

# Grading Intracranial Hemorrhage (Radiological Subtypes using Heidelberg Classification)

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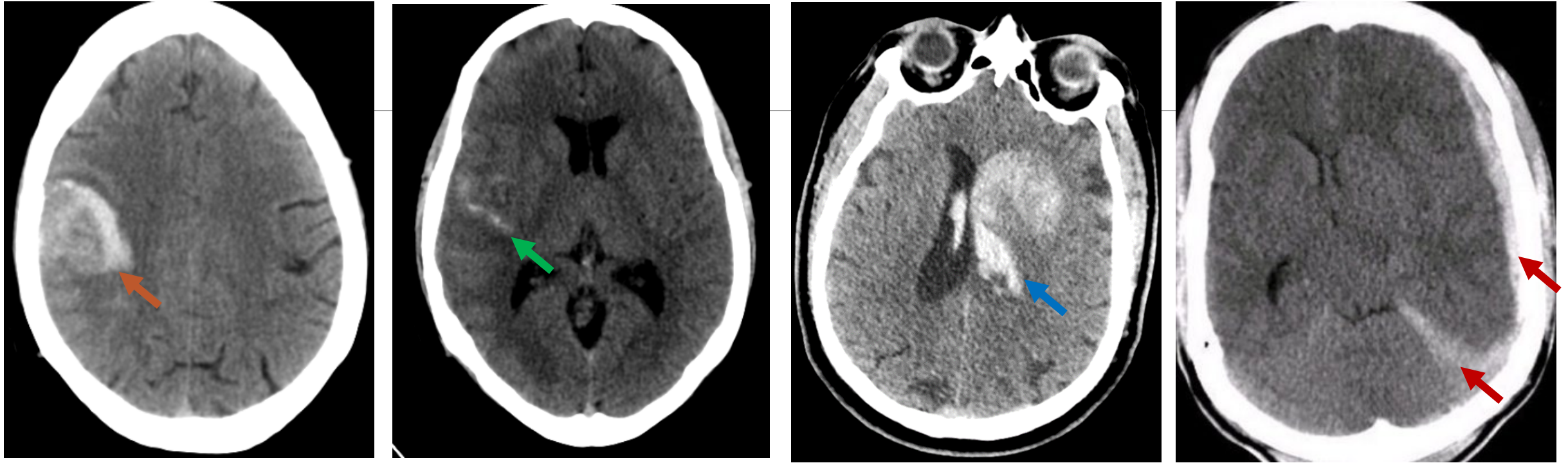
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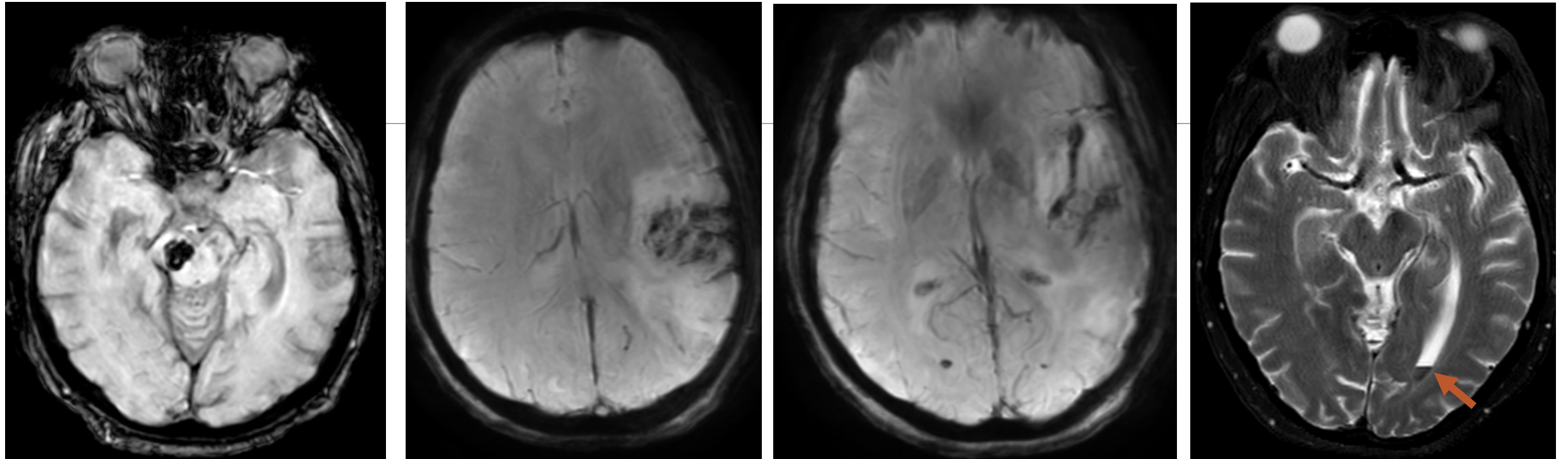
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## Identifying bleed on CT



Intracranial **parenchymal hemorrhage**, **Subarachnoid hemorrhage**, **intraventricular hemorrhage**, **subdural hemorrhage** - all appear hyperdense on CT

## Identifying bleed on MRI

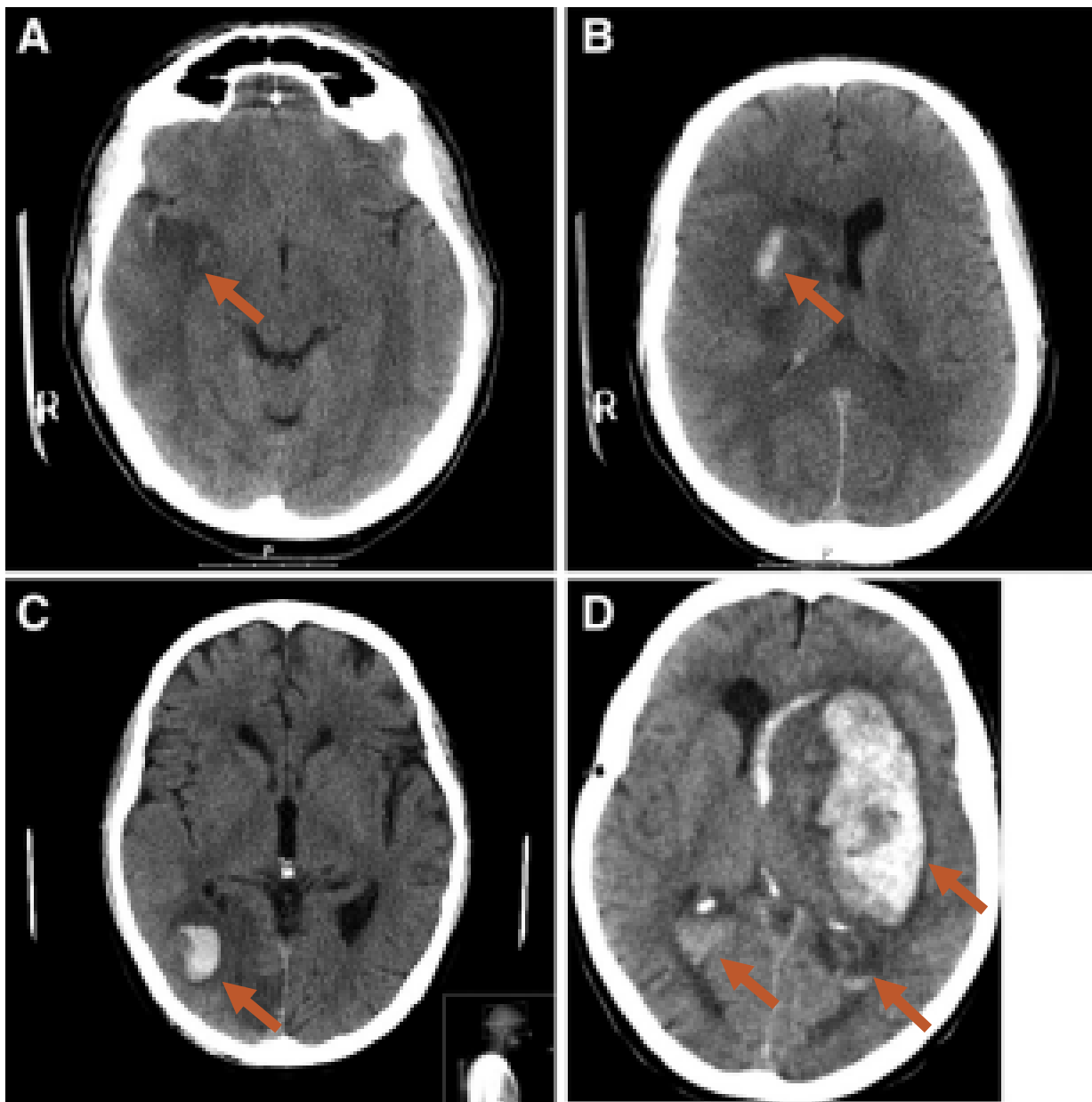


- Best sequence to identify intracranial bleed on MRI- **Susceptibility sequences (SWI,SWAN,GRE)- all bleed irrespective of their location or age appear hypointense on these sequences**
- SWAN sequences will be more sensitive than GRE
- Acute hemorrhage may show heterogenous or mixed signal intensities on other MRI sequences.
- **IVH** may appear as dependent fluid level or may partially/ completely fill the ventricle replacing the CSF signal intensity

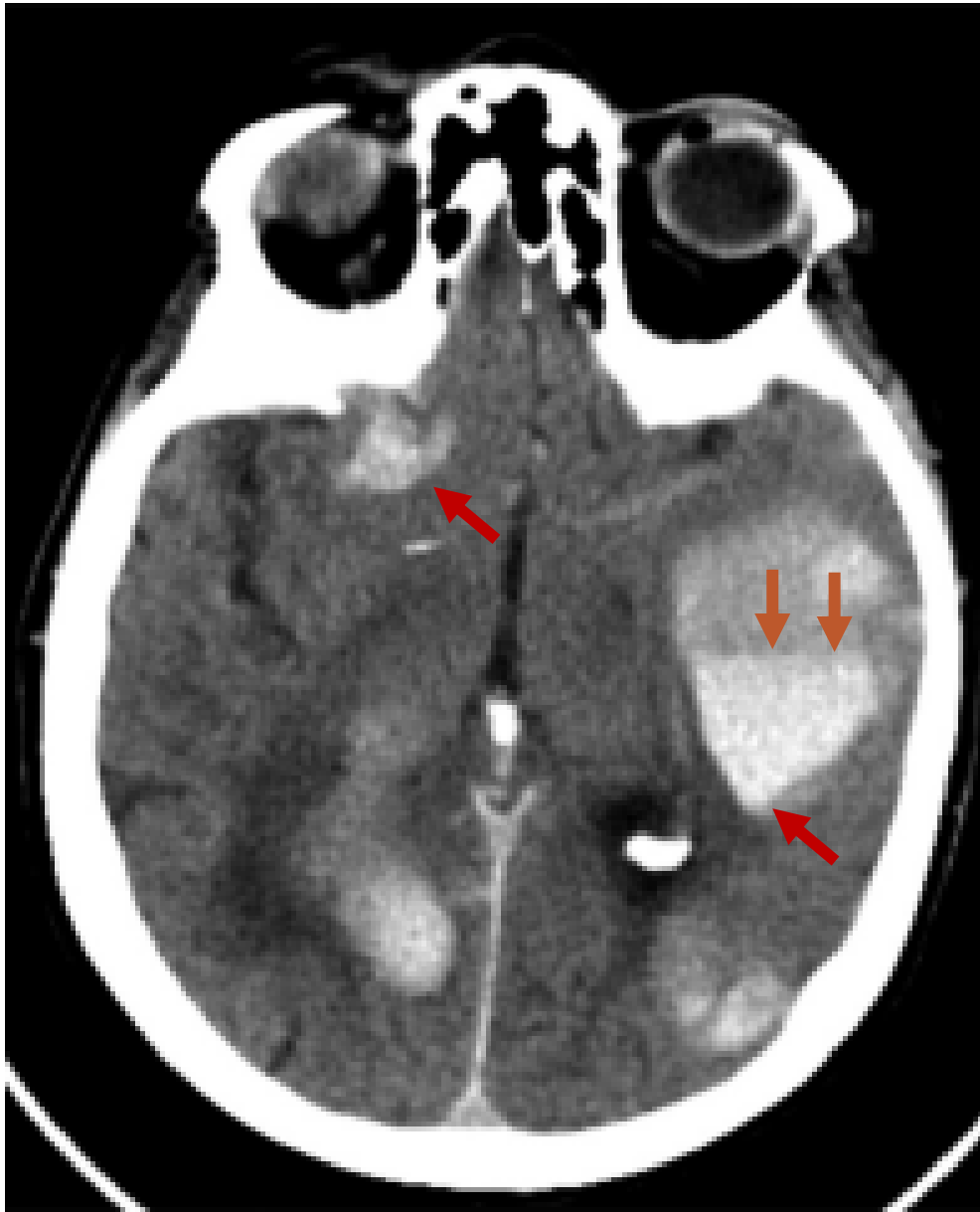
**Table 1. Anatomic Description of Intracranial Hemorrhages**

Class	Type	Description
1		Hemorrhagic transformation of infarcted brain tissue
1a	HI1	Scattered small petechiae, no mass effect
1b	HI2	Confluent petechiae, no mass effect
1c	PH1	Hematoma within infarcted tissue, occupying <30%, no substantive mass effect
2		Intracerebral hemorrhage within and beyond infarcted brain tissue
	PH2	Hematoma occupying 30% or more of the infarcted tissue, with obvious mass effect
3		Intracerebral hemorrhage outside the infarcted brain tissue or intracranial-extracerebral hemorrhage
3a		Parenchymal hematoma remote from infarcted brain tissue
3b		Intraventricular hemorrhage
3c		Subarachnoid hemorrhage
3d		Subdural hemorrhage

HI indicates hemorrhagic infarction; and PH, parenchymatous hematoma.



CT images showing hemorrhagic infarction type 1 (HI-1) right temporal lobe (A), HI-2 in right striatum (B), PH-1 in right posterior cerebral artery territory (C), and PH-2 with mass effect and IVH in left basal ganglia and internal and external capsules (D).



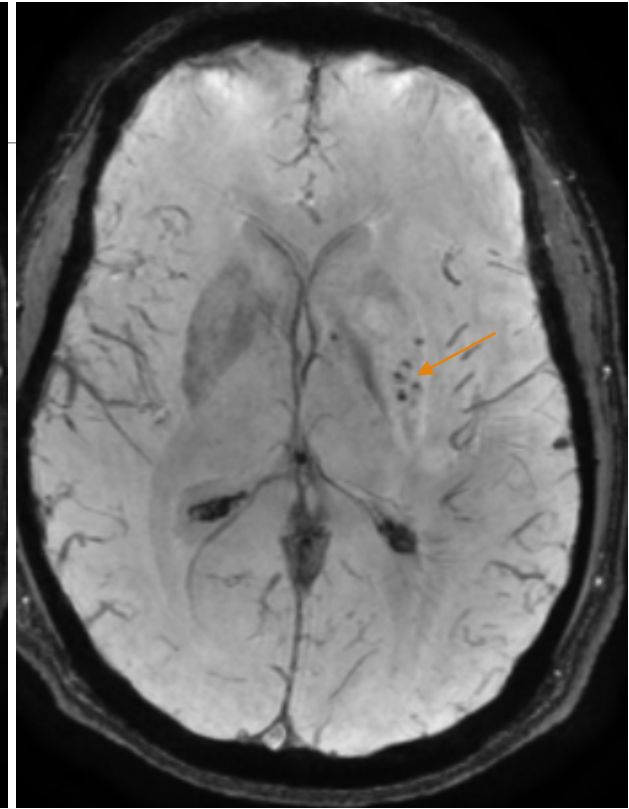
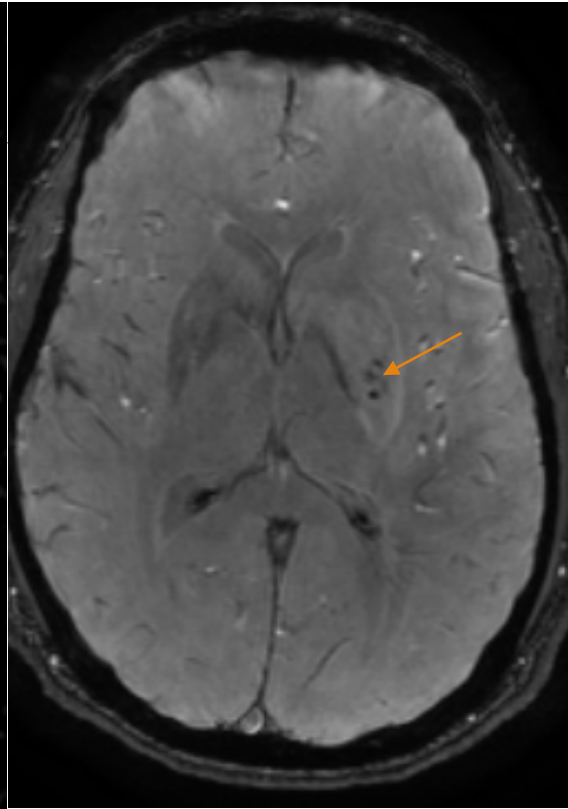
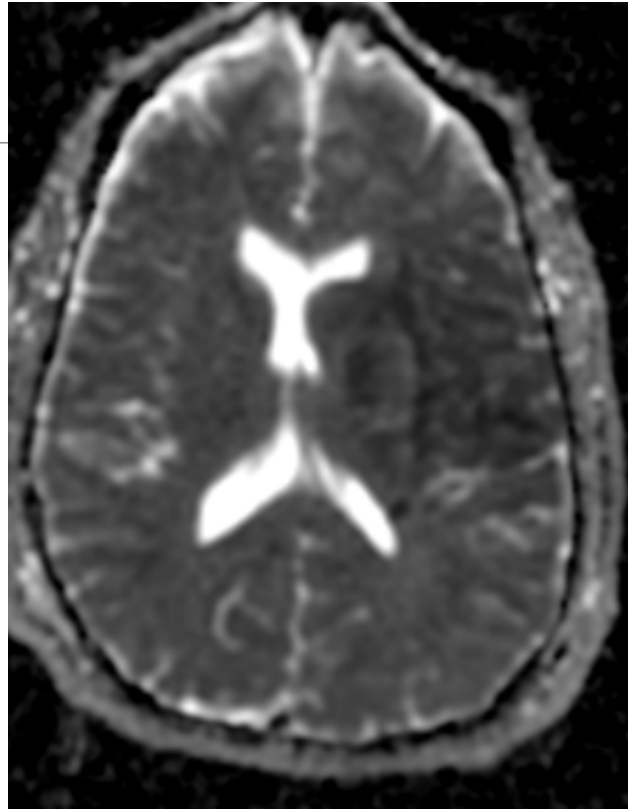
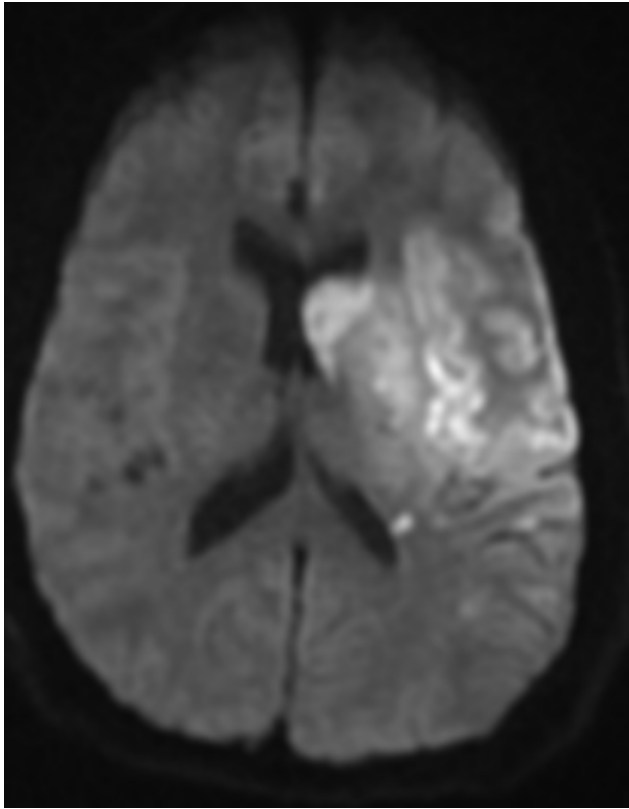
**Bilateral parenchymal hematomas** including remote parenchymal hematoma with **fluid level** in the left PH indicating coagulation disorder.

# Key point

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- **Original Heidelberg Classification was based on CT images.**
- **Hemorrhage is always better seen on MRI and the grading can be overestimated (particularly HI1 and HI2 categories)**

# HI-1: Scattered small petechiae, no mass effect



Diffusion Weighted Imaging (DWI): Large acute MCA territory infarct

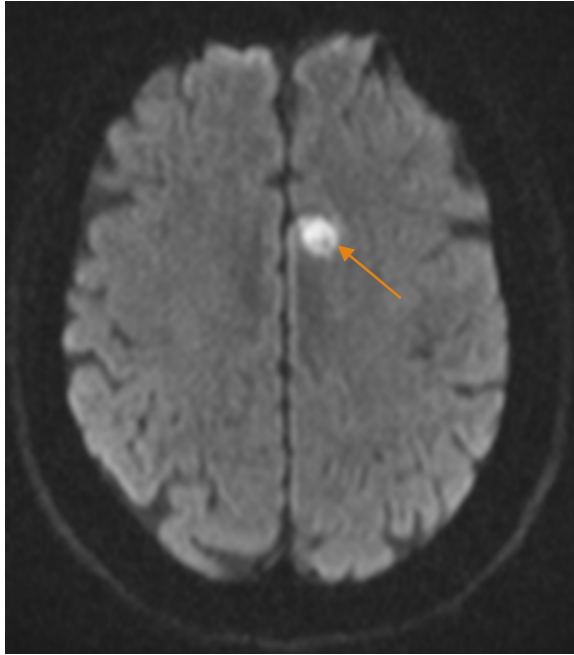
Apparent Diffusion Coefficient (ADC)

Saturation Weighted Imaging (SWI) shows **scattered small petechiae – HI1** in infarct region

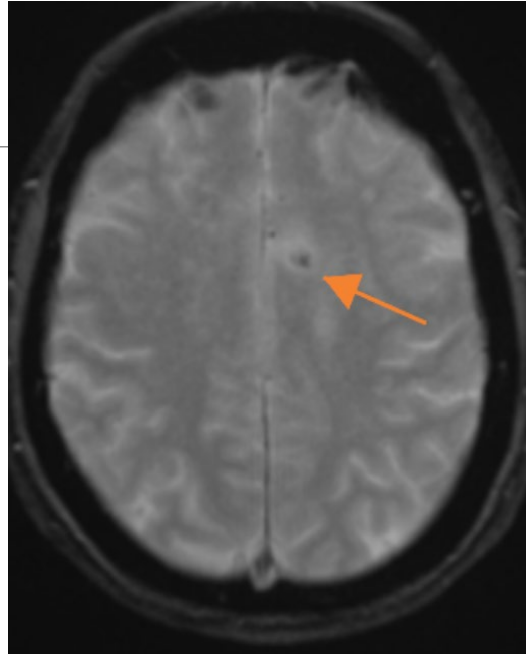
SWI- MIPs



## HI-1: More Examples

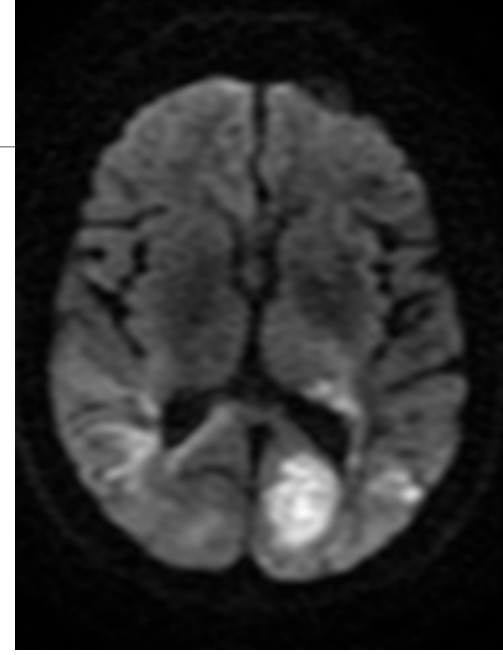


DWI

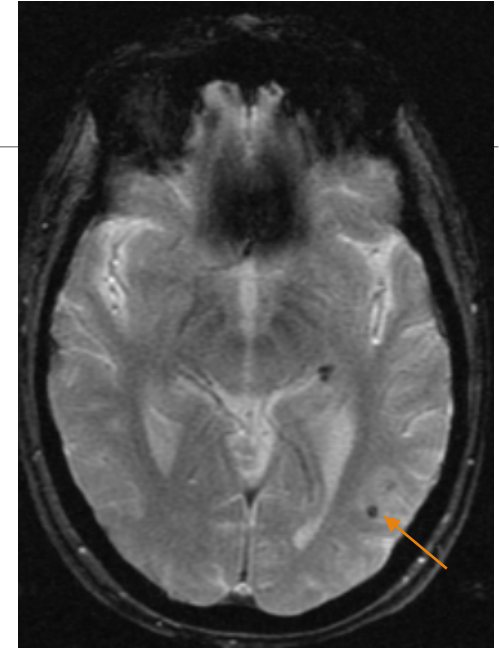


SWI

Acute infarct left ACA territory on DWI with small **petechial focus** suggestive of **HI-1** seen on DWI and better appreciated on gradient sequences (SWI)



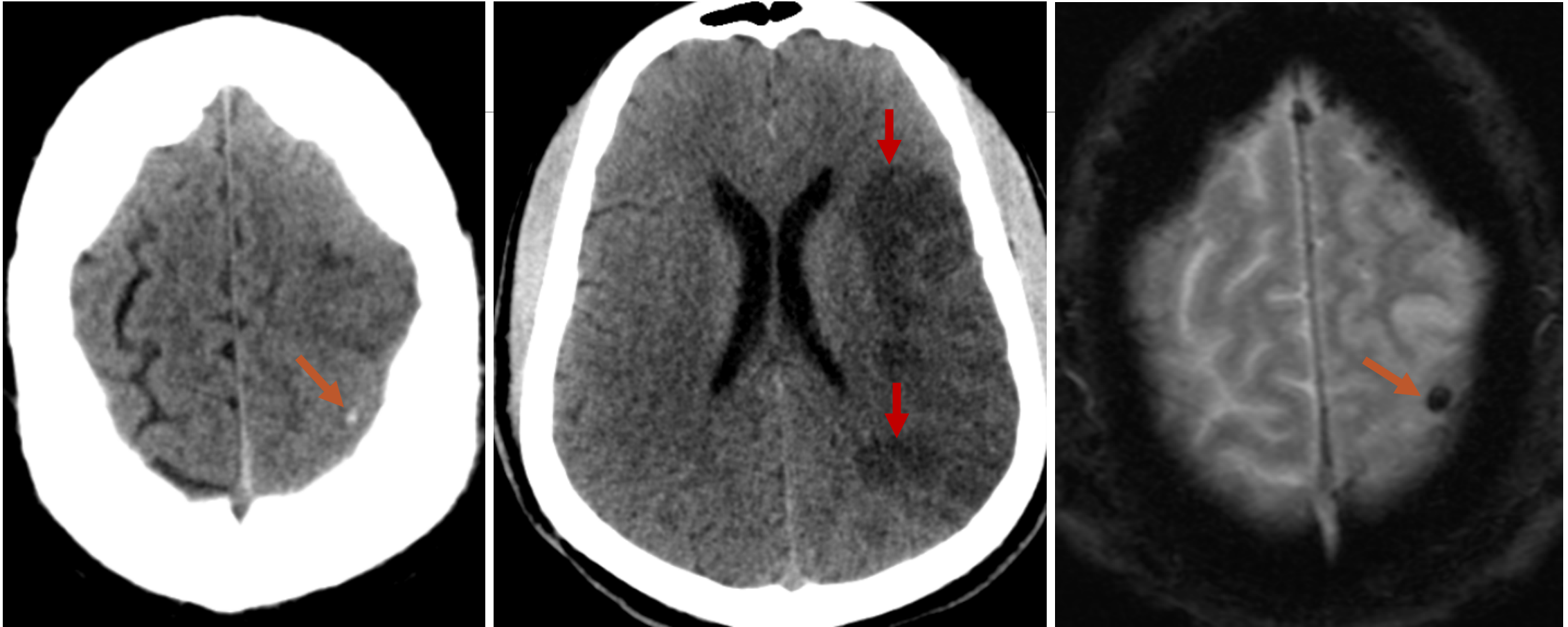
DWI



SWI

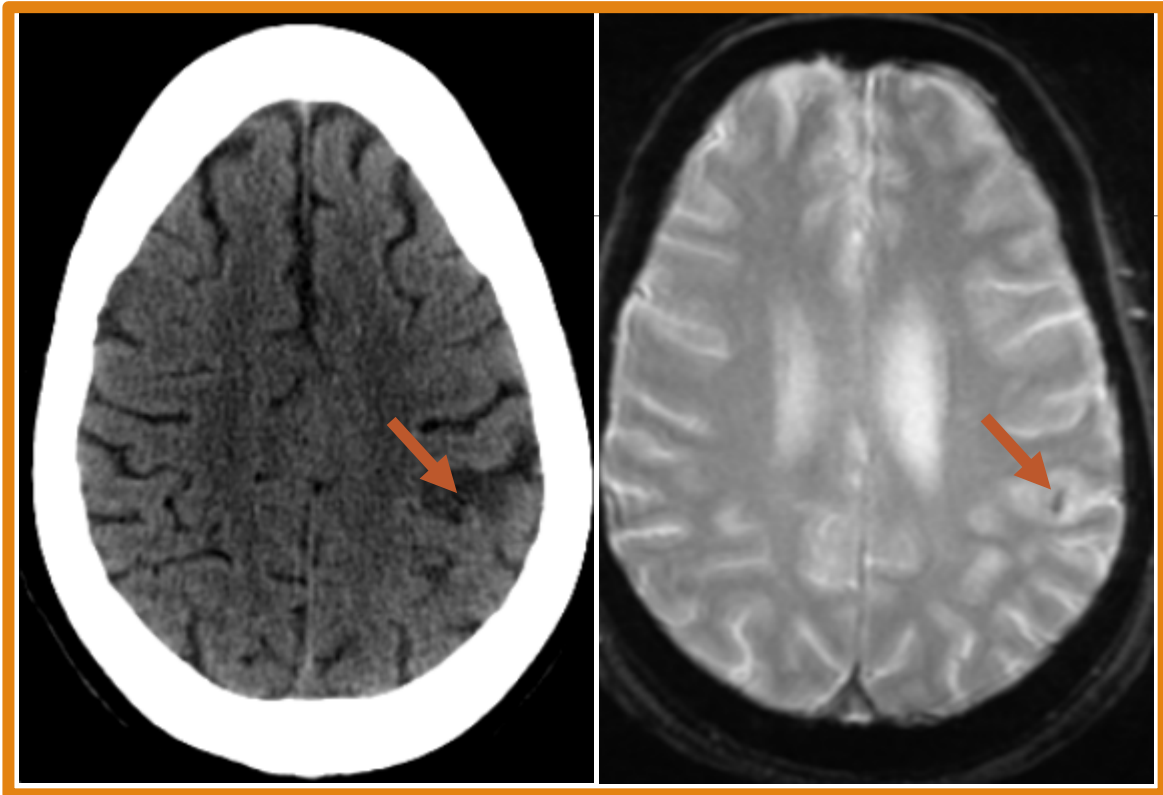
Acute infarct bilateral PCA territory on DWI with **small petechial focus** in left parietal region appreciated on SWI, not seen on DWI .

## HI-1: Scattered small petechiae, no mass effect

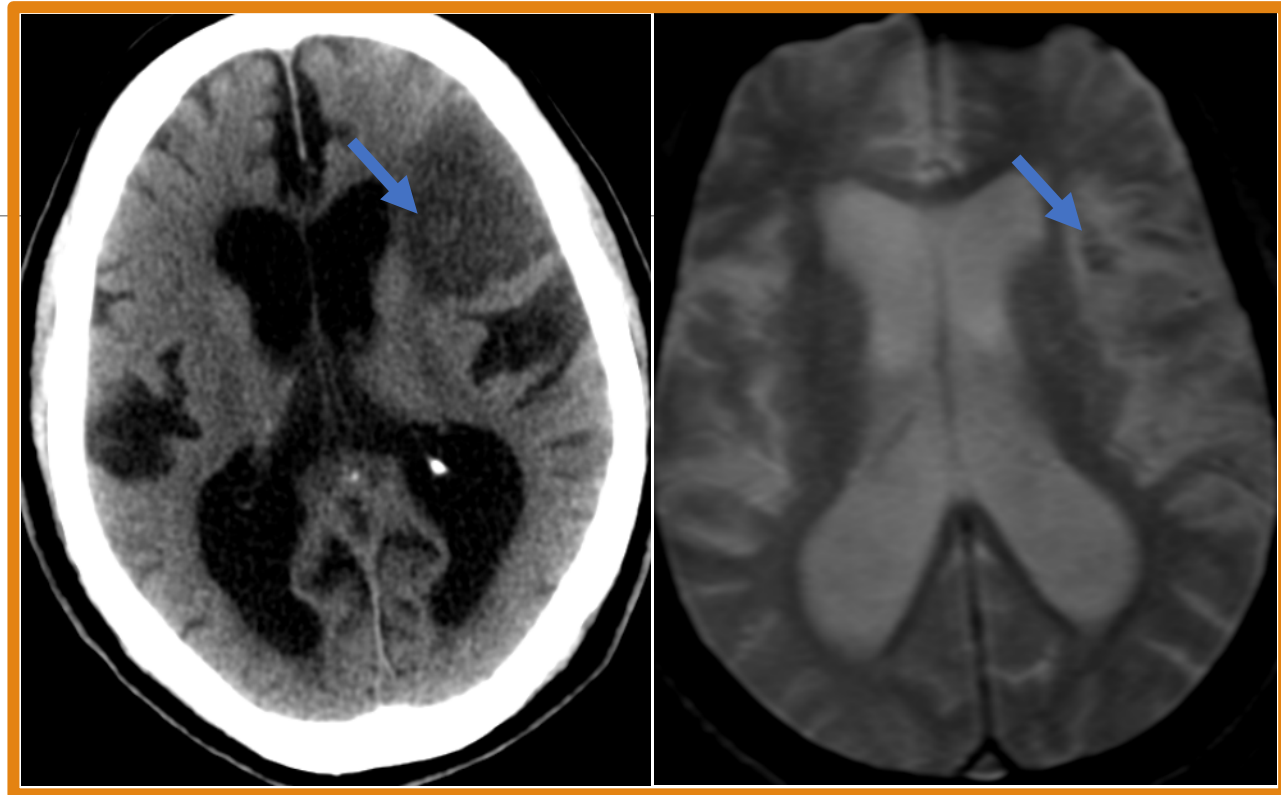


CT shows **small petechial focus suggestive of HI-1** in a case of **acute infarct** left MCA territory. Corresponding section on MRI (SWI) shows the petechia with blooming, suggesting that gradient sequences may overestimate the hemorrhagic component.

## HI-1: Scattered small petechiae, no mass effect

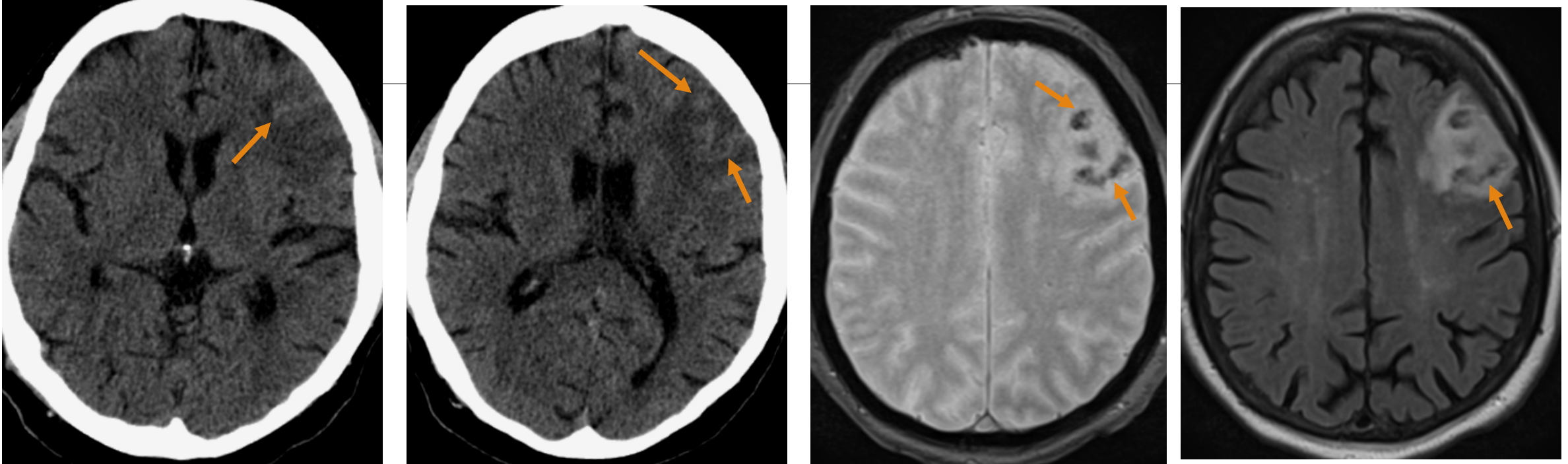


Acute infarct left MCA territory on CT with small **petechial focus** suggestive of **HI-1** seen along the posterior margin of the infarct. This is better appreciated on MR images (SWI).



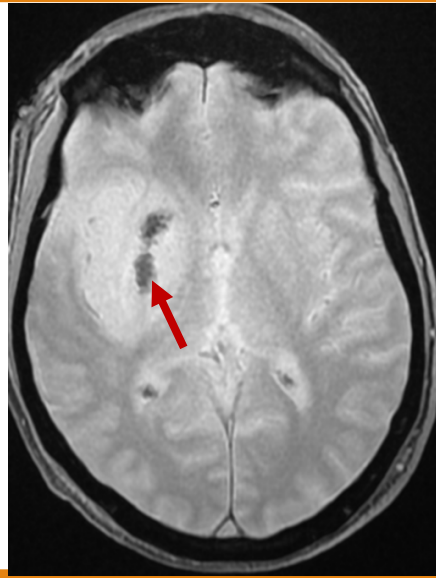
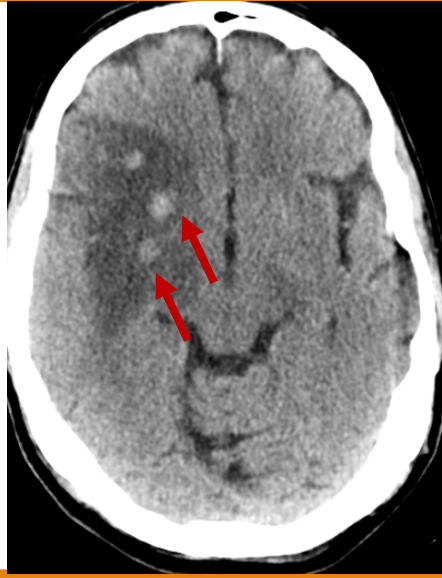
Acute infarct left MCA territory on CT with small **petechial focus** suggestive of **HI-1**, better appreciated on MRI (SWI).

## HI-2 : Confluent petechiae, no mass effect

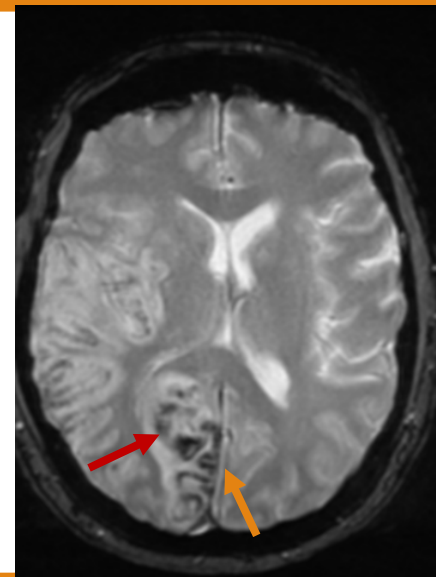


Acute infarct left anterior circulation on follow up **CT** with confluent petechial foci suggestive of **HI-2**. Corresponding section on MRI (SWI and FLAIR) shows similar findings, but the bleed is better appreciated.

## HI-2 : Confluent petechiae

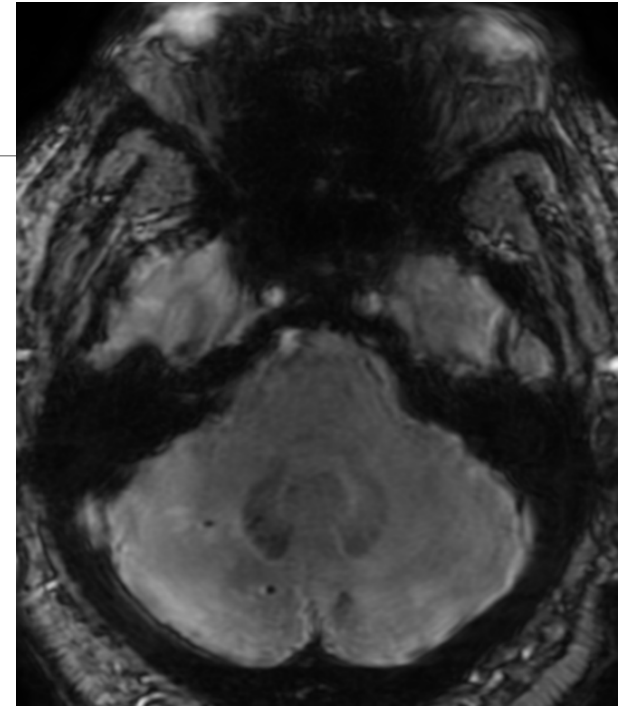
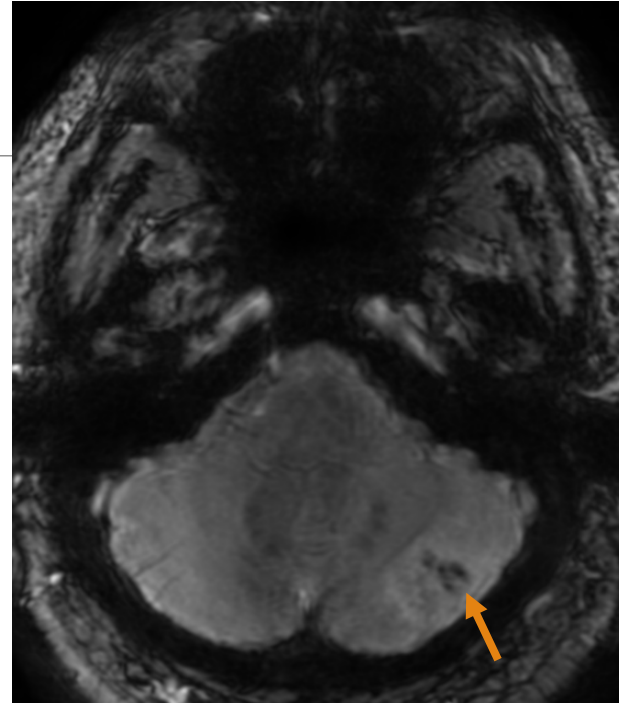
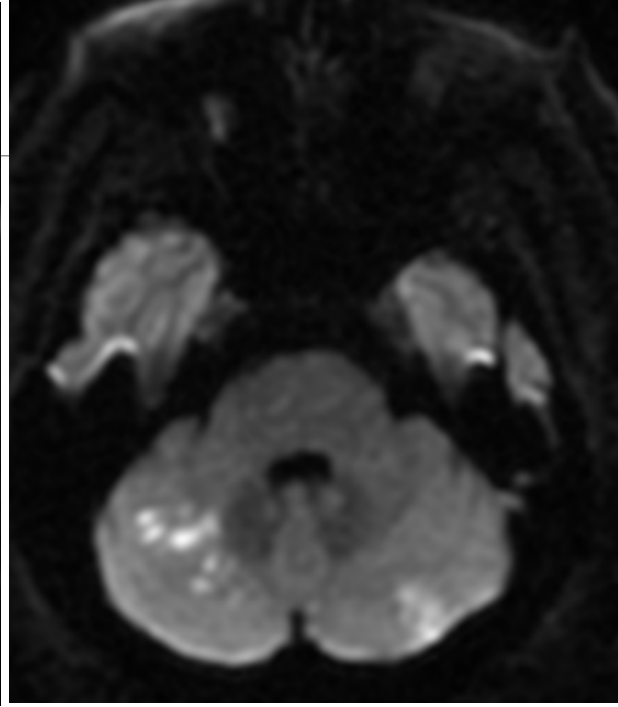
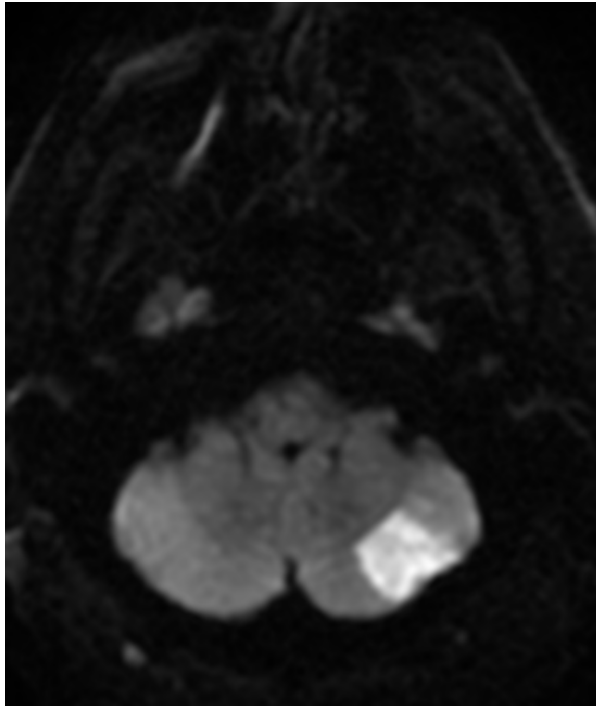


Acute infarct right MCA territory with confluent hemorrhagic petechiae suggestive of **HI-2**, seen on CT and SWI-MRI. No mass effect is seen.



Acute infarct right MCA and PCA territories with **HI-2** in occipital lobe mixed with **mild SAH**, , seen on CT and SWI-MRI

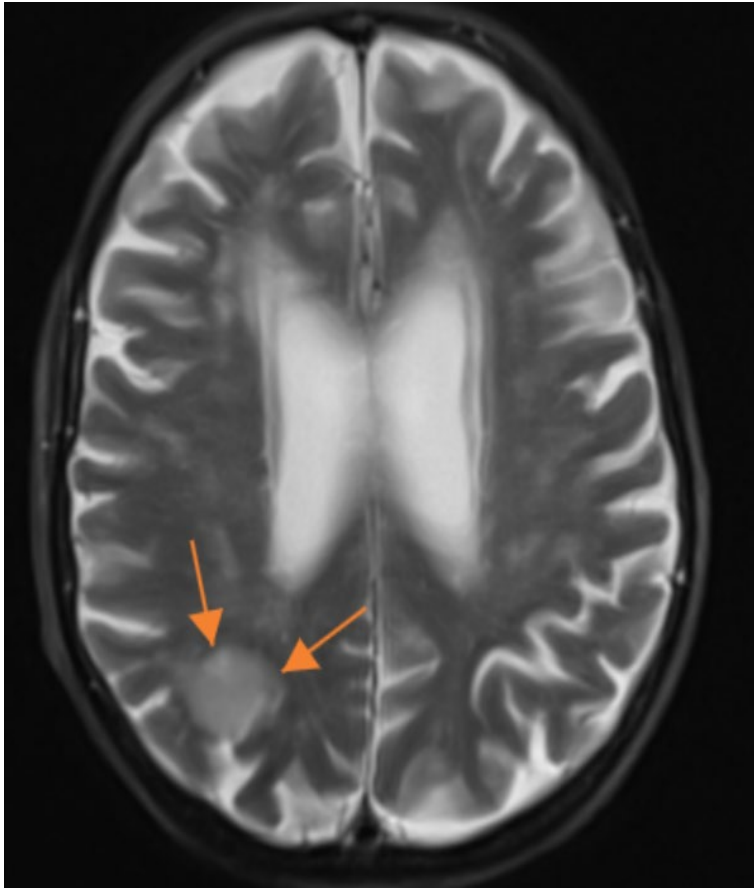
## HI-2 : Confluent petechiae, no mass effect



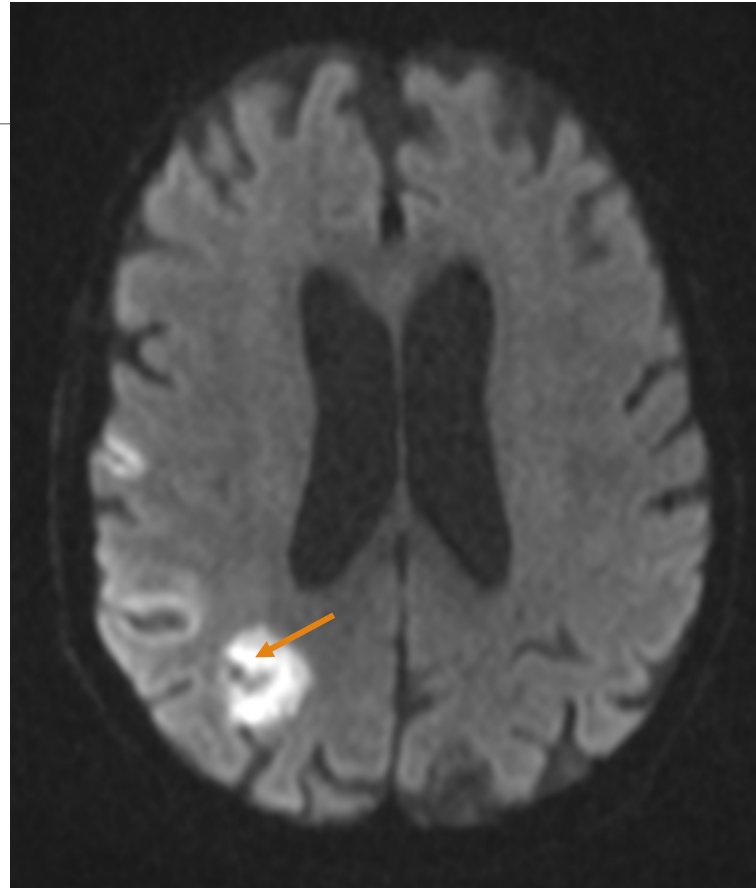
**DWI** shows bilateral cerebellar infarcts.

**SWI** shows confluent petechiae in infarct region suggestive of **HI-2**

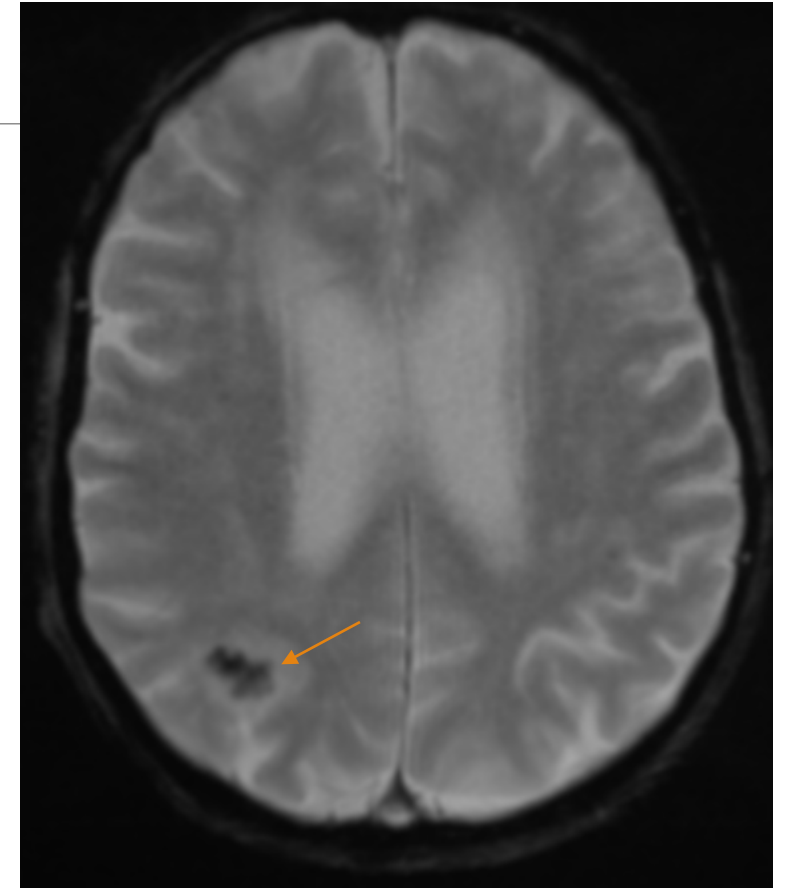
## HI-2: confluent small petechiae



T2W images: baseline MRI shows acute infarct right parietal lobe

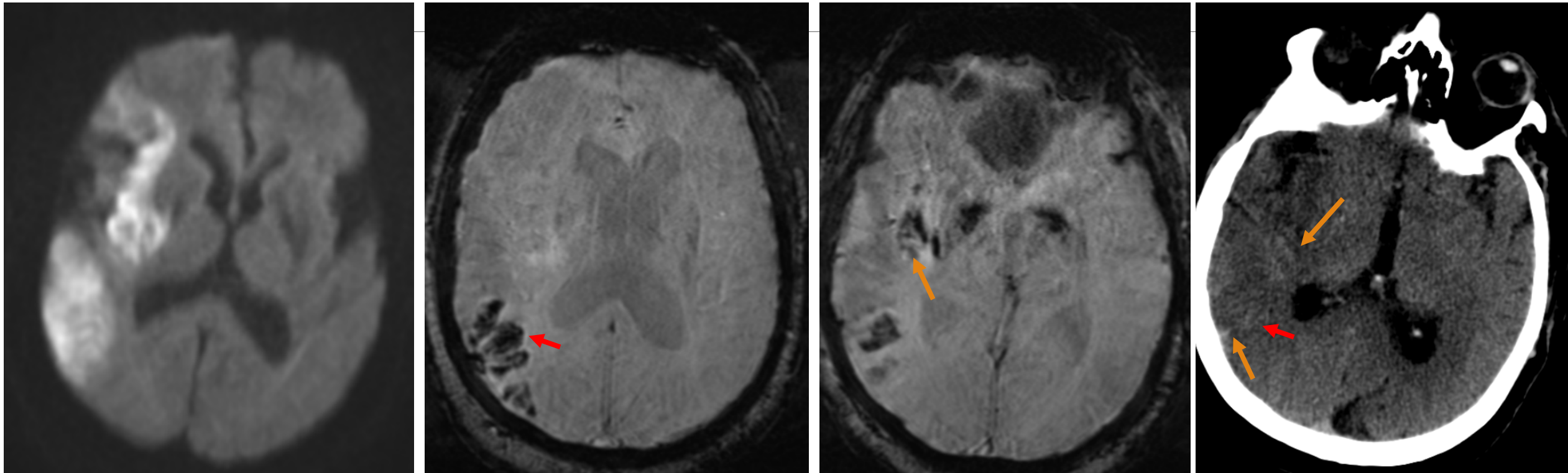


Follow up DWI shows acute infarct in right parietal lobe with punctate hypointense foci



SWI: hemorrhagic petechiae causing no mass effect

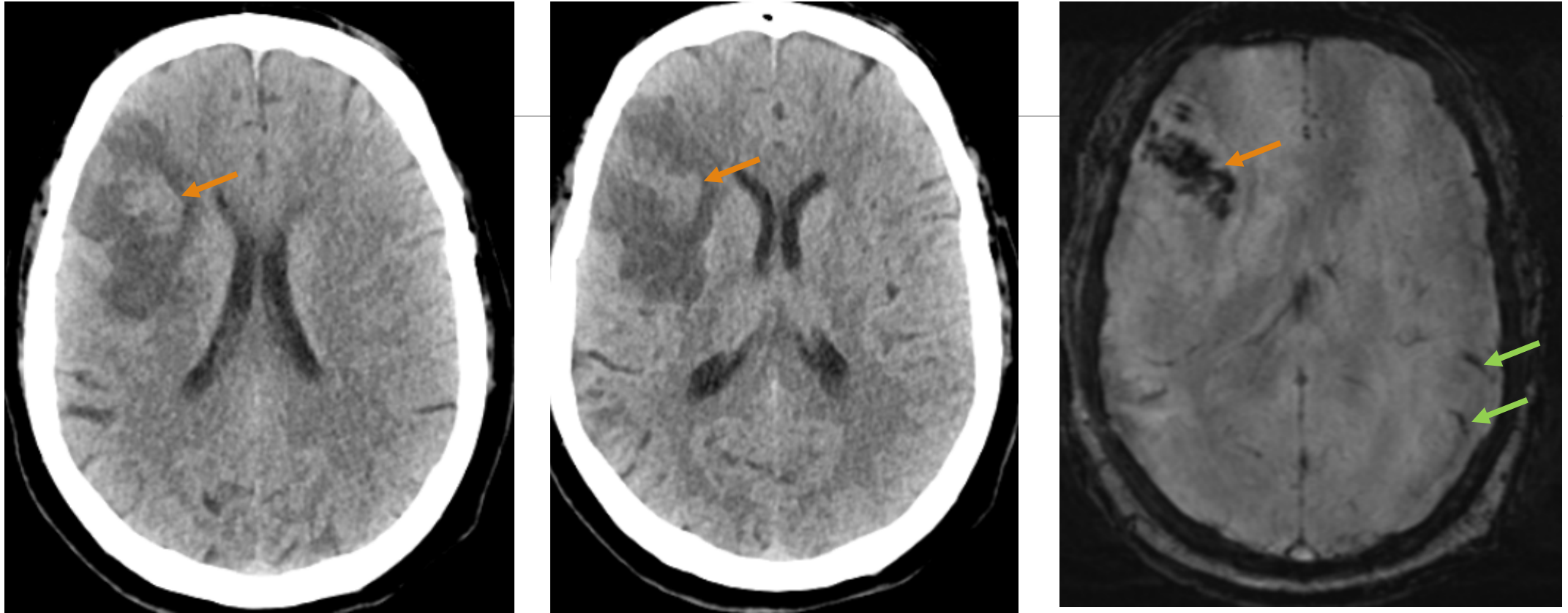
## HI-2 with subarachnoid hemorrhage (SAH)



DWI showing acute right MCA territory infarct. SWI shows **HI-2** along with **SAH in left parieto-temporal sulci**. Follow-up CT demonstrates **SAH** and faint **parenchymal petechiae**.

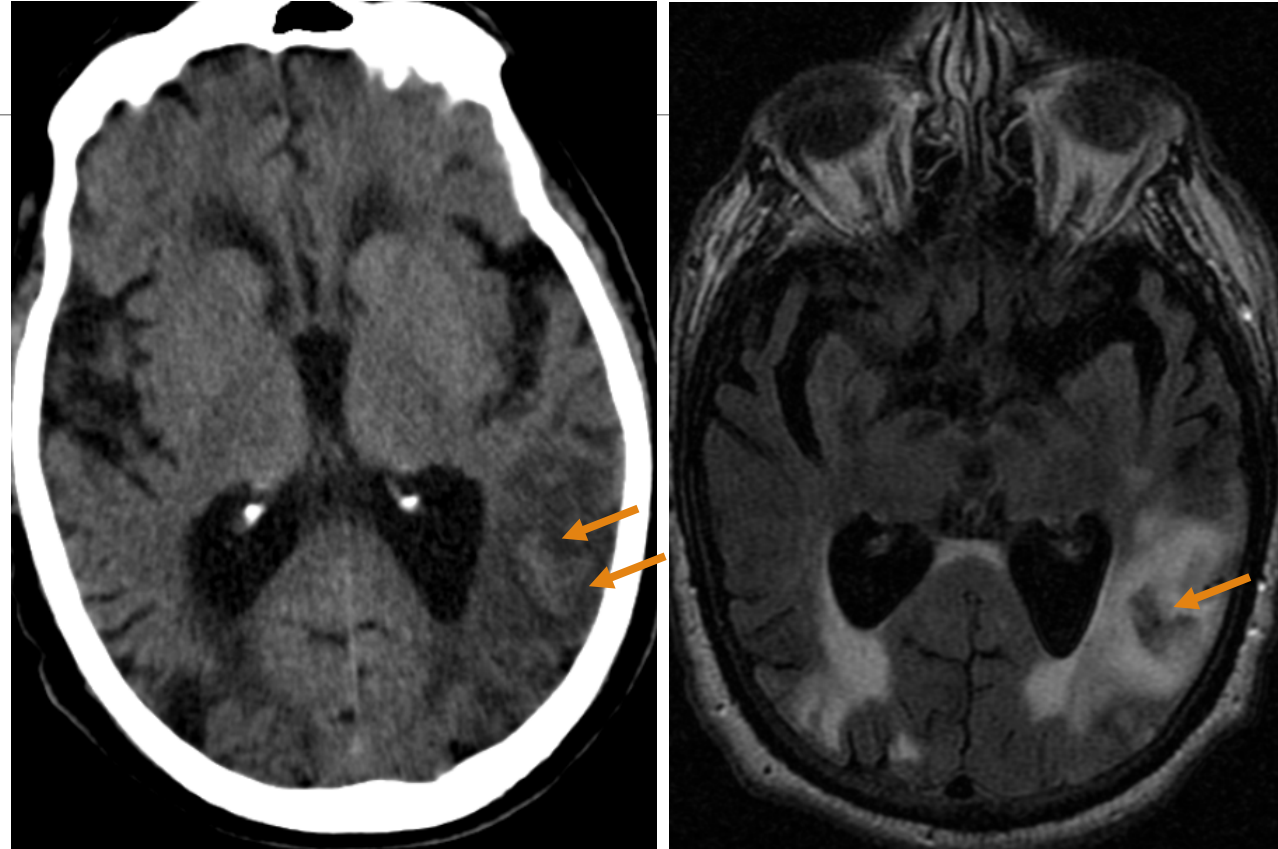


PH1: Hematoma within infarcted tissue, involving <30%, no substantiative mass effect



CT images show **hyperdense areas** in the infarct in right MCA territory suggestive of **PH-1**, confirmed on SWI. Some parietal **superficial siderosis** is also noted.

**PH1: Hematoma within infarcted tissue, involving <30%, no substantiative mass effect**

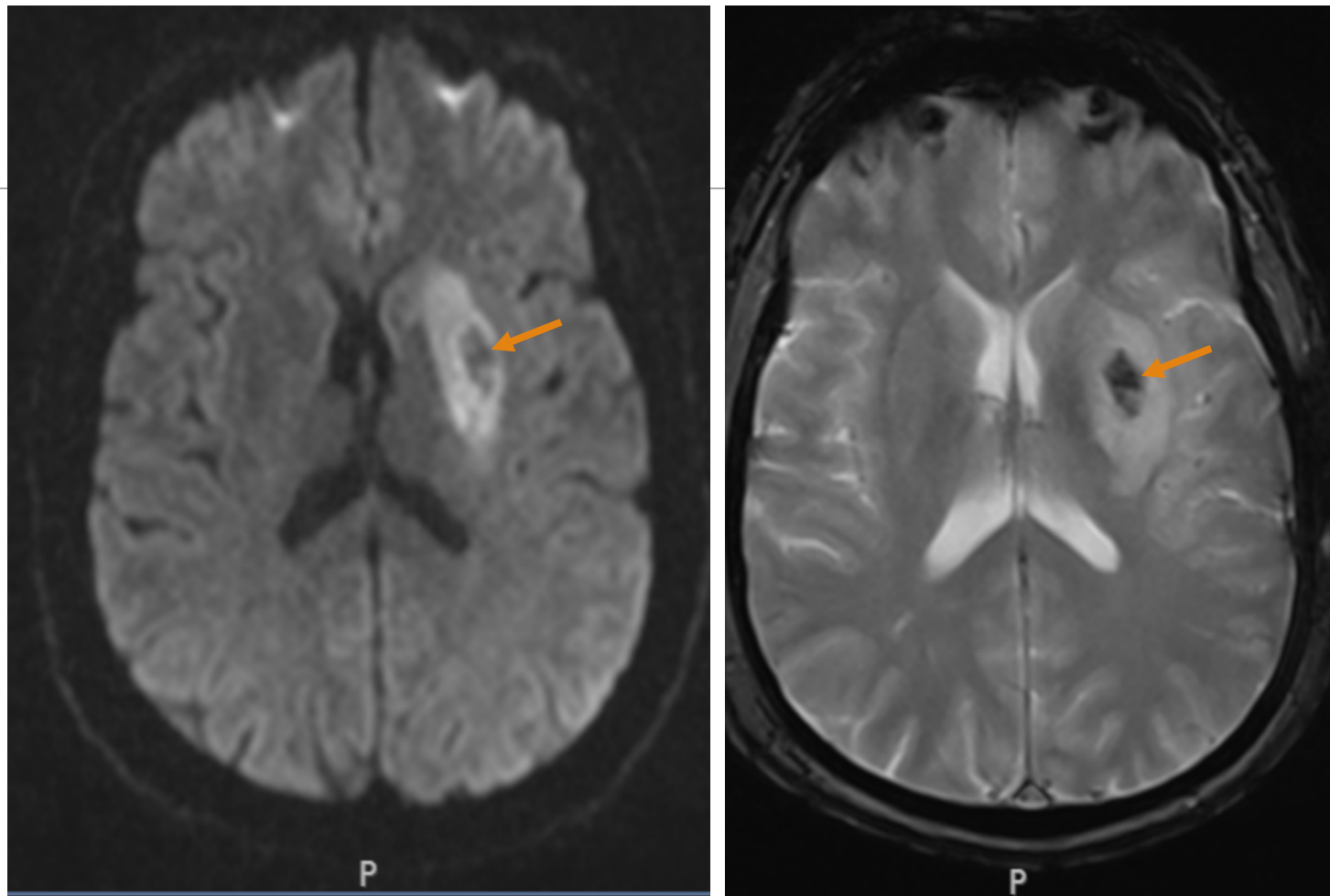


Hyperdensity is seen on **CT** in the infarcted left MCA/ watershed territory suggestive of **PH1**.

**FLAIR-MRI images** show **hypointense hematoma** in the infarct region.

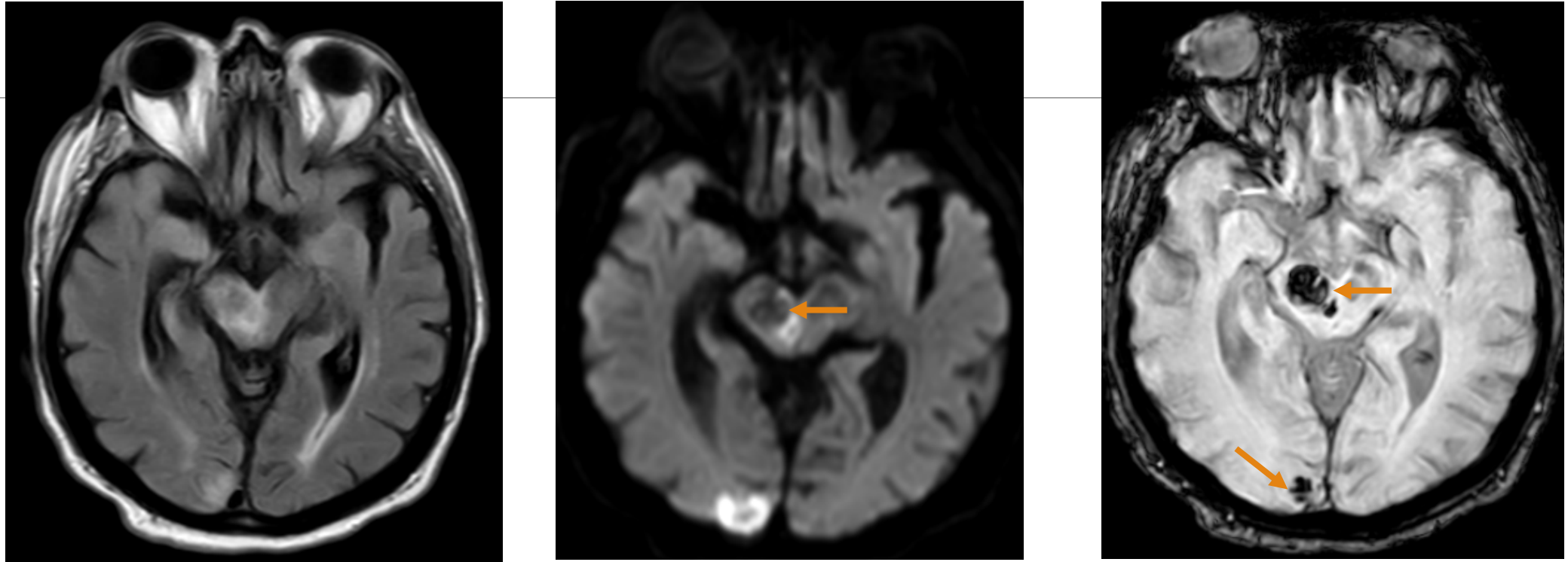
Note that there is no significant mass effect due to the hematoma.

## PH-1: Hematoma within infarcted tissue, involving <30%, no substantiative mass effect



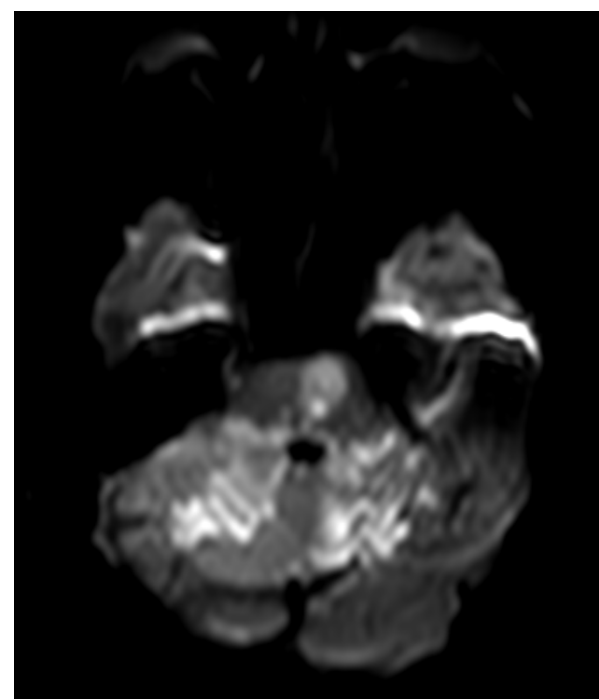
**DWI and T2W images:** Hyperintense acute ischemic infarct left basal ganglia with central hypointense hematoma. Note that there is no significant mass effect due to the hematoma.

PH-1: Hematoma within infarcted tissue, involving <30%, no substantiative mass effect

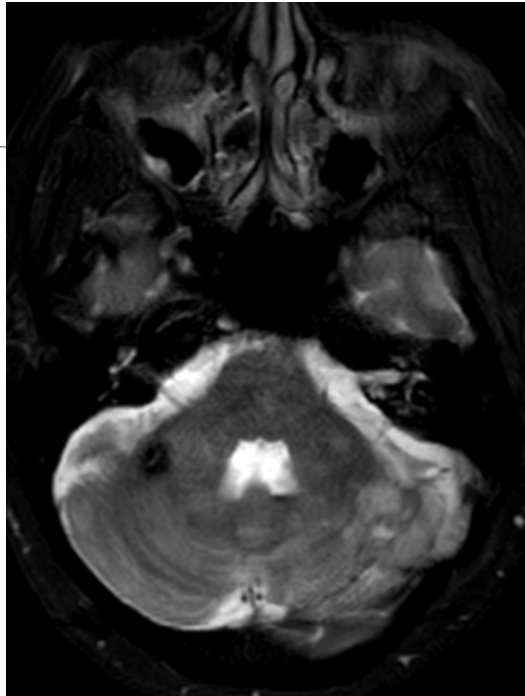


**FLAIR and DWI** show hyperintense acute infarcts in right posterior circulation territory with some heterogeneity in midbrain and right occipital lobe. **SWI** confirms **PH-1** at these regions.

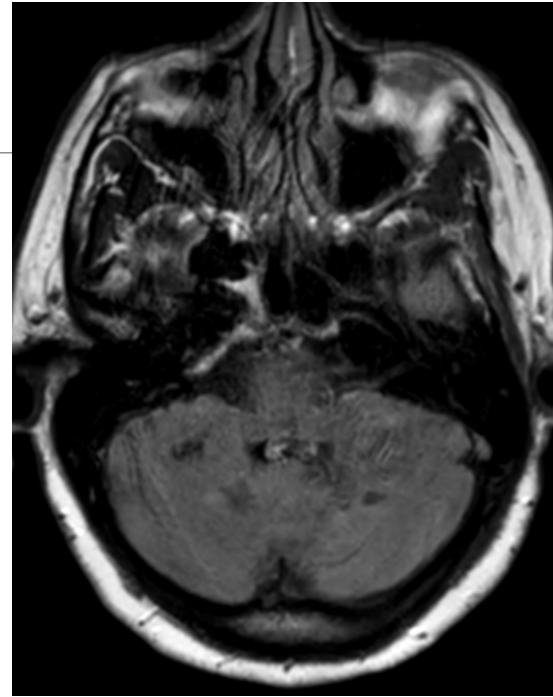
# PH-1 with Intraventricular hemorrhage (IVH) with subdural hemorrhage (SDH) along Tentorium Cerebelli



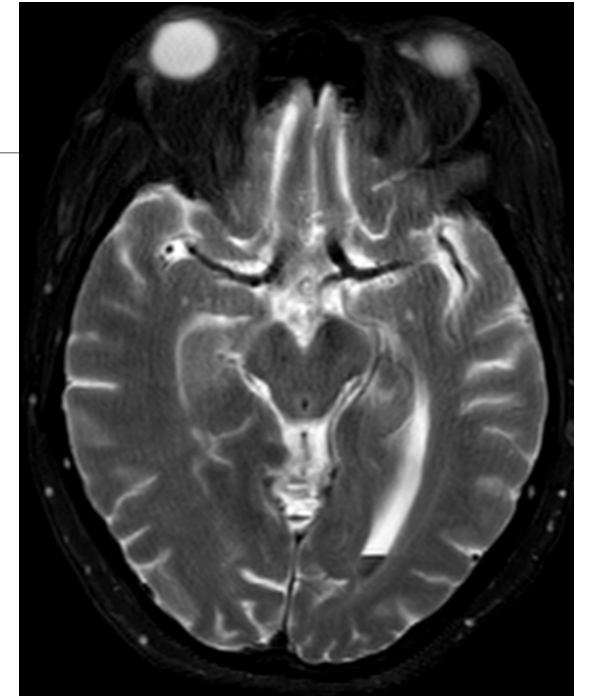
**DWI** – acute infarct – posterior vascular territories



**T2 weighted images**- PH1 in right middle cerebellar peduncle



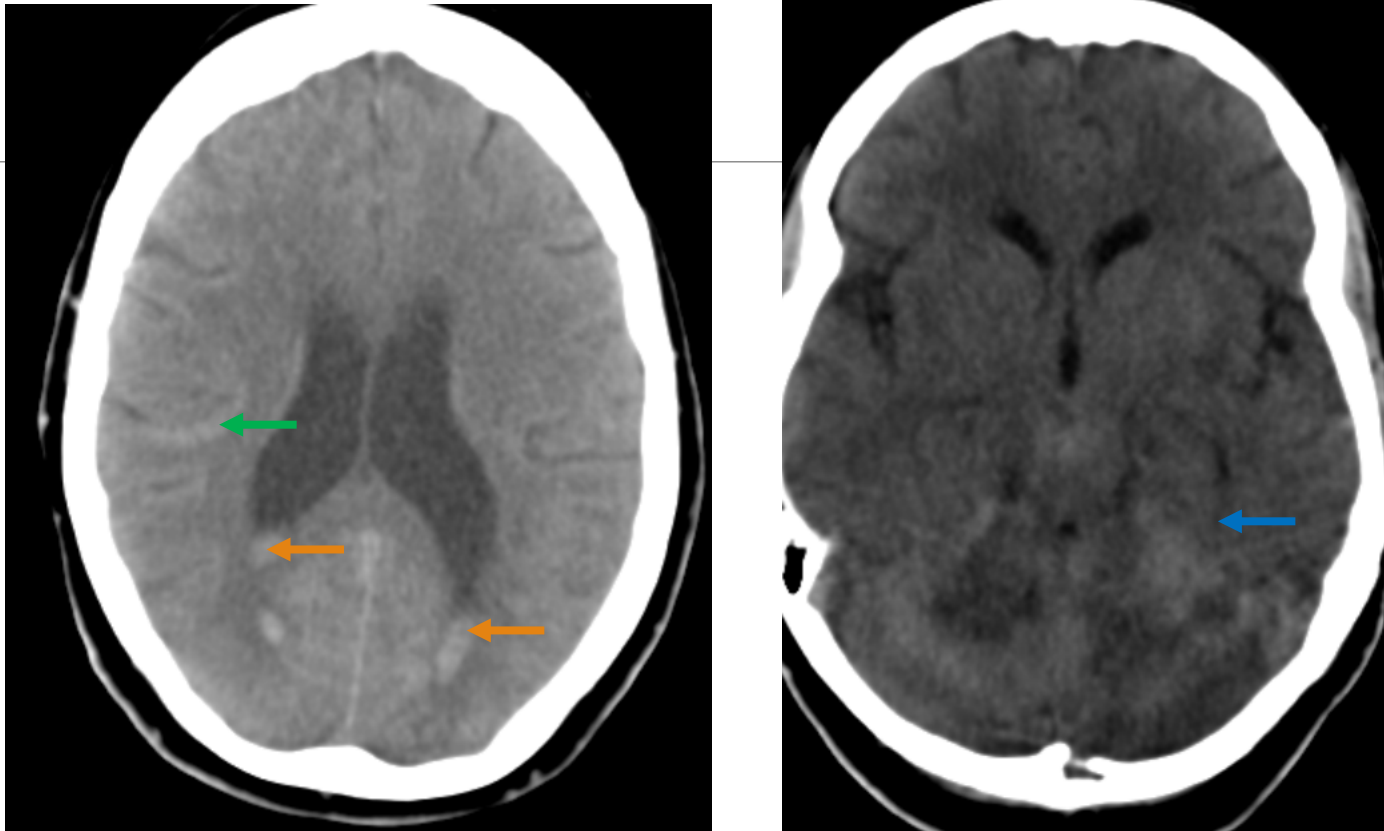
**FLAIR** – showing other foci of hemorrhage



**T2 W** – dependent IVH in left lateral ventricle

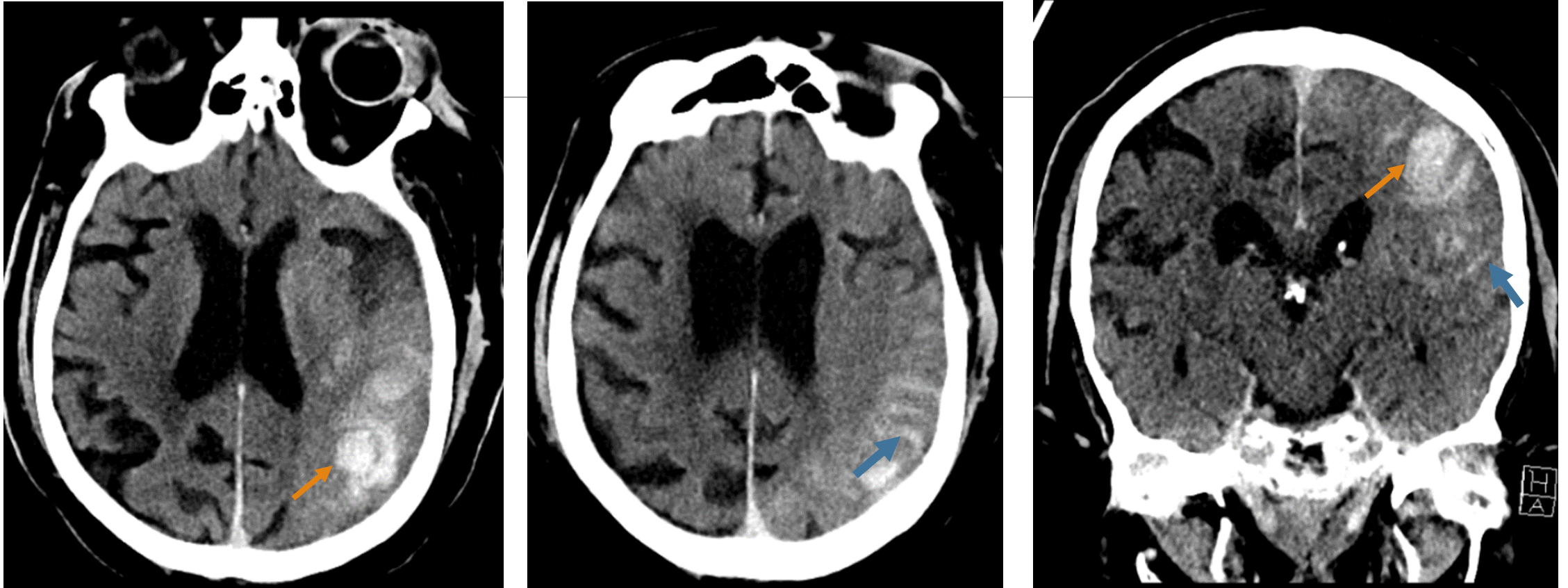
*Continued....*

## PH-1 with Intraventricular hemorrhage with subdural hemorrhage along tentorium cerebelli



CT images – **IVH** in bilateral lateral ventricles, **SAH** and **SDH** along tentorium cerebelli.

PH-2: Hematoma involving  $\geq 30$  percent of infarcted brain tissue, with obvious mass effect with Subarachnoid hemorrhage (SAH)

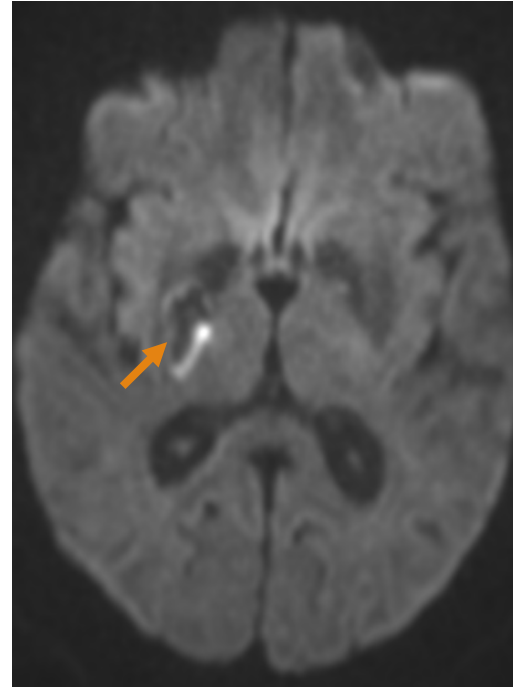


CT shows hyperdense **parenchymal hematoma suggestive of PH-2** in left parietal lobe causing mass effect, along with **hyperdense sulcal spaces suggestive of acute SAH**.

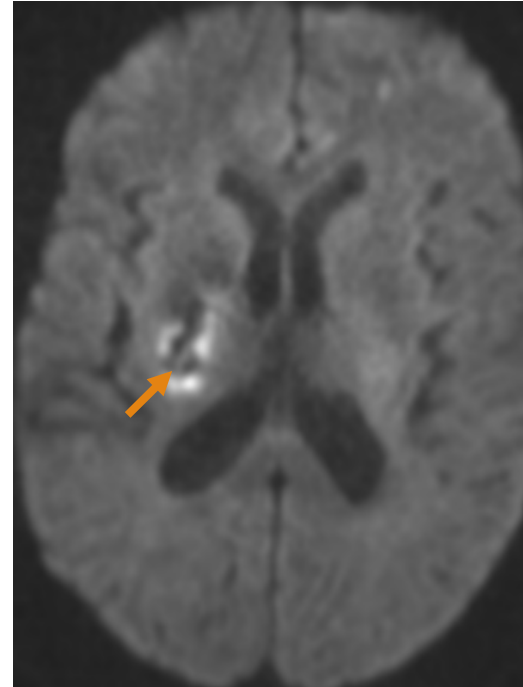
PH-2: hematoma involving 30 percent or more of infarcted brain tissue, with obvious mass effect



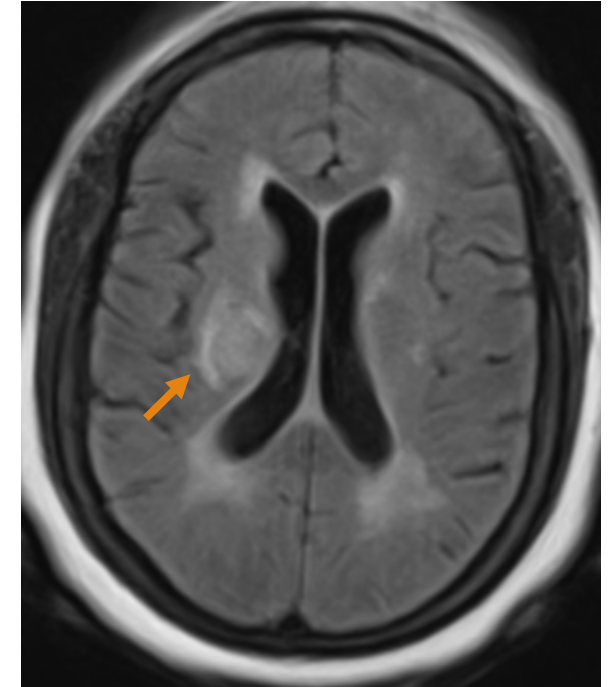
CT



DWI



DWI



FLAIR

CT shows hyperdense **parenchymal hematoma suggestive of PH-2** in right basal ganglia involving more than 30% of infarct volume. , along with **hyperdense sulcal spaces suggestive of acute SAH**.



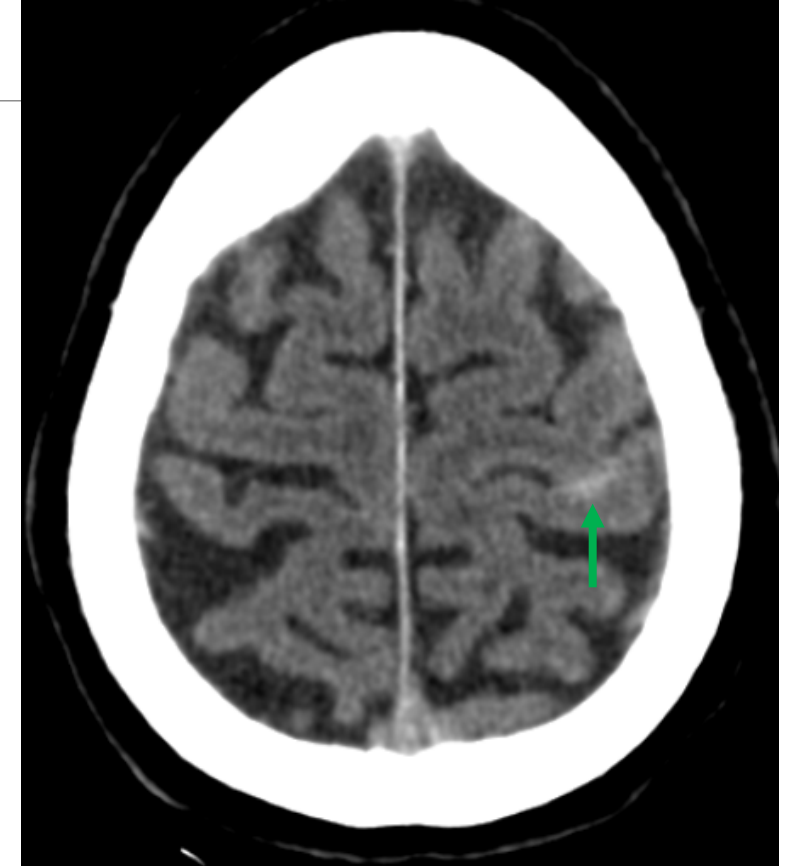
## PH-2 with intraventricular hemorrhage (IVH) with subarachnoid hemorrhage (SAH)



Left MCA territory infarct with **large parenchymal hematoma** left basal ganglia with **IVH** in bilateral lateral ventricles

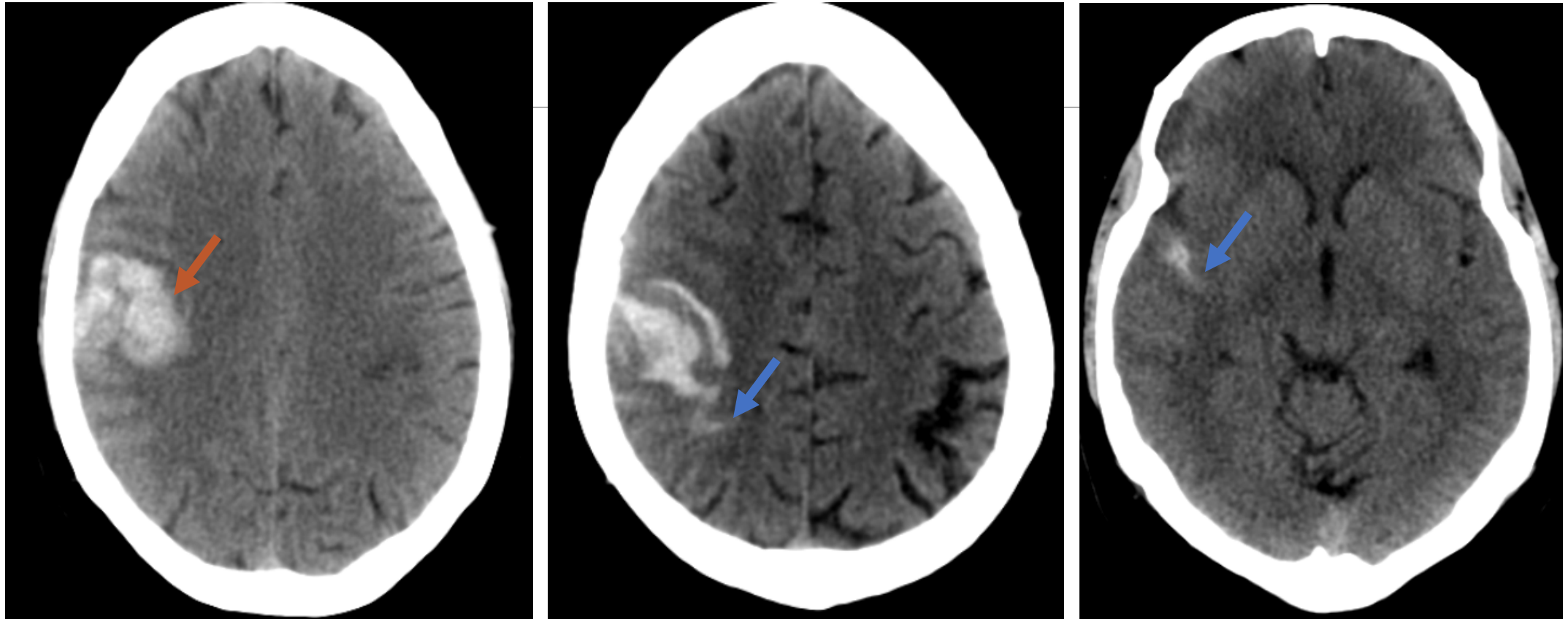


IVH seen extending to third ventricle (**blue arrow**)



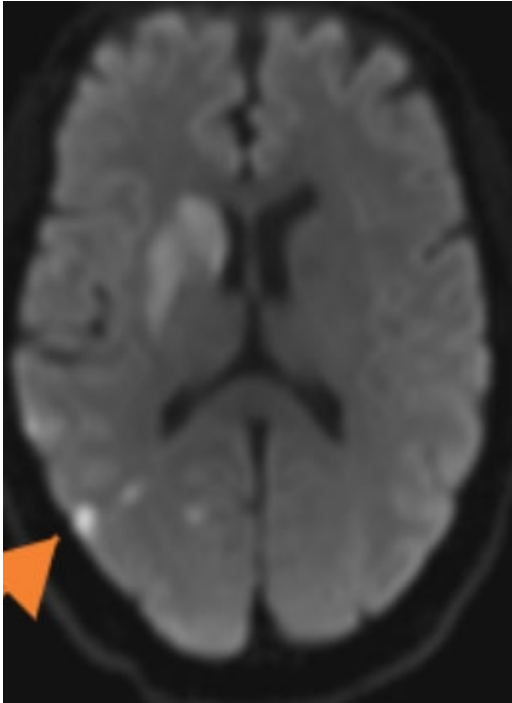
**SAH** in left frontal sulcal spaces

## PH-2 with Subarachnoid Hemorrhage

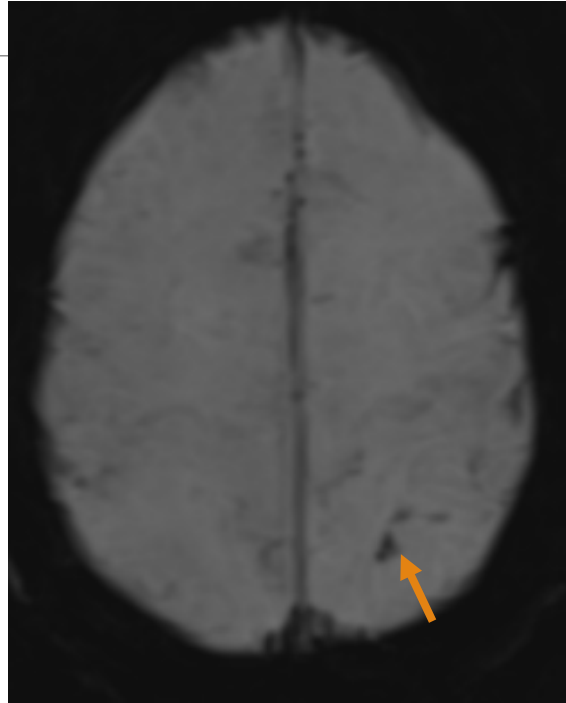


Noncontrast CT images show **parenchymal hematoma** right frontal lobe with accompanying **SAH** seen in right frontal sulci and right sylvian fissure.

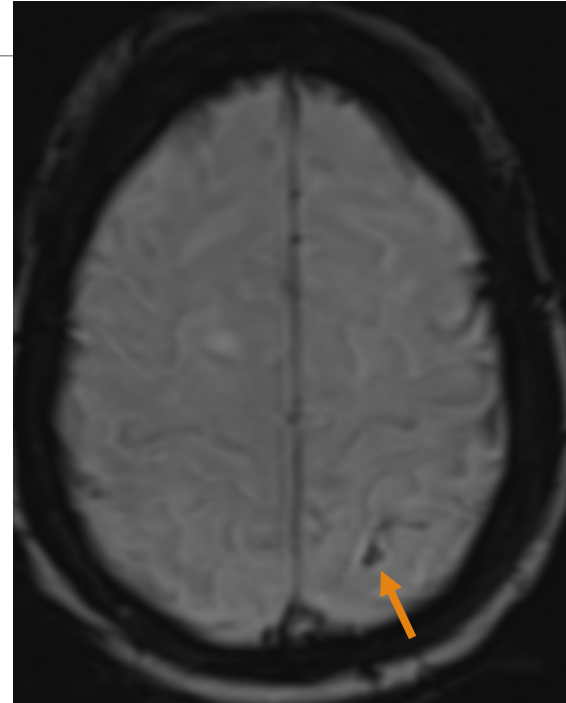
## Subarachnoid hemorrhage (SAH)- Heidelberg Class 3c (can be seen away from the infarct location)



**DWI** – Acute infarcts in right basal ganglia and right MCA territory

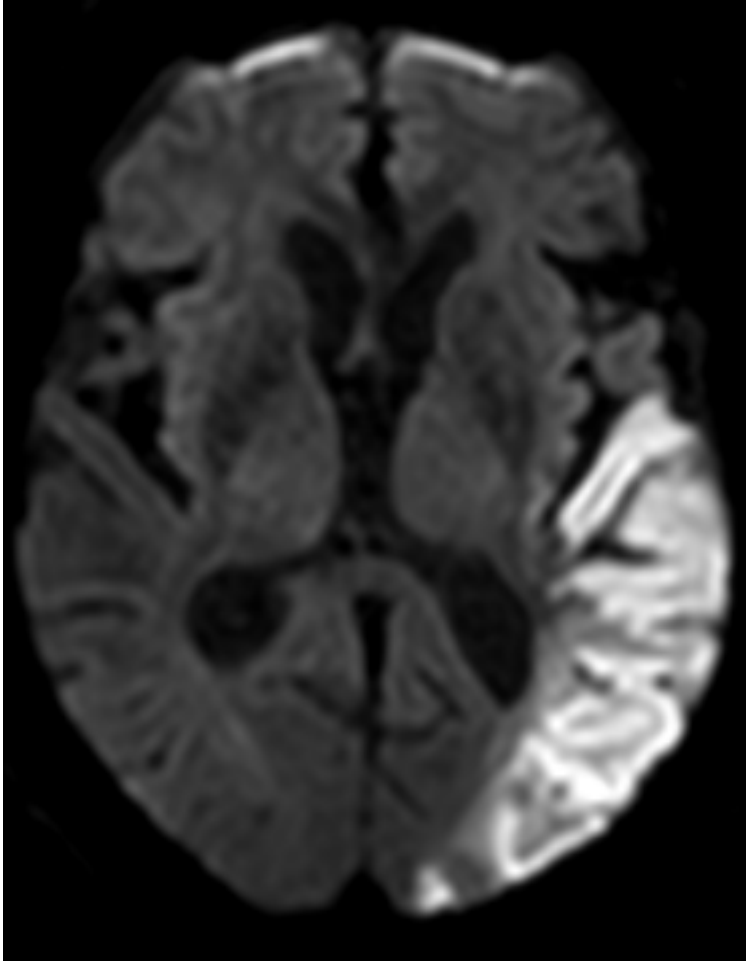


**SWI** – SAH in Left high Parietal sulci

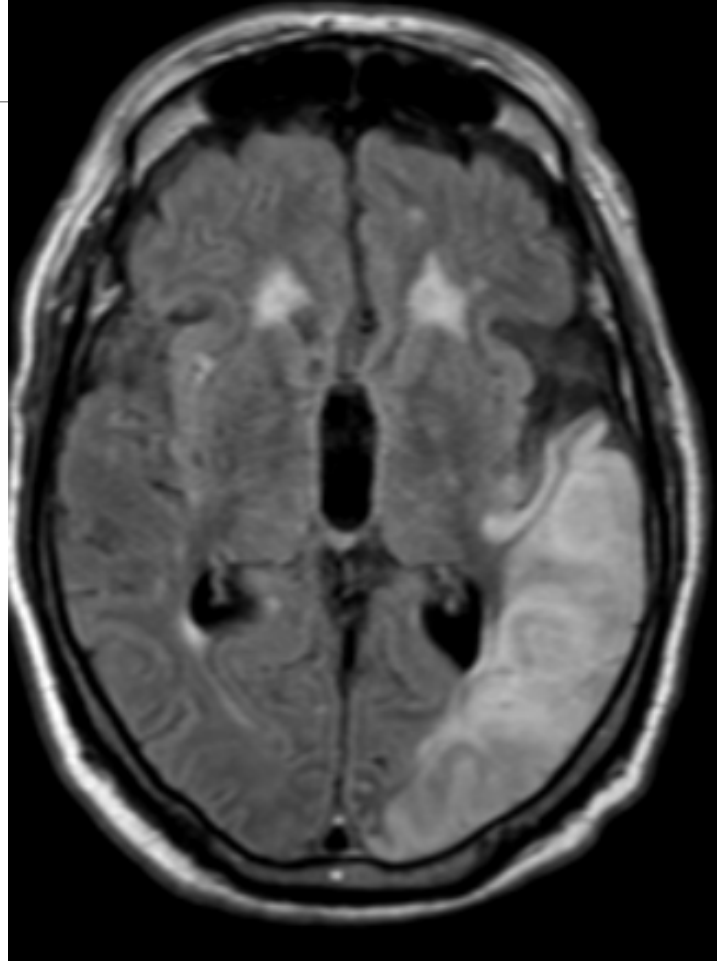


**DWI** – Acute SAH in Left parietal sulcus may appear bright on diffusion weighted images

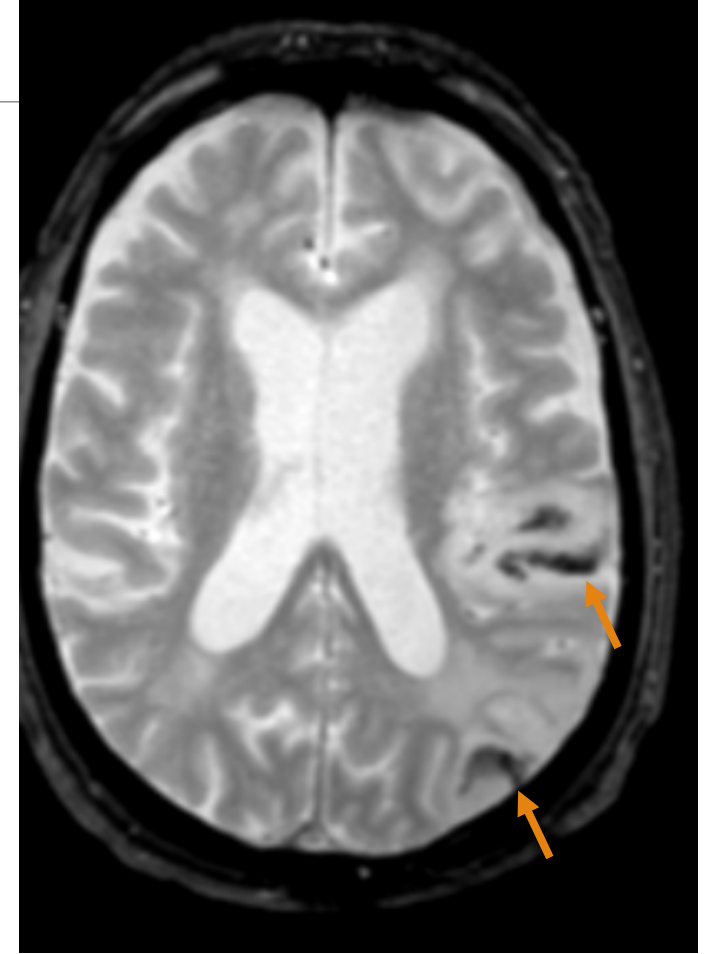
## Subarachnoid Hemorrhage (SAH)- Heidelberg class 3c



DWI



FLAIR



SWI

## Take Home Points:

- Imaging criteria for the classification of intracranial hemorrhage in cases with infarct are well- defined.
- CT imaging was used for designing this classification.
- Hemorrhagic infarctions, especially HI-1, can be subtle on CT. It is easier to visualize these subtle findings on MRI using susceptibility sequences (SWI, GRE).
- While using SWI/GRE- it is important not to confuse old microbleeds/ remote hematoma with HI/PH. Other clinical MRI sequences and CT can be useful in this.
- It is important to be careful of artefacts and parenchymal calcifications or mineralizations on CT studies. Comparison with baseline imaging can be helpful in this.