the globus pallidi.

Neurology India; 57(6):812-13, 2009.

VASCULAR MALFORMATIONS



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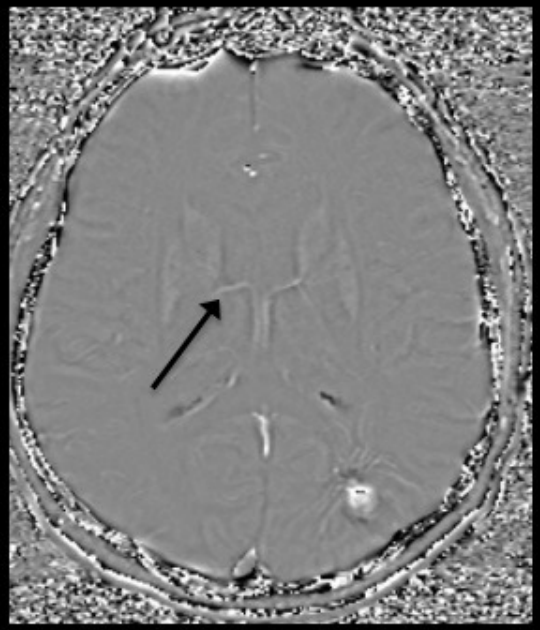

B.

Cavernous malformation.
SWI (A) shows a hypointense left parietal subcortical mass. SWI-Phase (B) shows that this lesion has the same signal as the deep venous system (arrow) corresponding to blood products.

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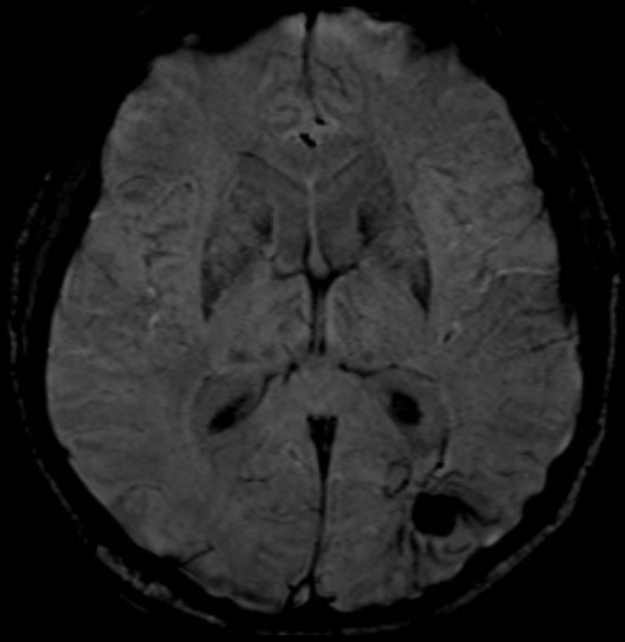

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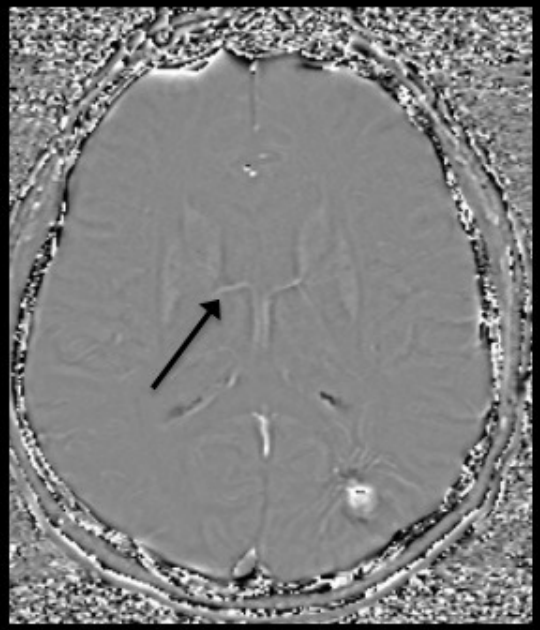

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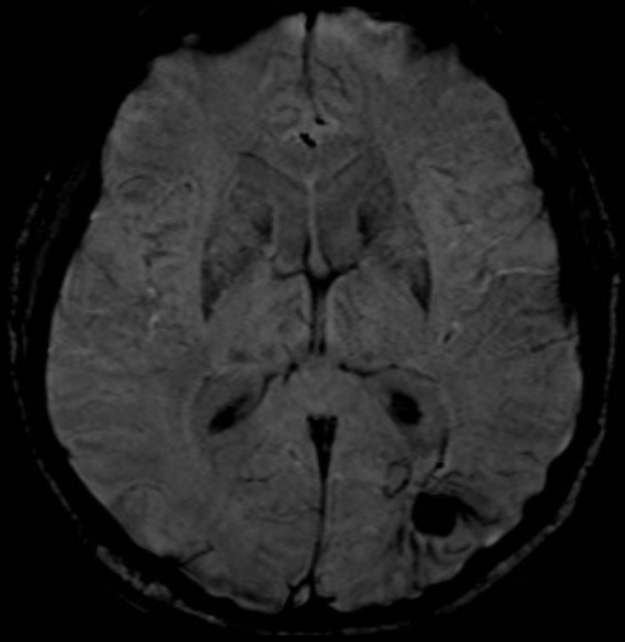

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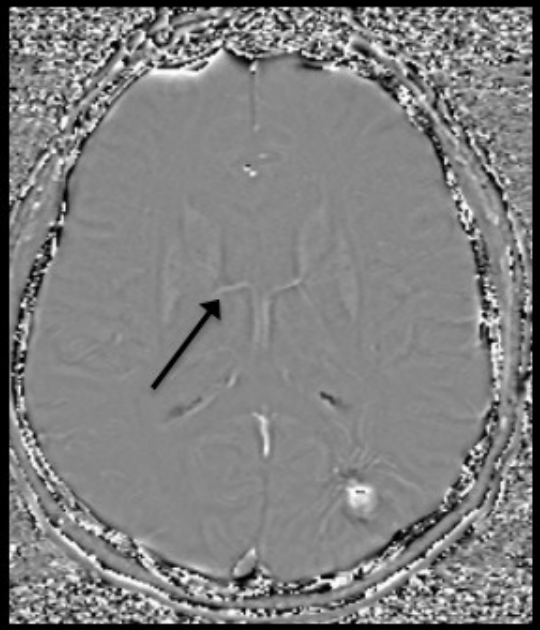

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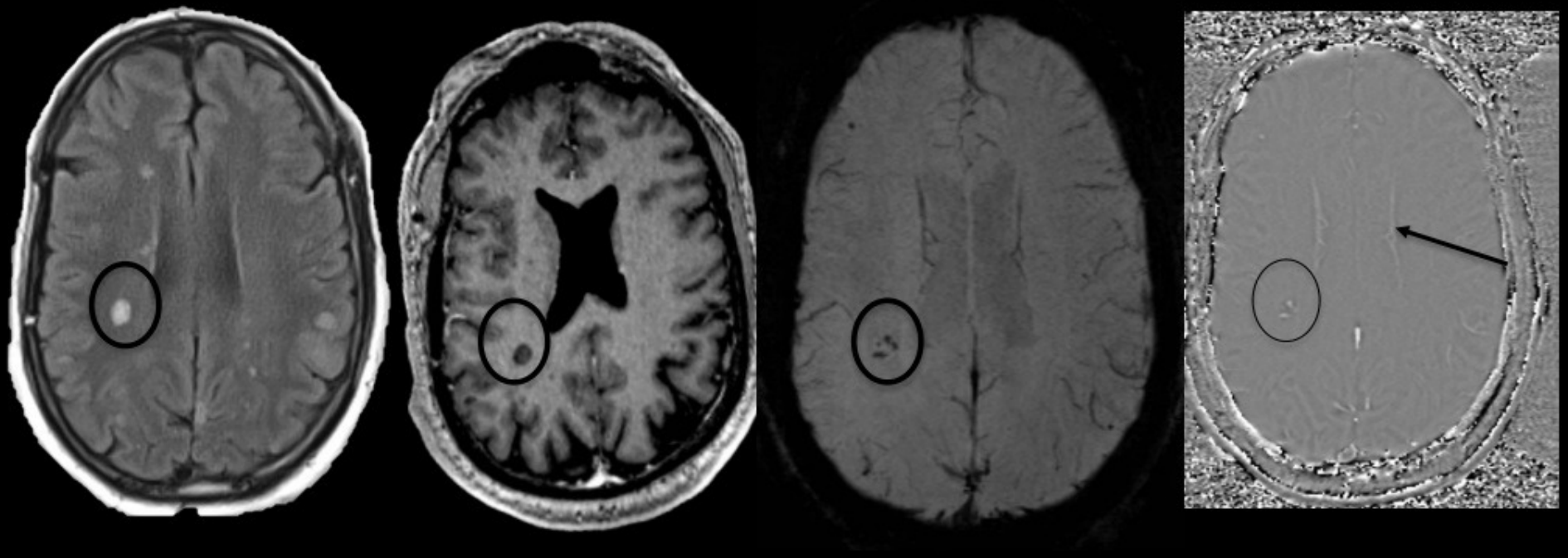

A B C D

Lung cancer metastasis.

A. FLAIR, B. post contrast T1WI, C. SWI and D. SWI-Phase show multiple hyperintense foci on FLAIR without gadolinium enhancement suggesting blood components (circles in all images). Presence of blood made the lesions more conspicuous & suggested hemorrhagic metastases. Signal intensity of intratumoral blood is similar to that in deep veins (arrow).

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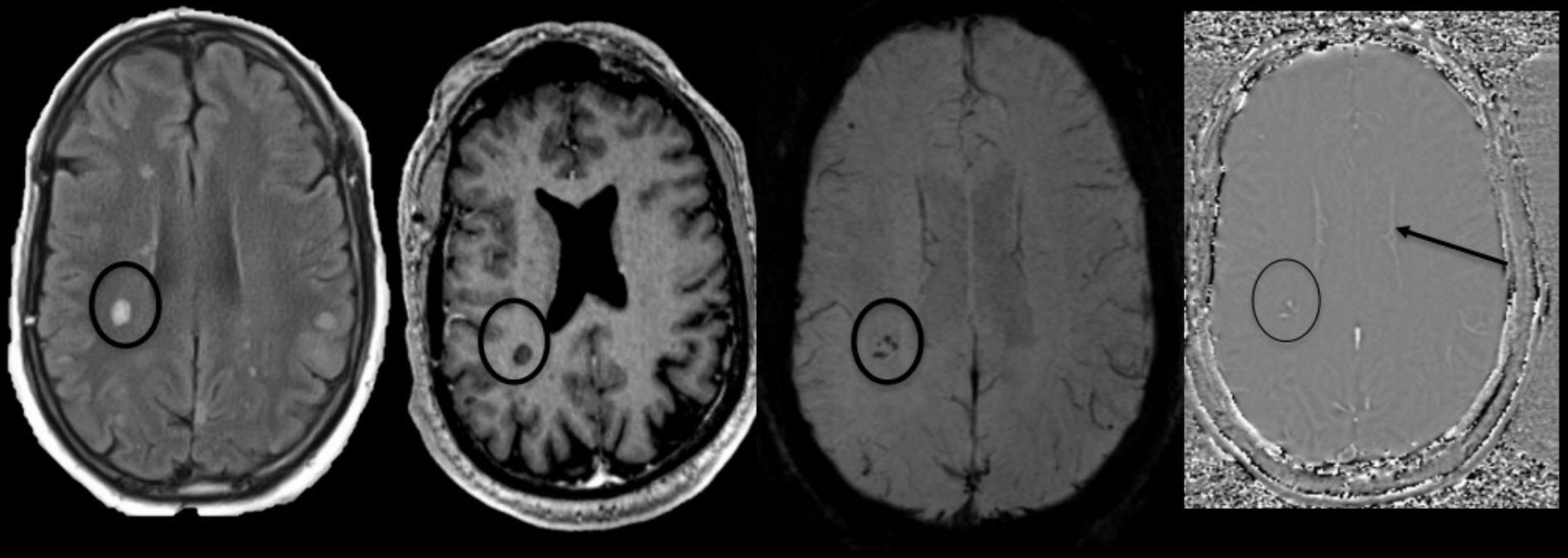

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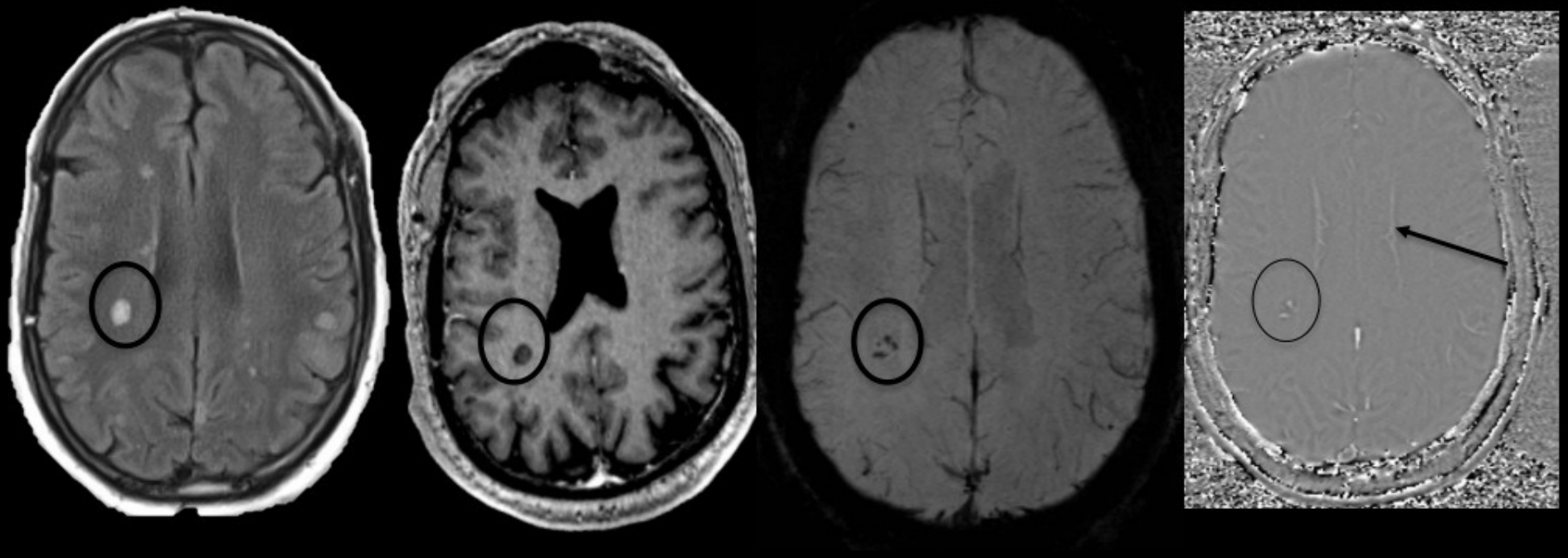

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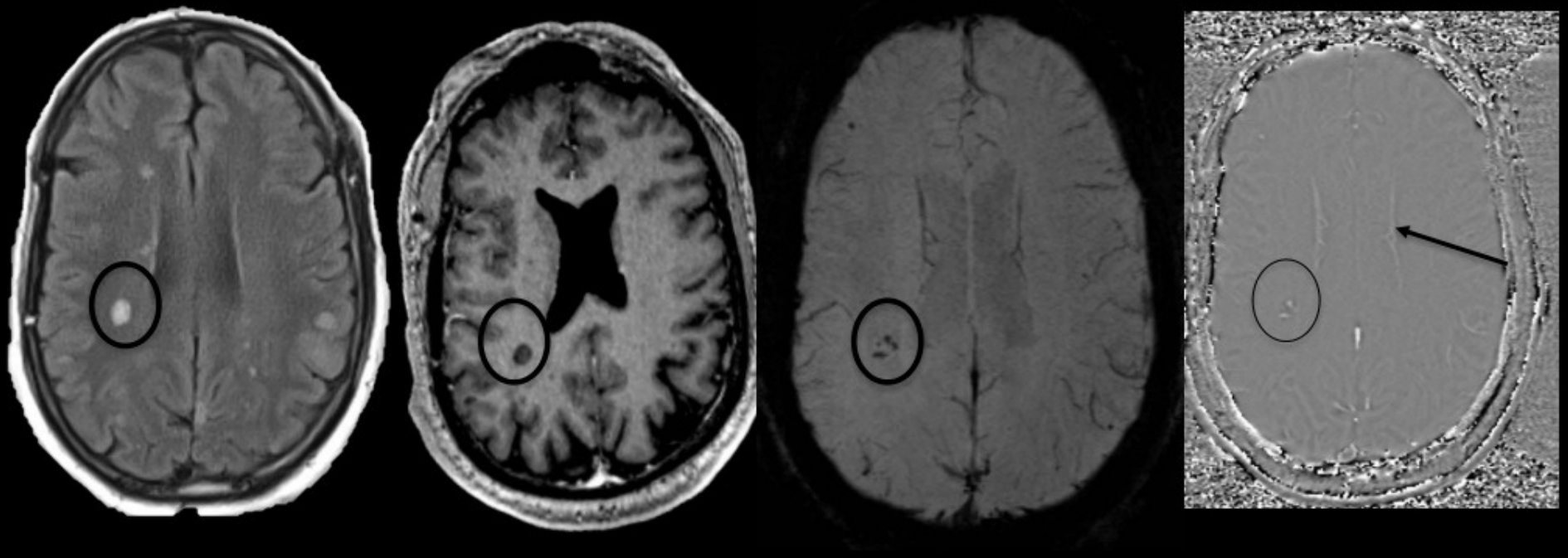

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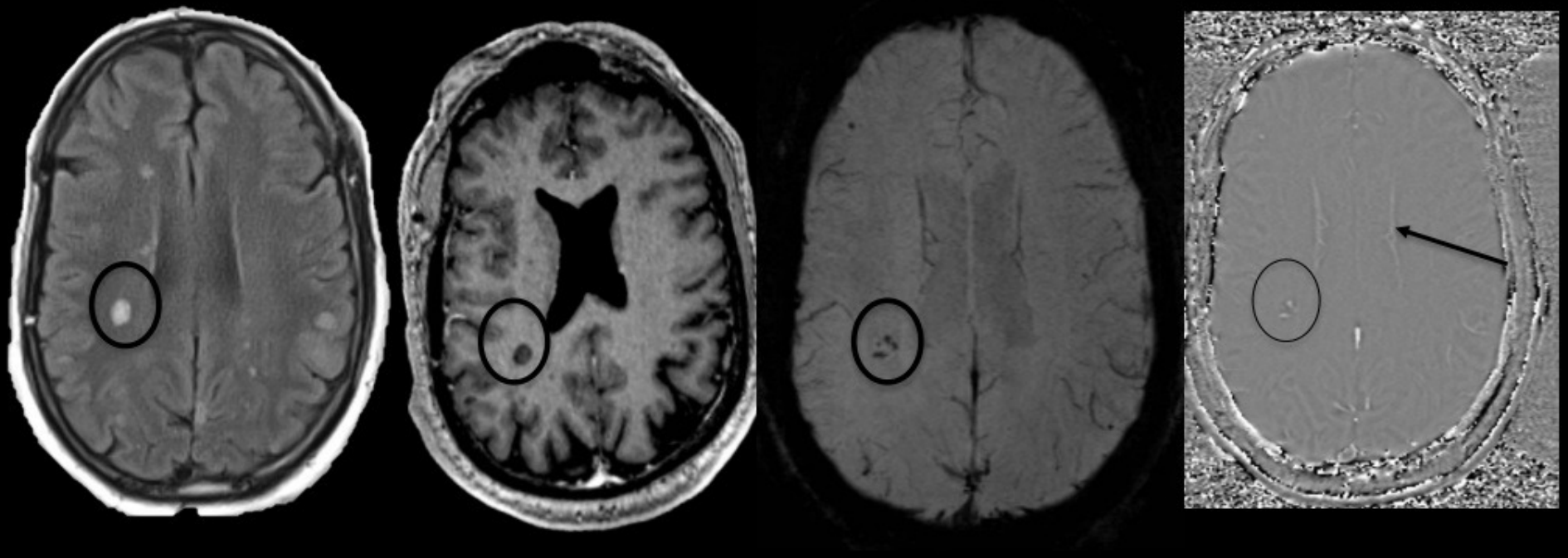

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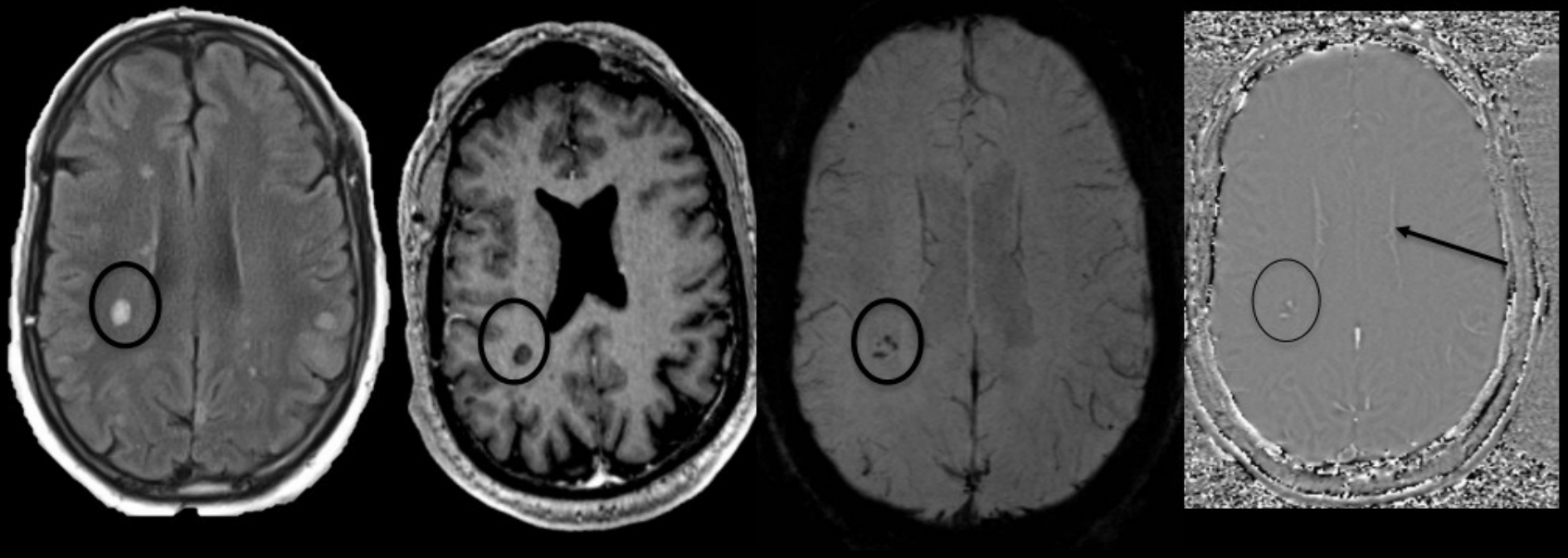

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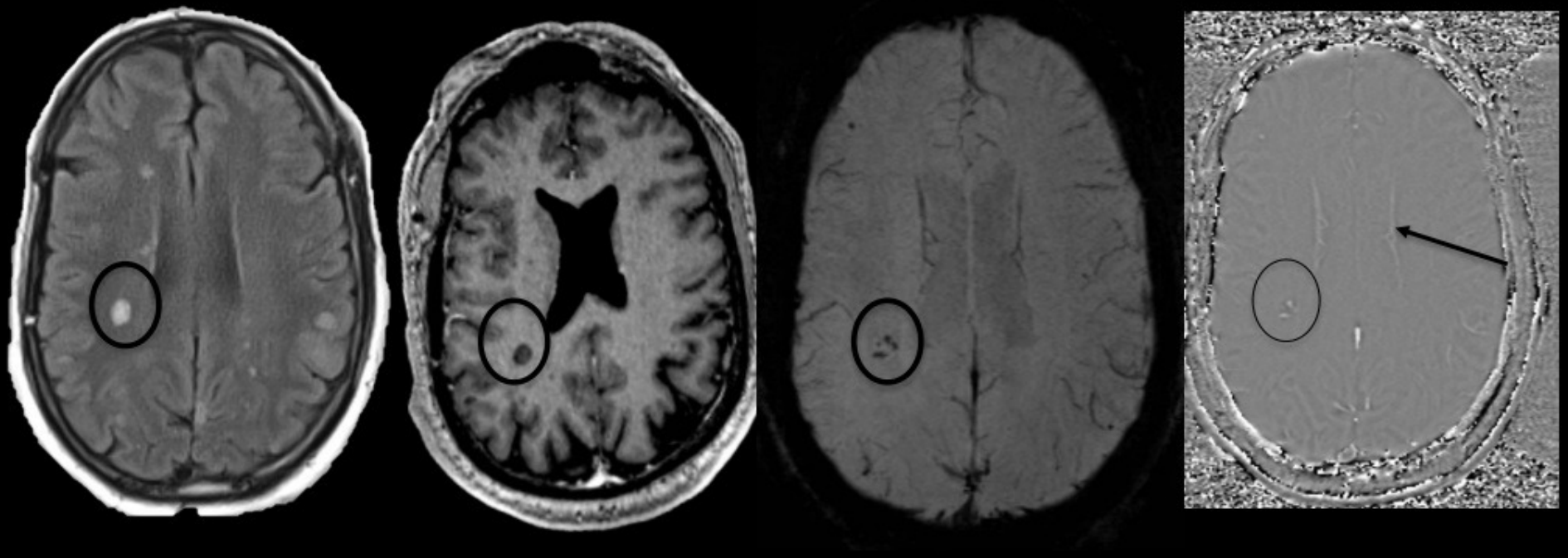

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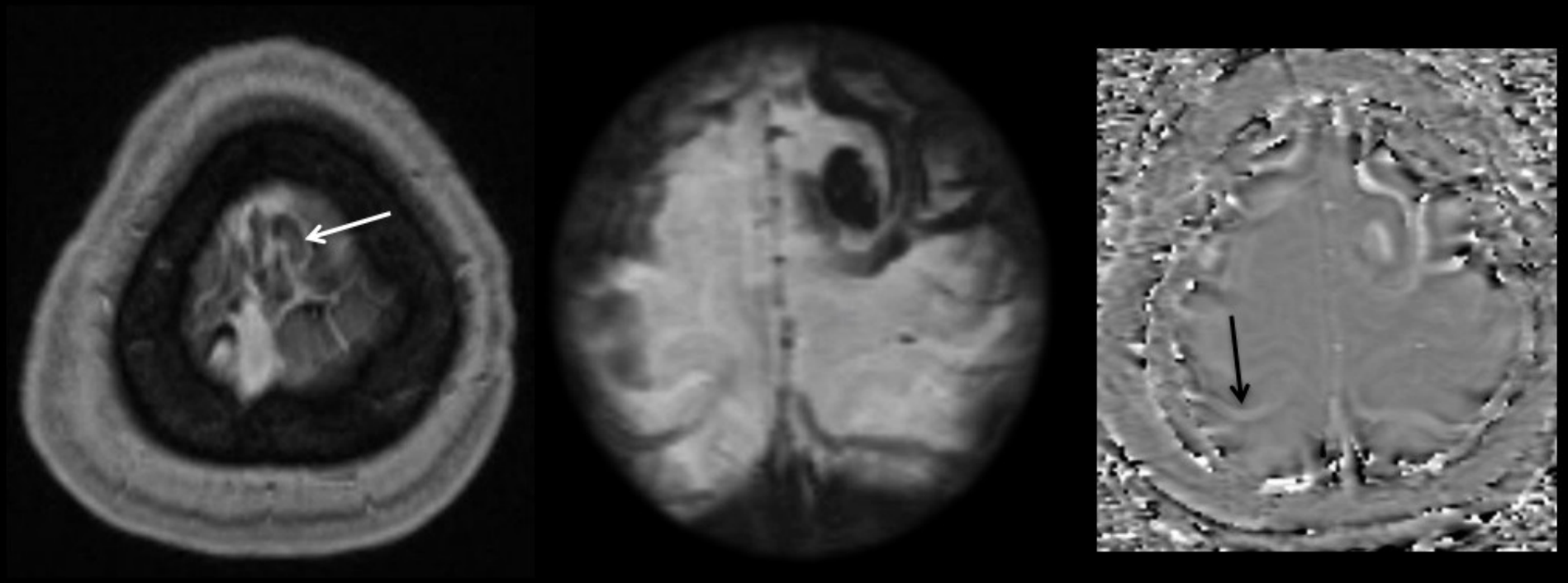

A B. C

Cortical vein thrombosis.
Post contrast T1WI (A) shows filling defect is seen in a cortical vein compatible with thrombus (white arrow). The thrombosed vein is better demonstrated in SWI (B) but on the phase image (C) its signal is equivalent to blood in non-thrombosed veins (black arrow) a possible pitfall.

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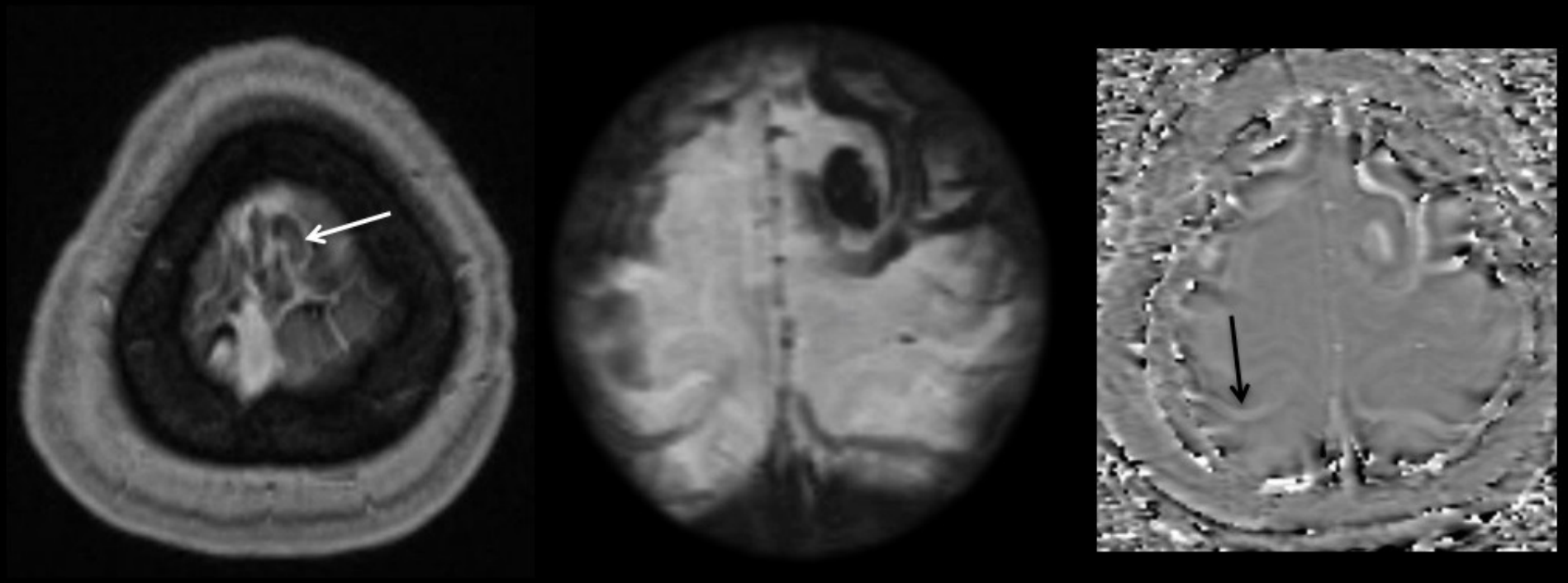

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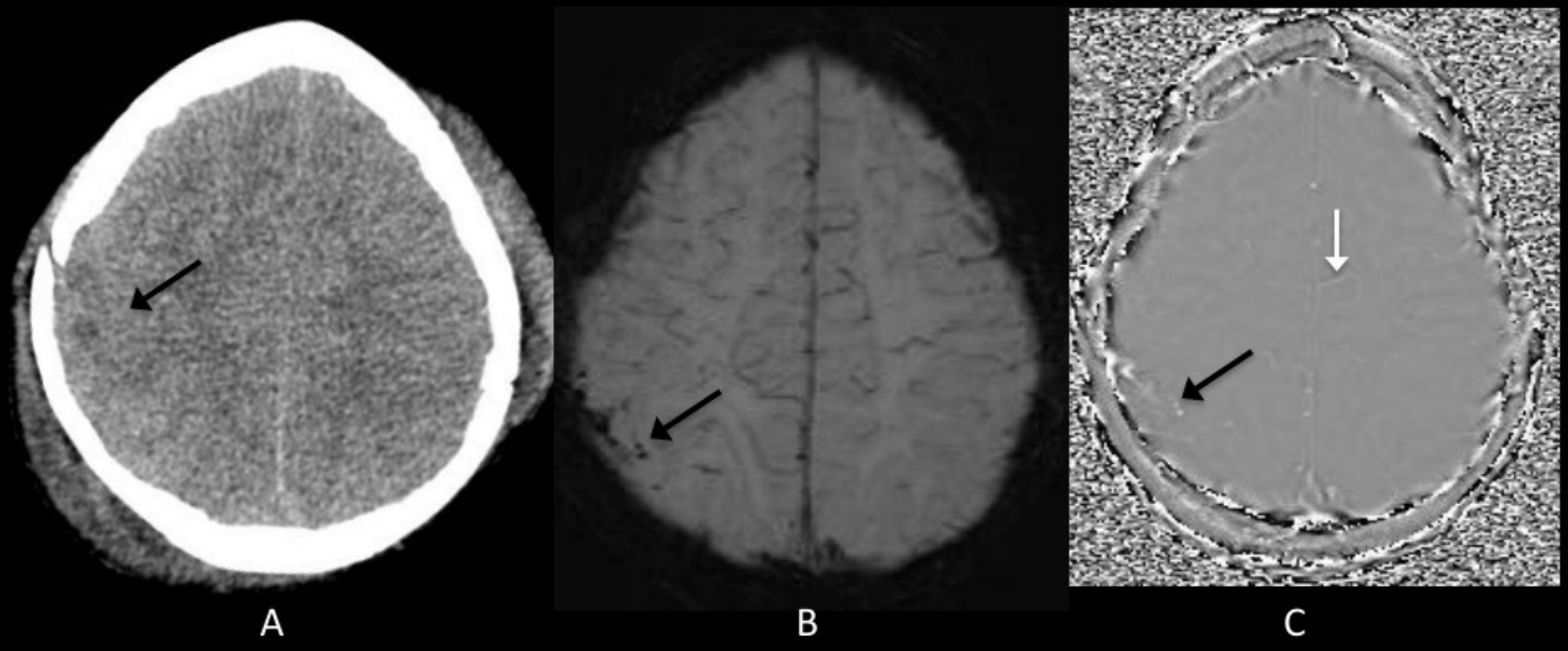
THRAUMATIC AXONAL INJURY



A B C

Non-enhanced CT (A) shows a hypodense area (black arrow) in contiguity to a skull fracture in a patient with head trauma. SWI (B) & SWI-Phase (C) reveal hemorrhagic in the lesion (black arrow) & adjacent subarachnoid space compatible with adjacent subcortical hemorrhagic axonal injury. Note that blood in lesion has similar signal to that in veins (white arrow).

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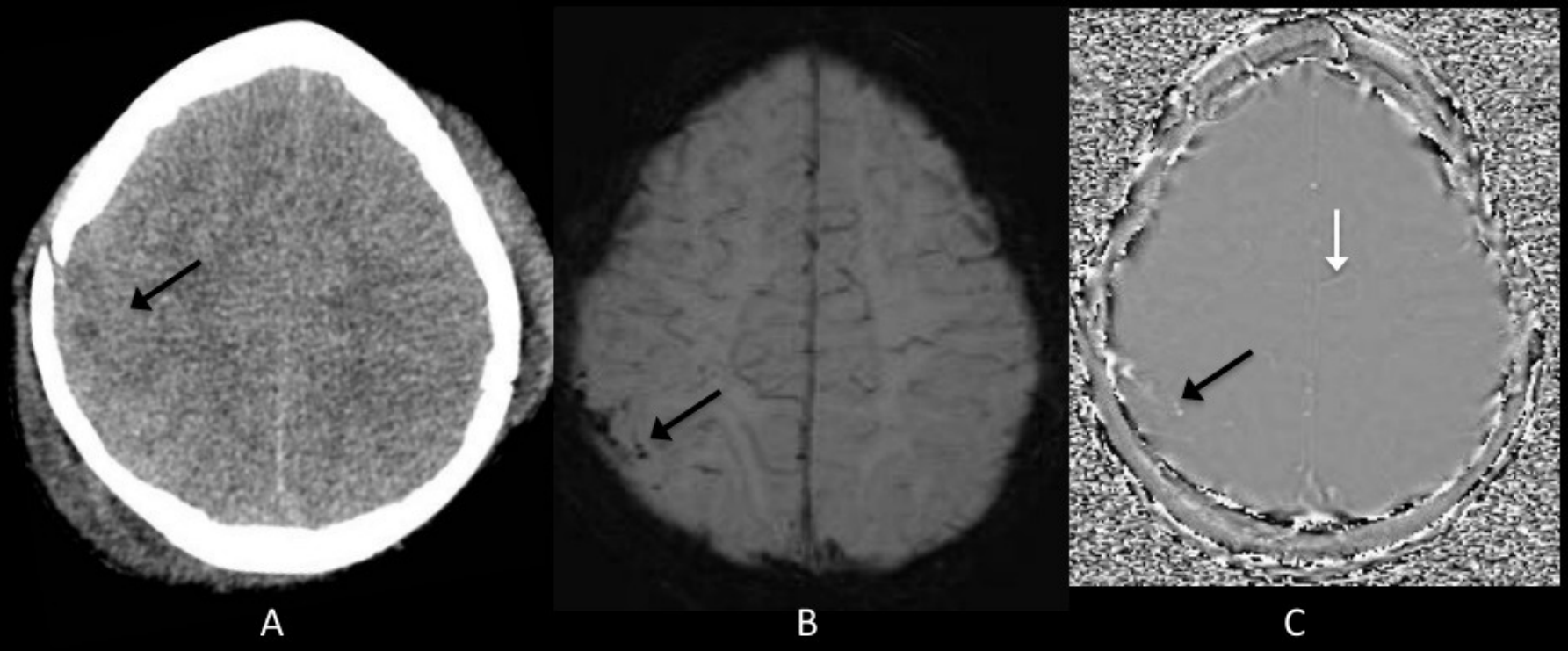

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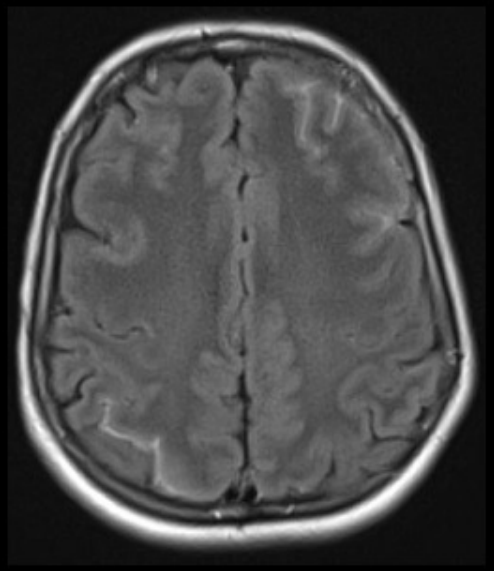

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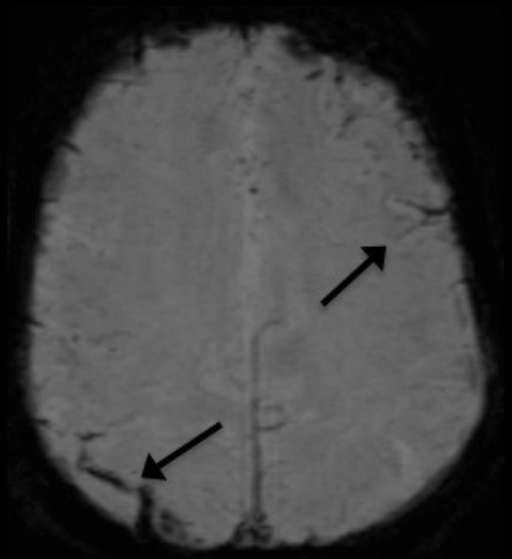

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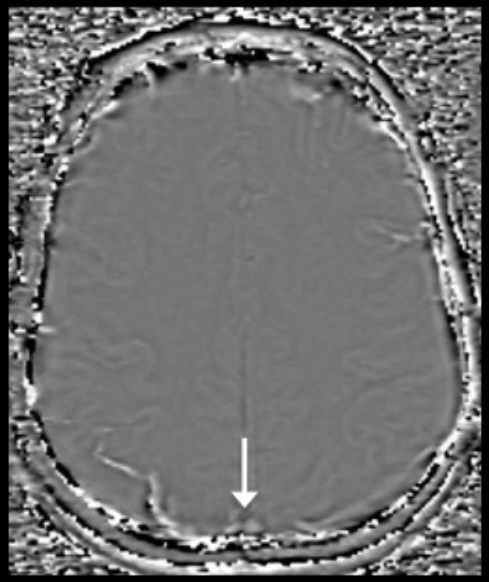

C.

Axial FLAIR (A) shows bright signal in sulci of the right parietal & left frontal lobes. SWI (B) reveals “blooming effect” in these areas (black arrows). SWI-Phase (C) confirms subarachnoid hemorrhage demonstrating bright lesion within the sulci displaying similar signal to that in the superior sagittal sinus (white arrow).

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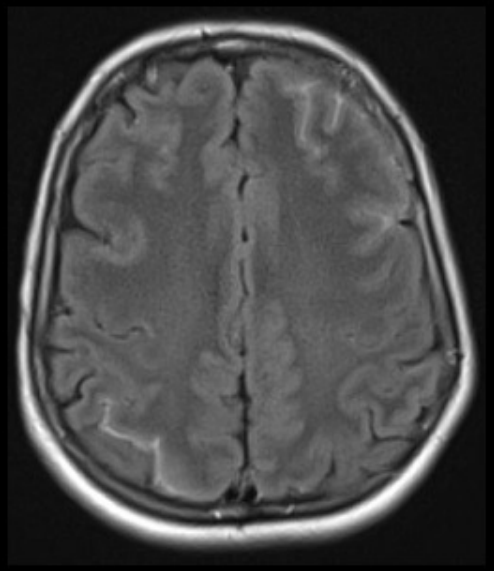

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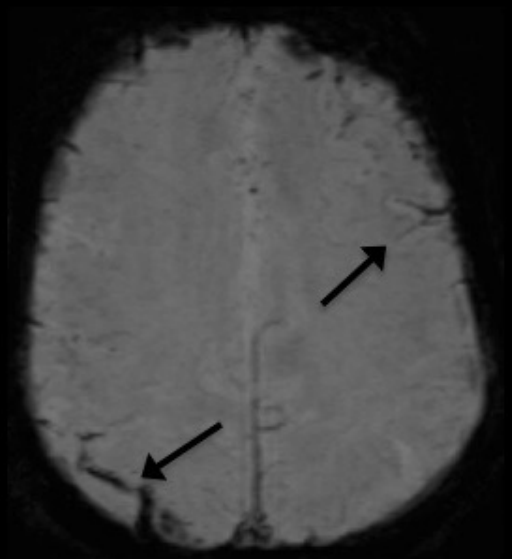

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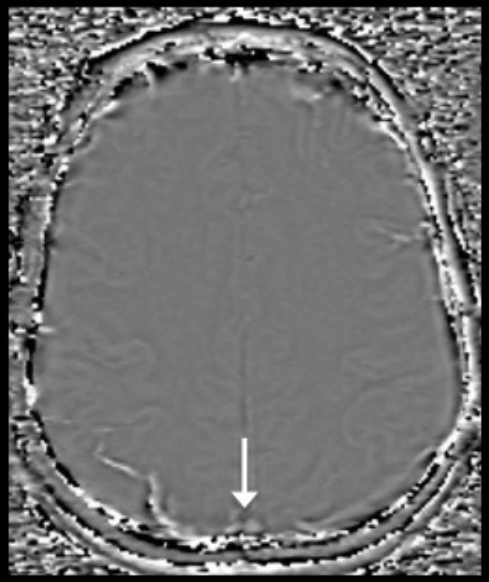

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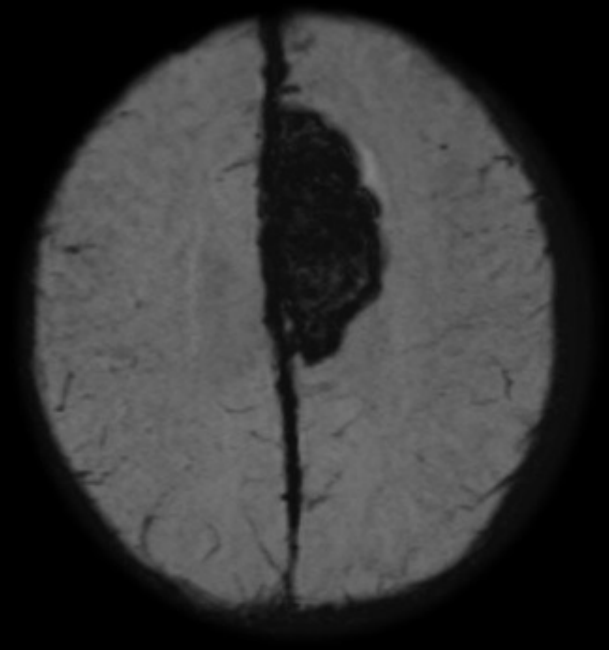
LIMITATIONS

- Aliasing
  - A major limitation in phase imaging is aliasing. Although filtered phase images are more sensitive to small amounts of calcium than CT they may perform poorly & can be confusing when larger amounts of calcification are present. When the field is large enough that the phase exceeds π (pi) radians, it will alias to -π radians & will appear dark rather than bright. The net effect is that large regions of calcifications and/or blood can be inhomogeneous & have signal dropout making it difficult to ascertain their nature.

Wu Z etal. Identification of calcification with MRI using susceptibility-weighted imaging: a case study. JMRI 2009;29: 177-82

ALIASING



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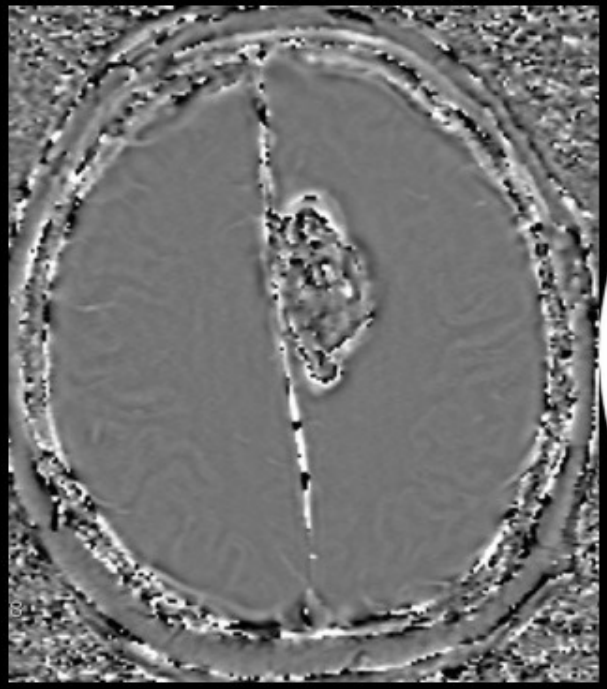

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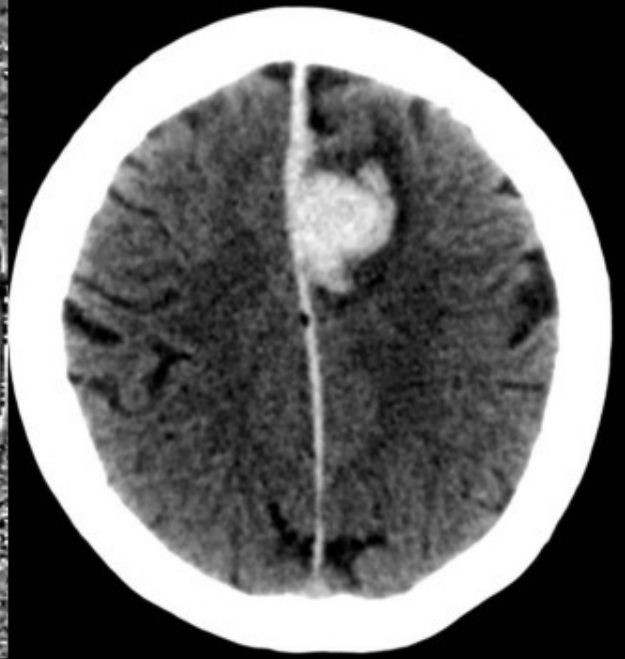

C

Parafalcine hemorrhagic lesion.
While SWI (A) shows a low signal lesion, the SWI-Phase (B) reveals mixed signal inside the lesion that prevents confirming its nature. Non-enhanced CT (C) shows no calcifications, compatible with a purely hemorrhagic lesion, which was later diagnosed as a meningioma.

CONCLUSIONS

- There are some several conditions in which SWI-Phase is a useful tool in clinical practice. The most relevant are the differentiation of microcalcifications from microbleeds related to small vascular lesions & to identify calcium or bleeds in tumors.
- It is important to be aware of artifacts, the most common one is aliasing that may limit visualization of large calcifications & hematomas as they appear of heterogeneous signal masking the underlying nature of the lesion.

REFERENCES

1.Thomas B, Somasundaram S, Thamburaj K, Kesavadas C, Gupta AK, Bodhey NK, et al. Clinical applications of susceptibility weighted MR imaging of the brain - a pictorial review. Neuroradiology. 2008;50(2):105-16.

2. Tong KA, Ashwal S, Obenaus A, Nickerson JP, Kido D, Haacke EM. Susceptibility-weighted MR imaging: a review of clinical applications in children. AJNR American journal of neuroradiology. 2008;29(1):9-17.

3.Sehgal V, Delproposto Z, Haacke EM, Tong KA, Wycliffe N, Kido DK, et al. Clinical applications of neuroimaging with susceptibility-weighted imaging. Journal of magnetic resonance imaging : JMRI. 2005;22(4):439-50.

4. Yamada N, Imakita S, Sakuma T, Takamiya M. Intracranial calcification on gradient-echo phase image: depiction of diamagnetic susceptibility. Radiology. 1996;198(1):171-8.

5. Mittal S, Wu Z, Neelavalli J, Haacke EM. Susceptibility-weighted imaging: technical aspects and clinical applications, part 2. AJNR American journal of neuroradiology. 2009;30(2):232-52.

6. Reichenbach JR, Venkatesan R, Schillinger DJ, Kido DK, Haacke EM. Small vessels in the human brain: MR venography with deoxyhemoglobin as an intrinsic contrast agent. Radiology. 1997;204(1):272-7.

7. Baheti, Neeraj. and Hassan, Haseeb. and Rathore, Chaturbhuj. Acquired hepatolenticular degeneration: Is the T1 hyperintensity due to manganese deposition? Neurology India; 57(6):812-13, 2009.

8. Wu Z, Mittal S, Kish K et-al. Identification of calcification with MRI using susceptibility-weighted imaging: a case study. J Magn Reson Imaging. 2009;29 (1): 177-82.