Intracranial Pathology

A Systematic Radiological Approach

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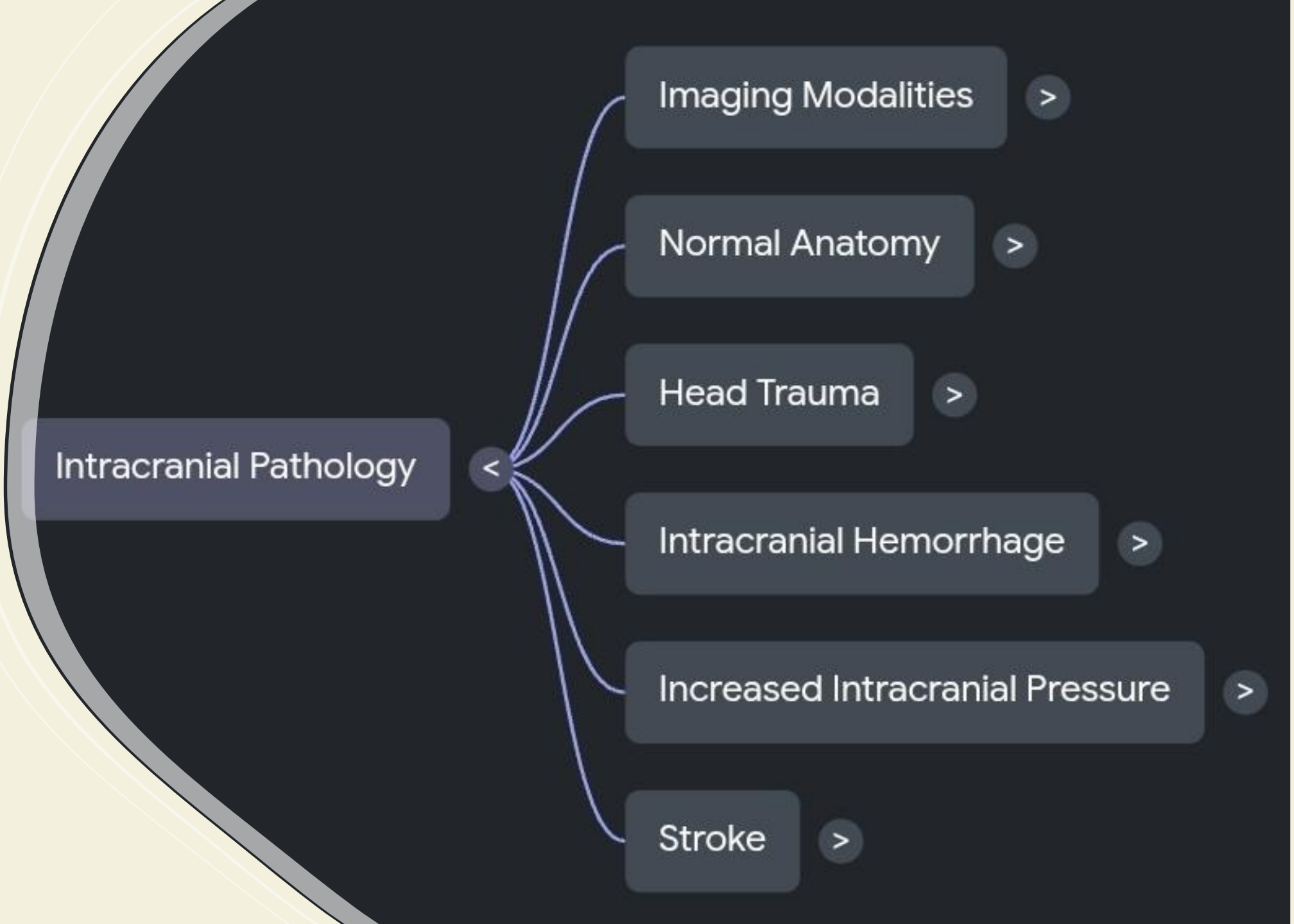
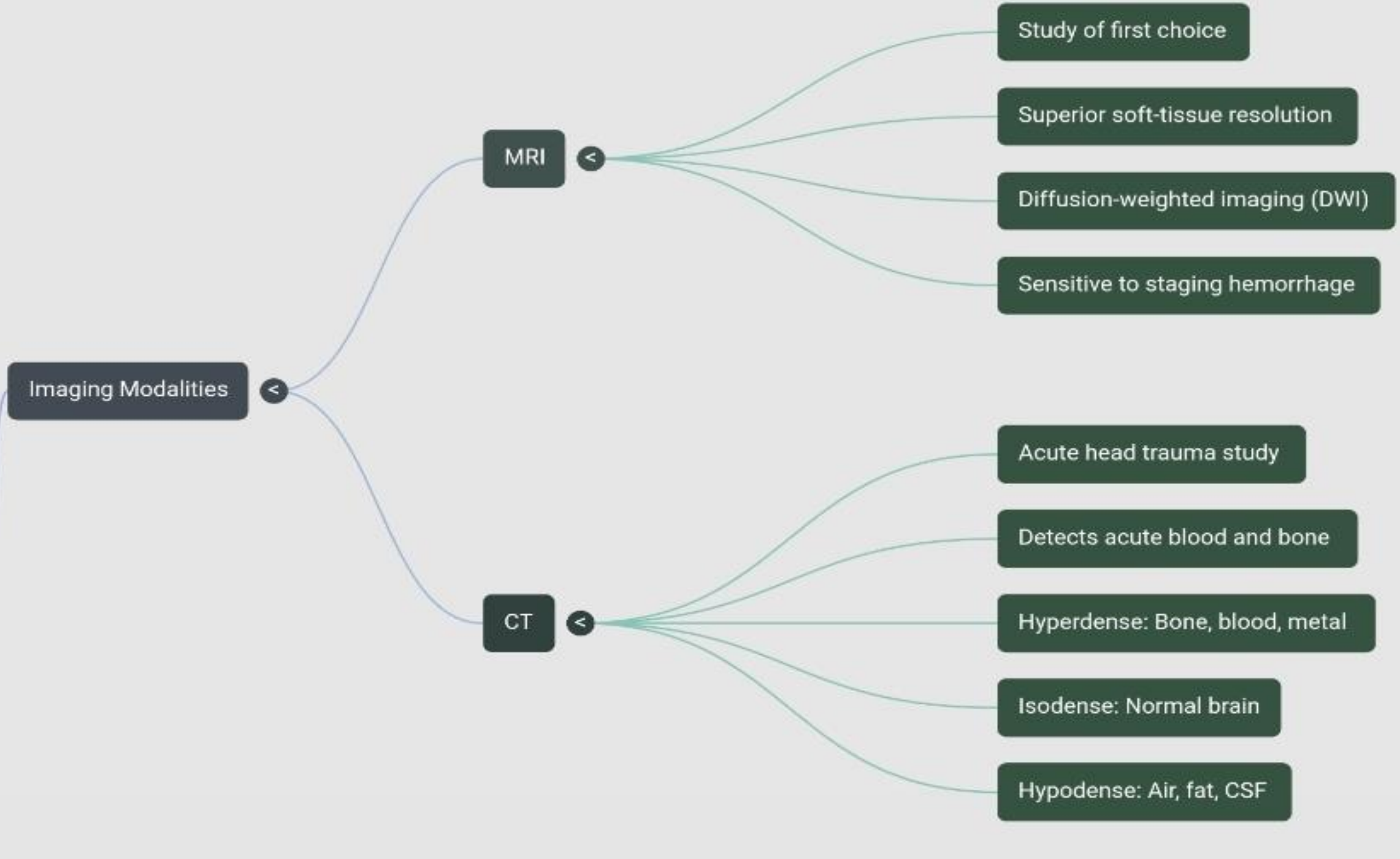

Intracranial Pathology
Imaging Modalities
Normal Anatomy
Head Trauma
Intracranial Hemorrhage
Increased Intracranial Pressure
Stroke


Imaging Modalities
MRI
Study of first choice
Superior soft-tissue resolution
Diffusion-weighted imaging (DWI)
Sensitive to staging hemorrhage
CT
Acute head trauma study
Detects acute blood and bone
Hyperdense: Bone, blood, metal
Isodense: Normal brain
Hypodense: Air, fat, CSF

MODALITY SELECTION

CT (Noncontrast)

Study of choice for acute head trauma, severe acute headache (SAH), and rapid detection of fresh blood or bone fractures.

MRI

Study of choice for almost all other scenarios (masses, chronic headaches, MS) due to superior soft-tissue resolution.

SIGNAL CHARACTERISTICS

CT Densities:

Hyperdense (White): Bone/Calcium, Acute Blood, Metal

Hypodense (Dark): Air, Fat, Water/CSF

MRI T1 vs T2:

Mnemonic: “WW2” (Water is White on T2)

T1: Water/CSF is Dark. Fat is Bright. Contrast is Bright. Gray matter is gray; White matter is lighter.

T2: Water/CSF is Bright.


Normal Anatomy
Ventricular System
Lateral ventricles
Third ventricle
Fourth ventricle
Basal Ganglia
Caudate nucleus
Lentiform nucleus
Thalamus
Brainstem
Midbrain
Pons
Medulla oblongata
Corpus callosum
Cerebellum

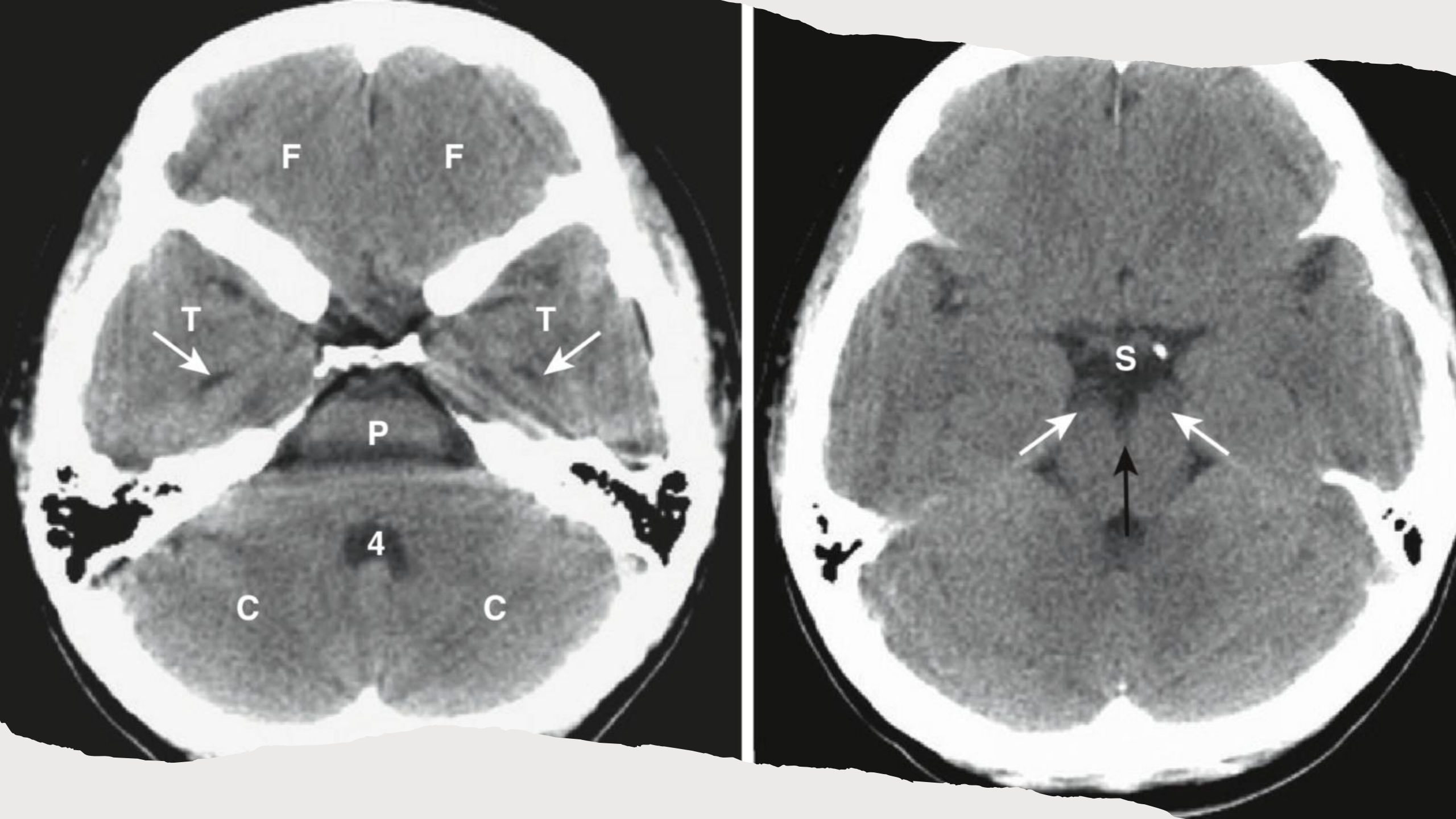
Deciphering CT Densities

HYPERDENSE (Bright White):
Bone, Blood

HYPODENSE (Dark Grey/Black):
Air, Fat, CSF

Hypodense (Dark) (AKA Hypointense)	Isodense	Hyperdense (Bright) (AKA Hyperintense)
Fat (not usually present in the head)	Normal brain	Metal (e.g., aneurysm clips or bullets)
Air (e.g., sinuses)	Some forms of protein (e.g., subacute subdural hematomas)	Iodine (after contrast administration)
Water (e.g., CSF)		Calcium
Chronic subdural hematomas/hygromas		Hemorrhage (high protein)

Intraaxial/extraaxial	Intraaxial lesions originate in the brain parenchyma and extraaxial lesions originate outside of the brain substance (i.e., meninges, intraventricular).
Infratentorial	Beneath the tentorium cerebelli, which includes the cerebellum, brainstem, fourth ventricle, and cerebellopontine angles.
Supratentorial	Above the tentorium cerebelli, which includes the cerebral hemispheres (frontal, parietal, occipital, and temporal lobes) and the sella.
Transient ischemic attack (TIA)	Sudden neurologic loss that persists for a short time and resolves within 24 hours.
Completed stroke	Neurologic deficit lasts for >21 days.
Open versus closed head injuries	***Open*** = communication of intracranial material outside of the skull. ***Closed*** = no external communication.
Increased attenuation/ hyperattenuation/hyperdense/ hyperintense	On CT, tissue that is of increased attenuation, hyperattenuates, or hyperdense is **whiter** than surrounding tissues. Hyperintense refers to **increased signal** on MRI imaging.
Decreased attenuation/ hypoattenuation/hypodense/ hypointense	On CT, tissue that is of decreased attenuation, hypoattenuates, or hypodense is **darker** than surrounding tissues. Hypointense refers to **decreased** signal on MRI imaging.
Diffusion-weighted imaging (DWI)	An MRI sequence that can be rapidly acquired and which is extremely sensitive to detecting abnormalities in normal water movement in the brain so that it can identify a stroke within 20 to 30 minutes after the event. DWI also helps differentiate acute infarction from more chronic infarction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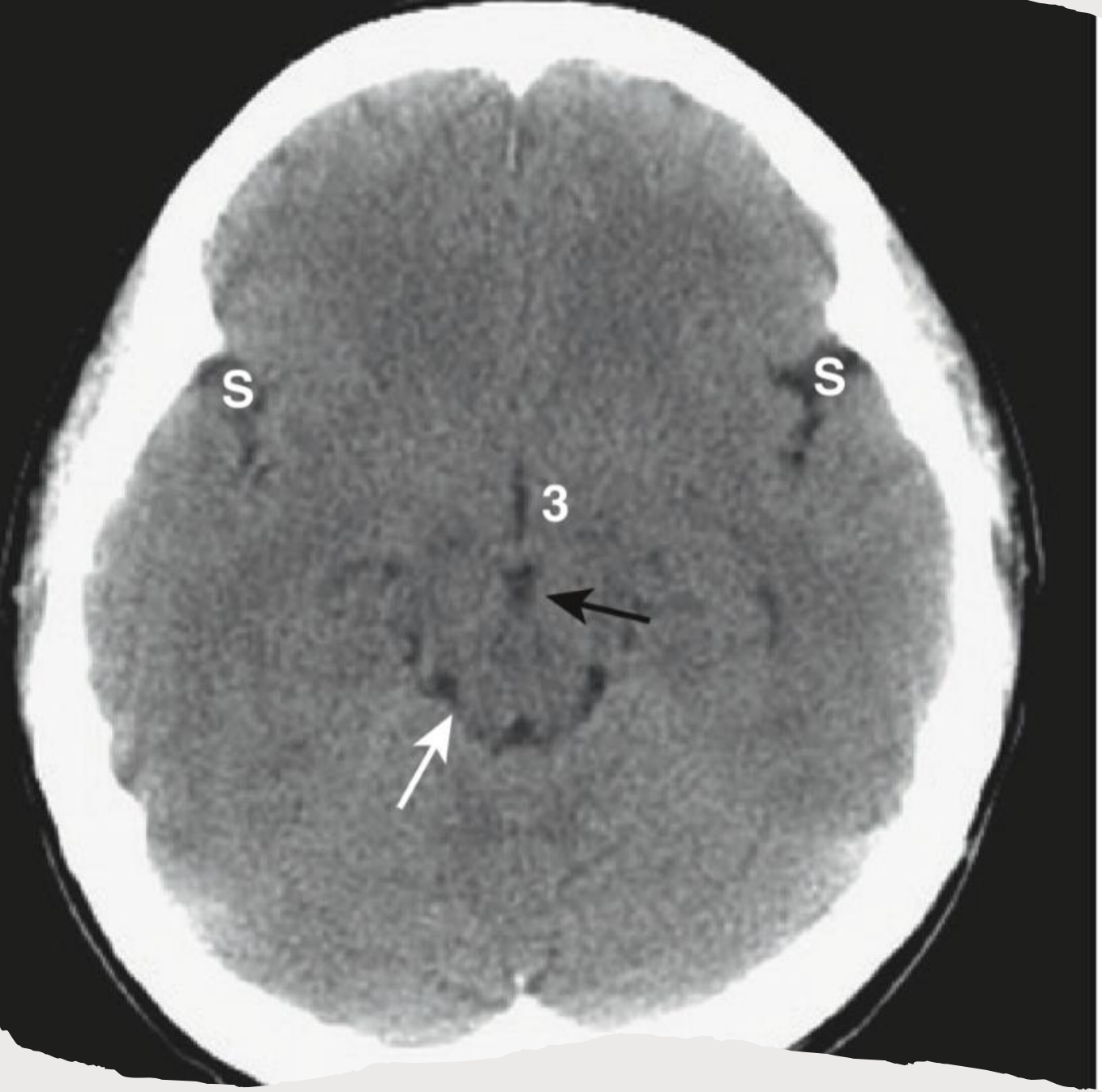
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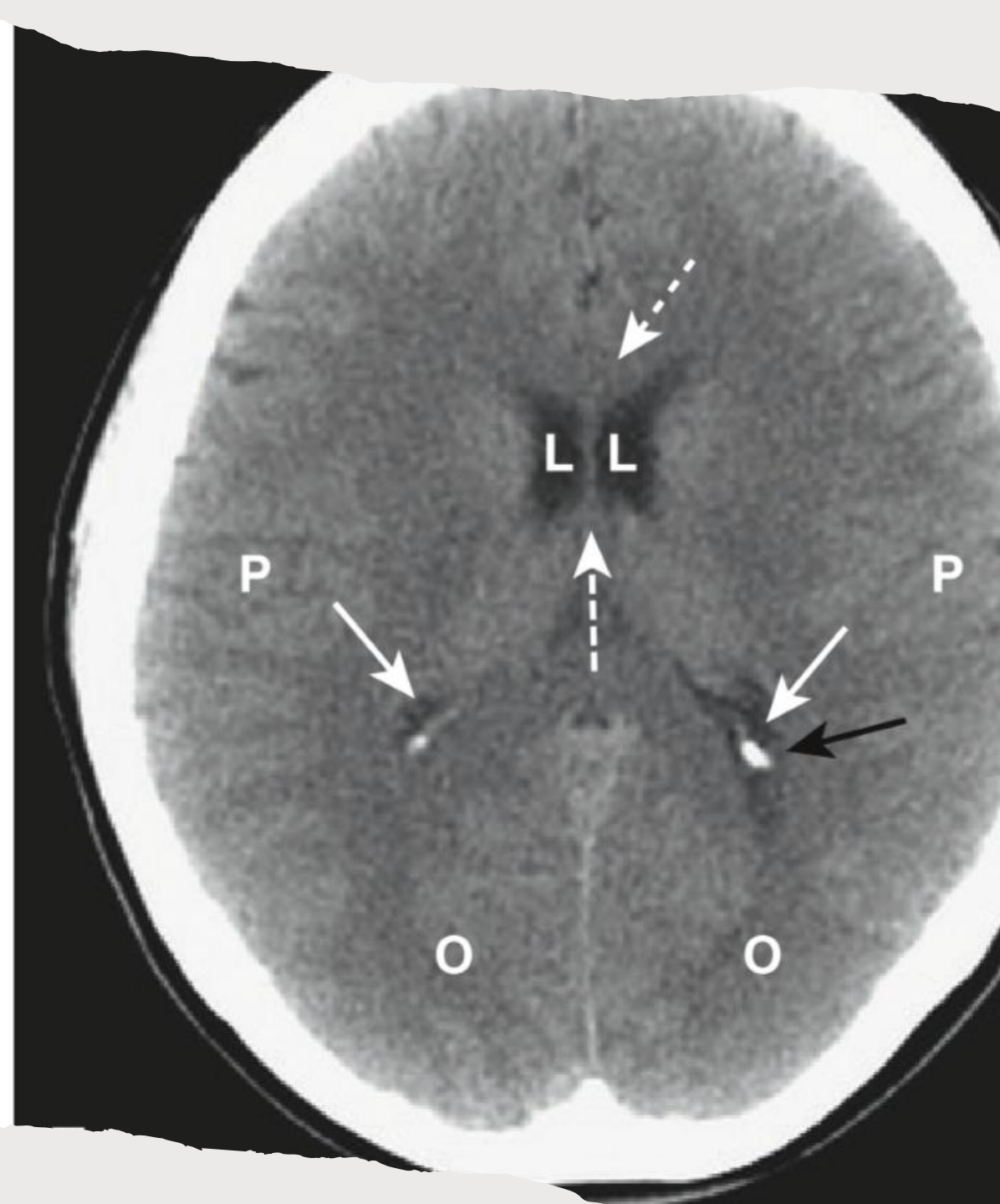
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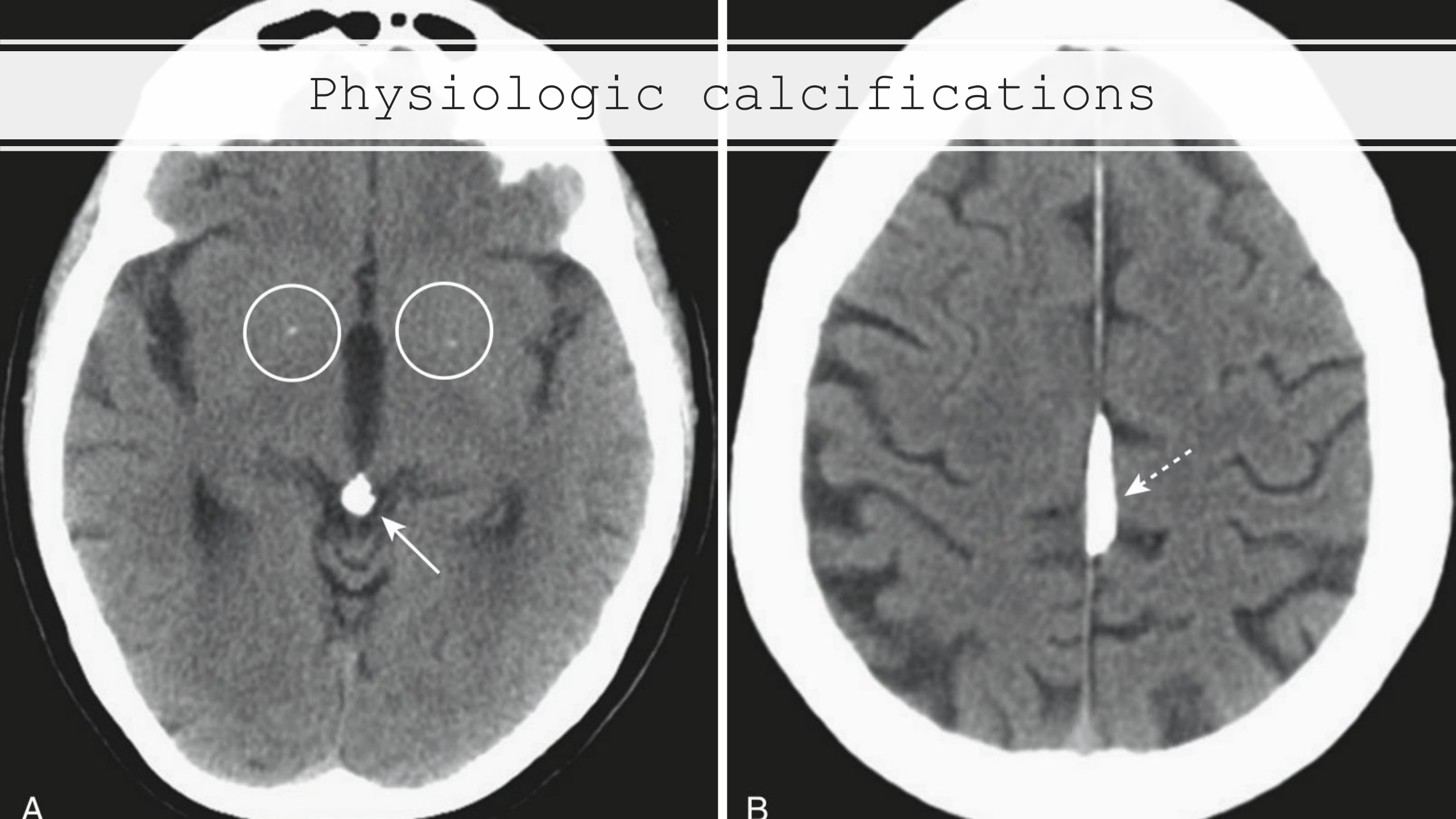
Physiologic calcifications

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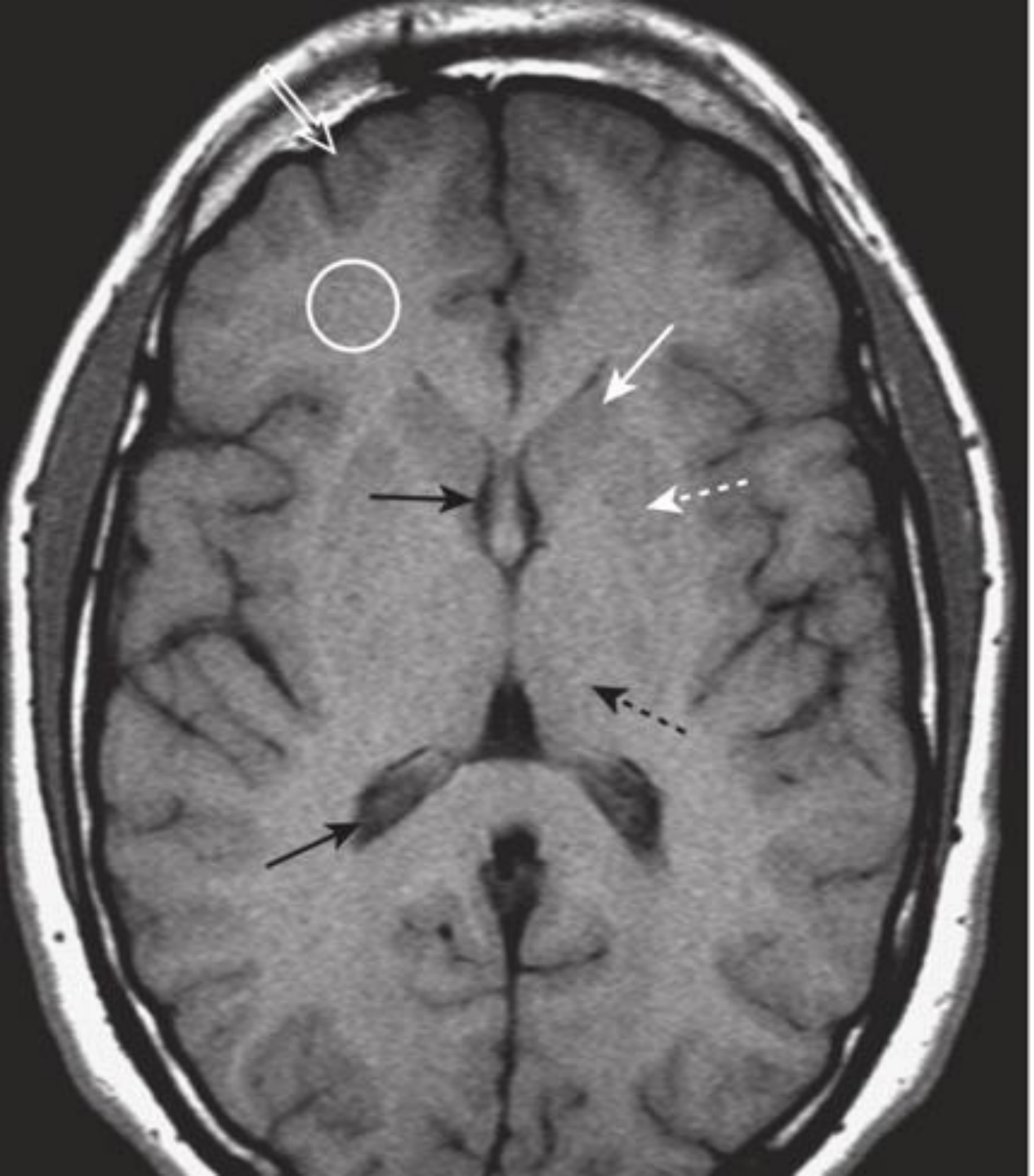
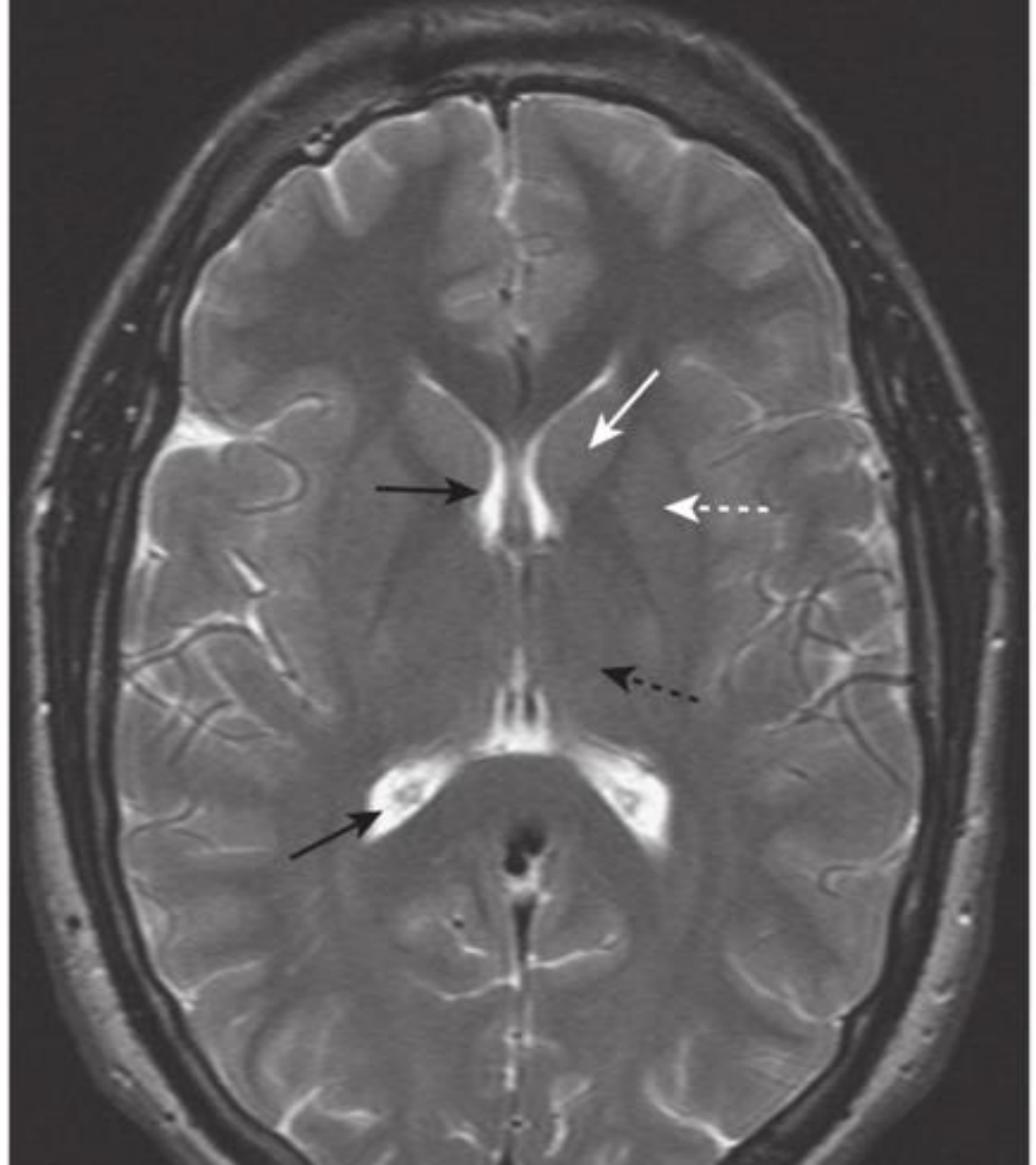
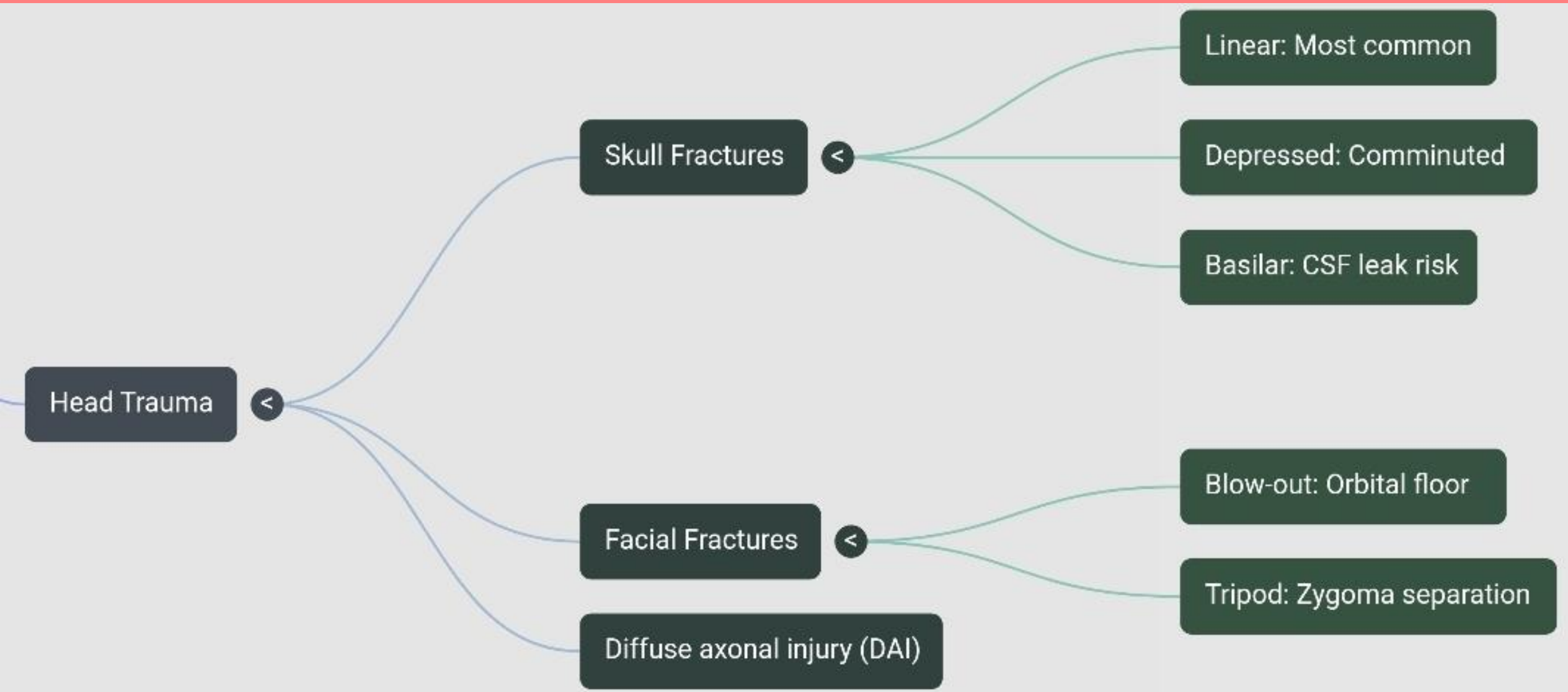
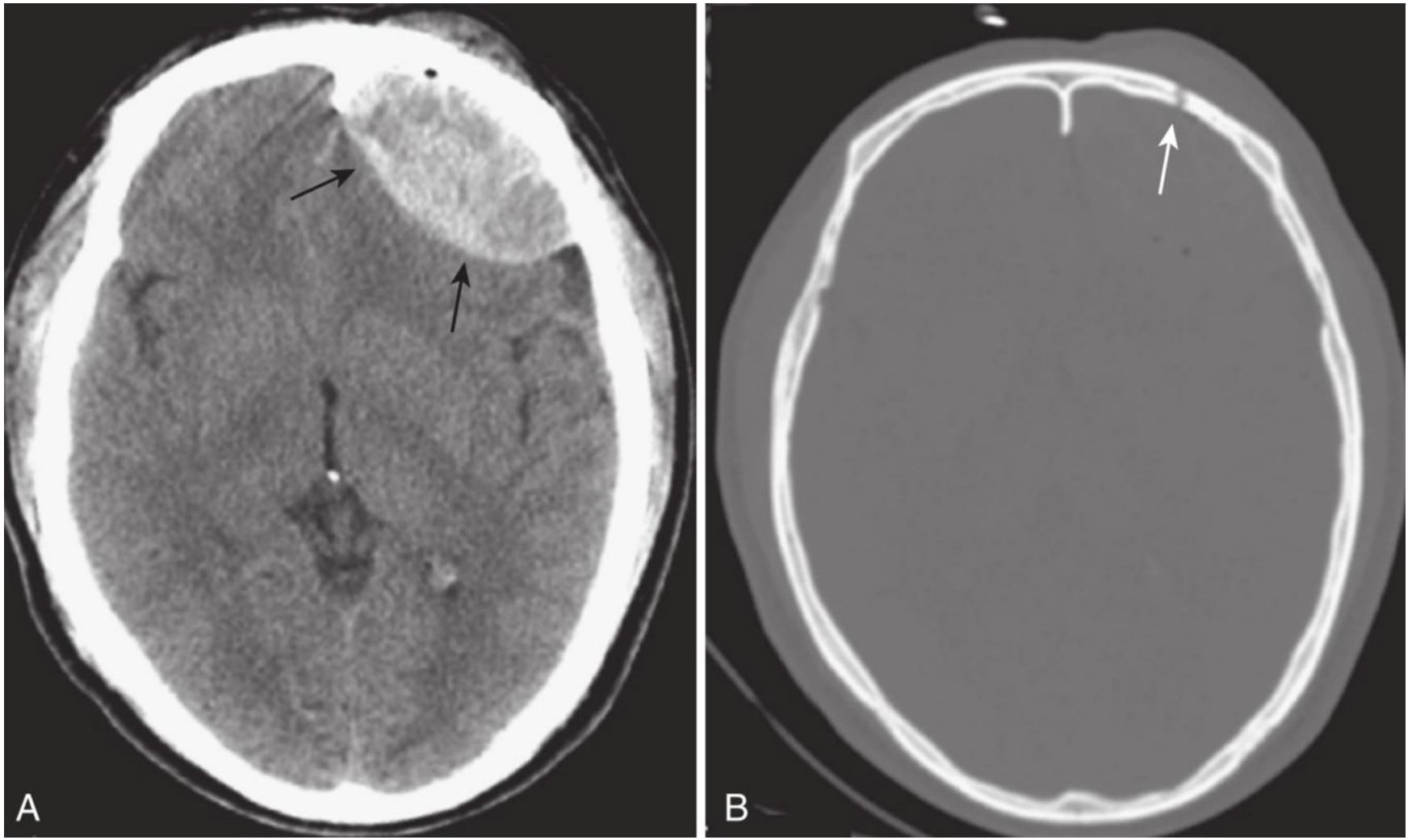
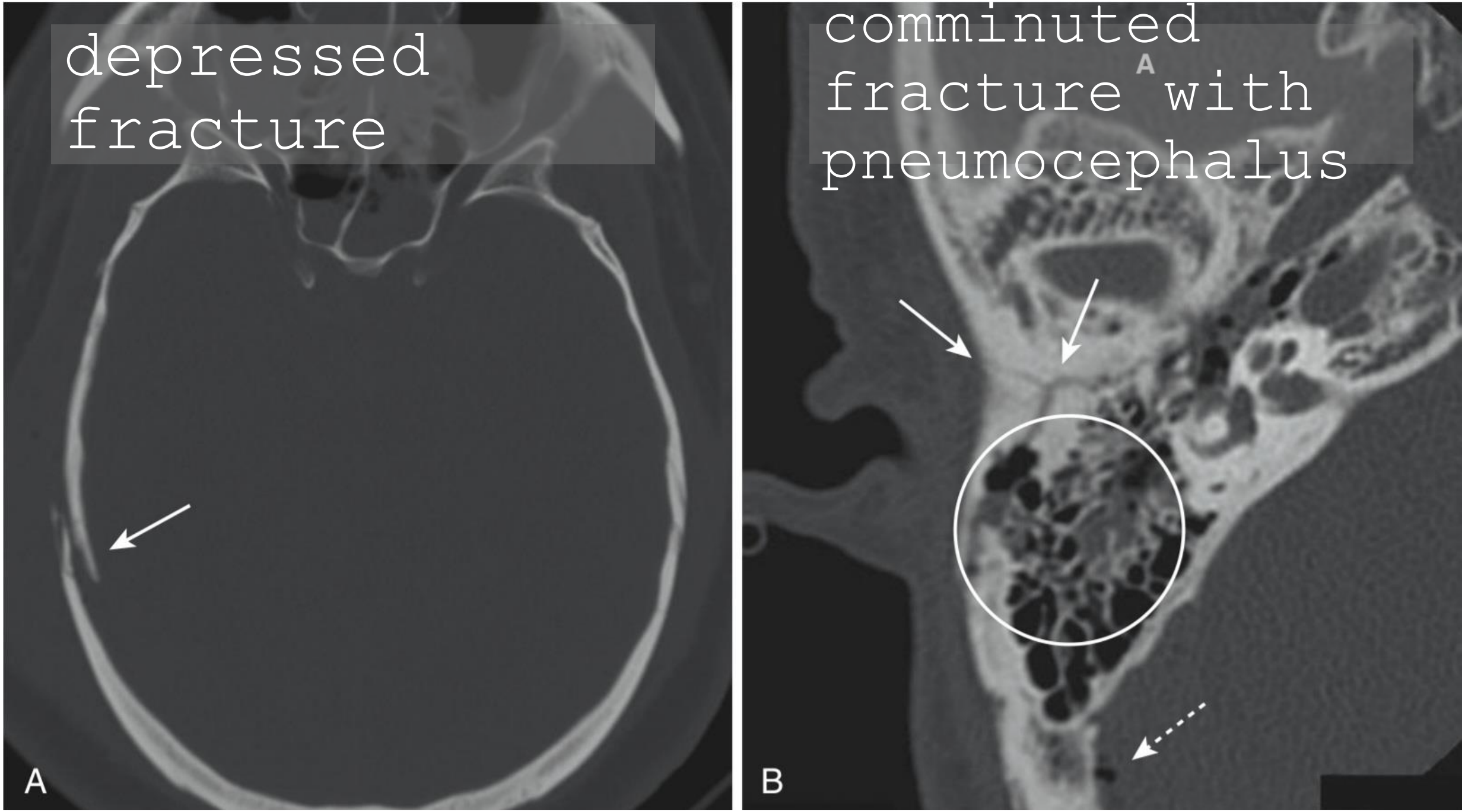


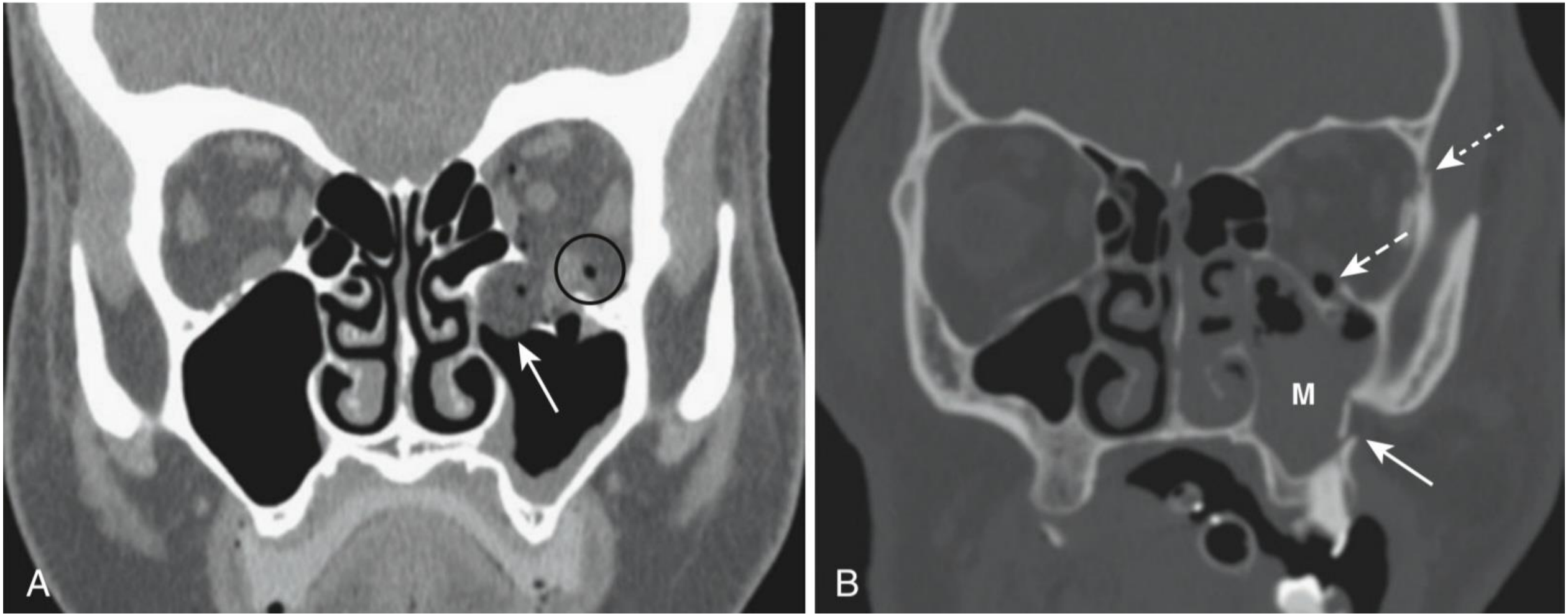



Head Trauma
Skull Fractures
Linear: Most common
Depressed: Comminuted
Basilar: CSF leak risk
Facial Fractures
Blow-out: Orbital floor
Tripod: Zygoma separation
Diffuse axonal injury (DAI)

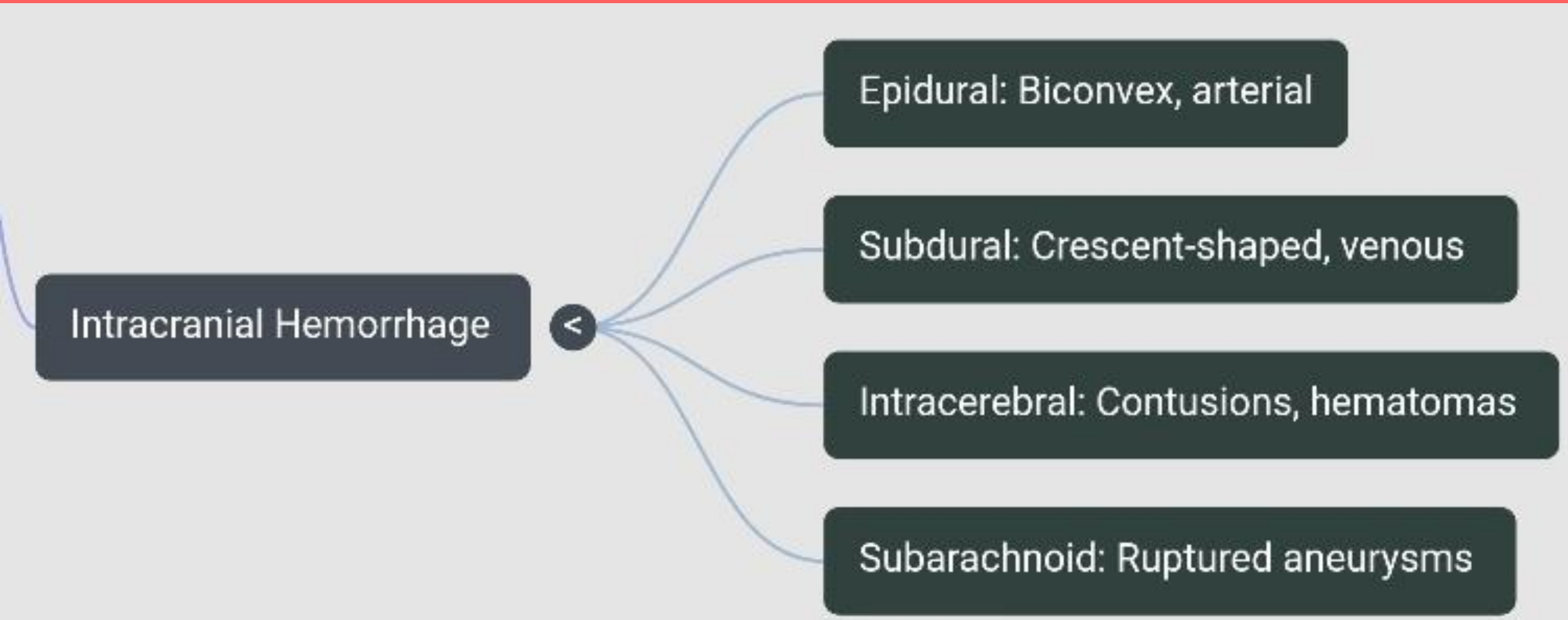
"Brain" and "Bone" Windows




depressed fracture
A
comminuted fracture with pneumocephalus
A
B

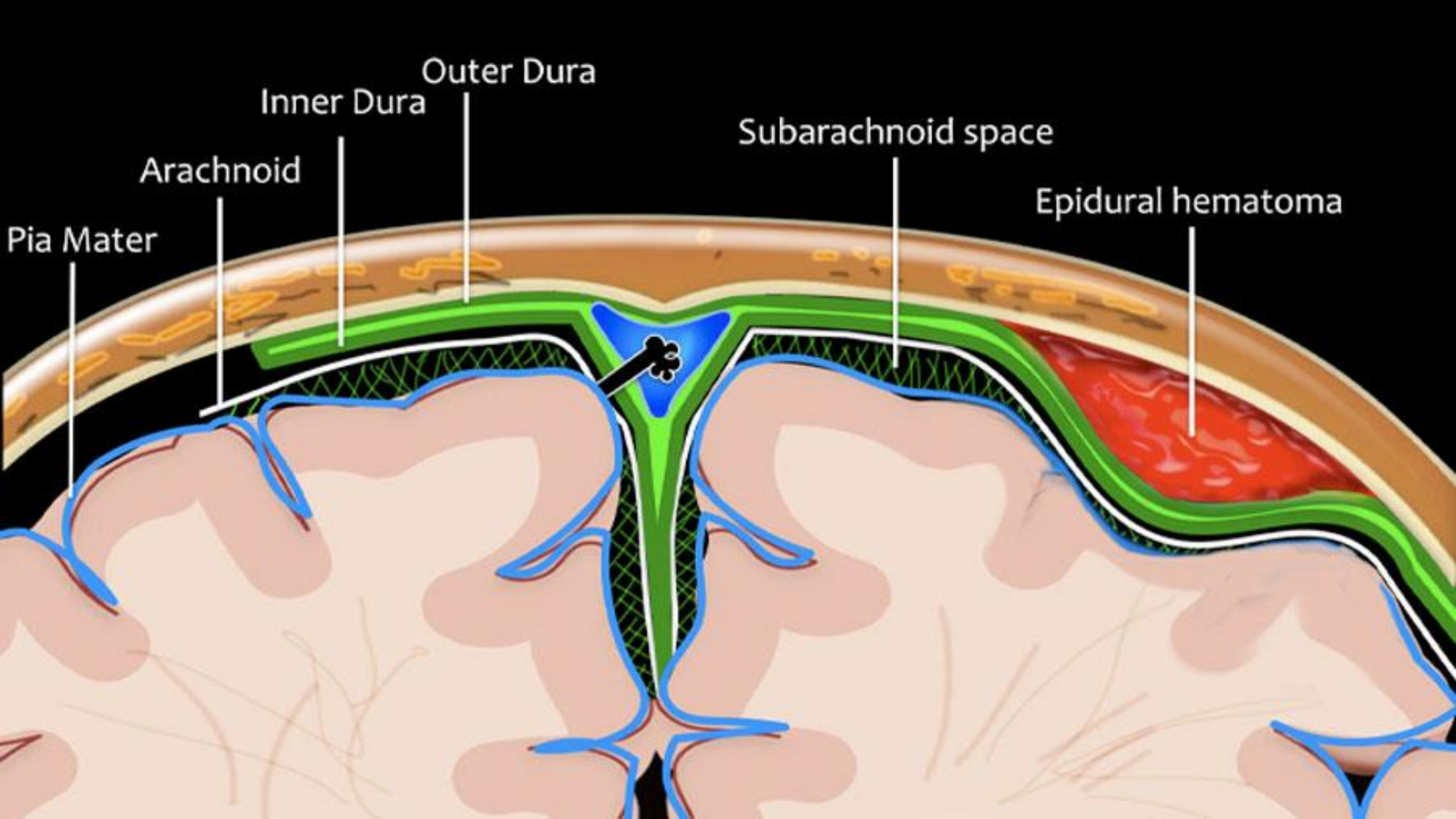


Blow-out fracture & Tripod fracture

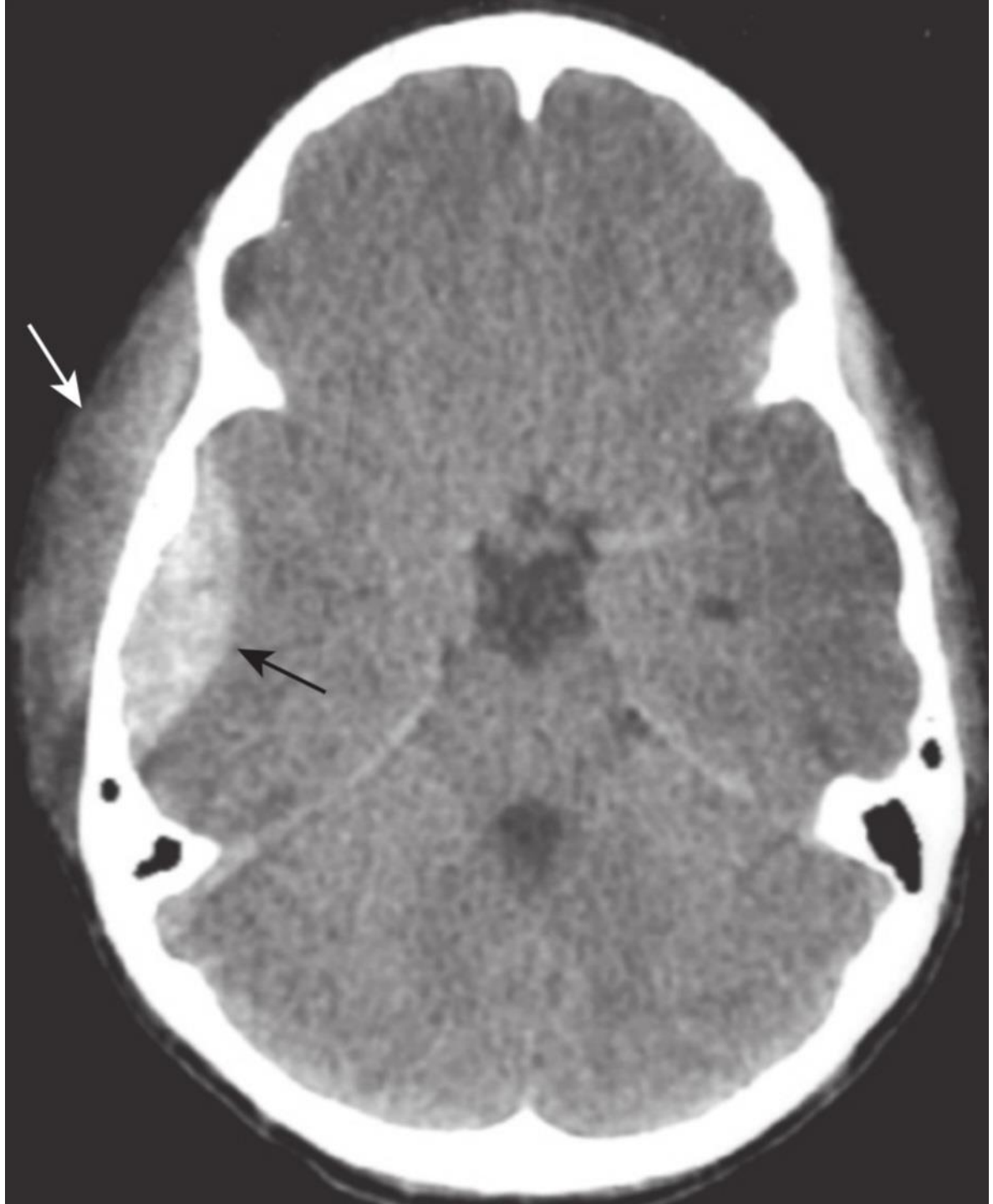

Intracranial Hemorrhage
Epidural: Biconvex, arterial
Subdural: Crescent-shaped, venous
Intracerebral: Contusions, hematomas
Subarachnoid: Ruptured aneurysms

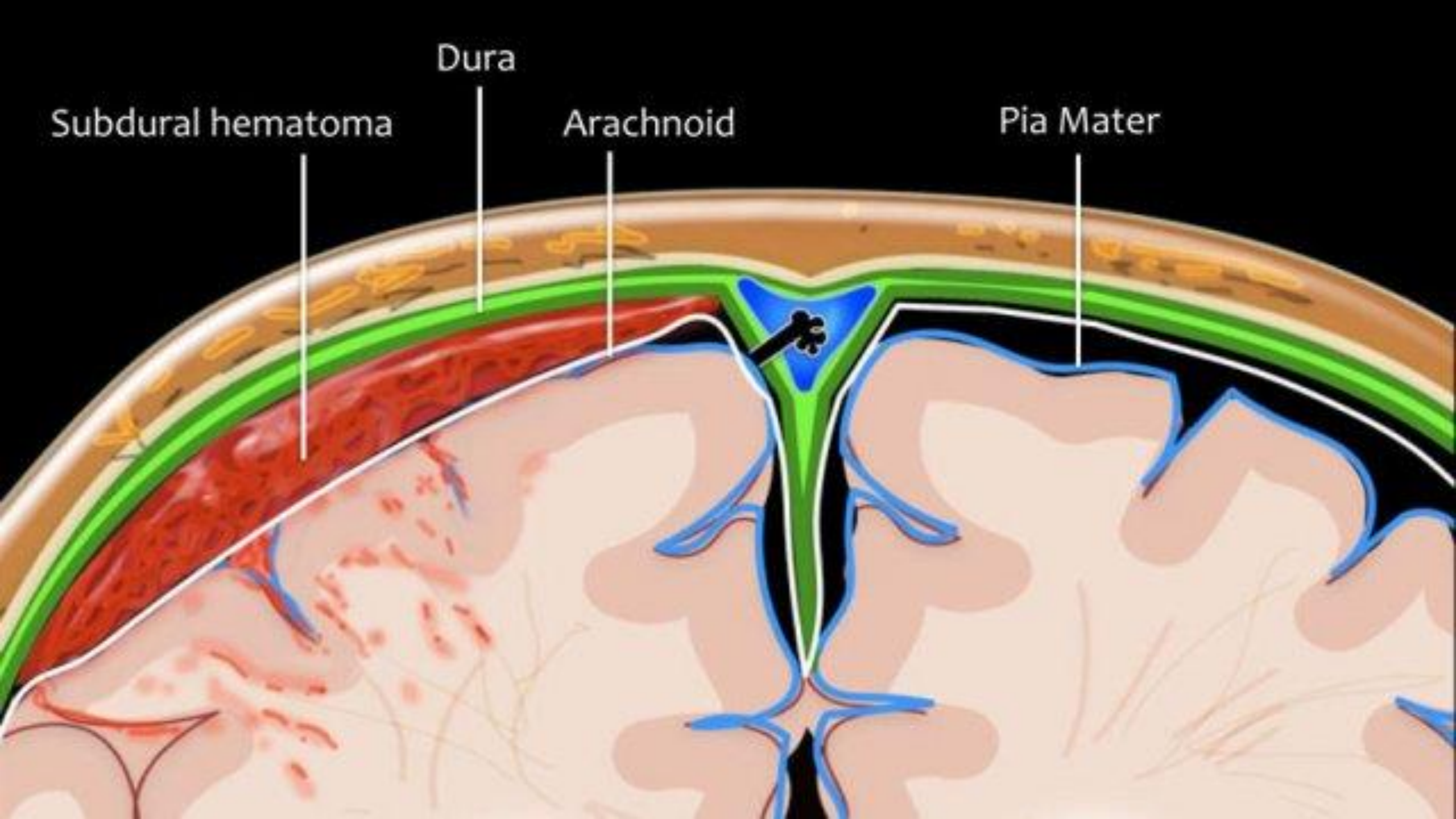
Diagnostic Matrix: Epidural vs. Subdural Hematoma

Feature	Epidural Hematoma (EDH)	Subdural Hematoma (SDH)
Location	Between skull and dura mater.	Between dura mater and arachnoid.
Vessel Type	Arterial (Middle meningeal artery/vein tear).	Venous (Tearing of bridging veins from deceleration injury).
Shape on CT	Biconvex (Lens-shaped), convex inward toward brain.	Crescent-shaped, concave inward toward brain.
Skull Fracture	Almost always present (95%).	Usually not associated.
Boundaries	Cannot cross suture lines (dura is fused to calvarium), but can cross the tentorium.	Can cross suture lines, but does NOT cross the midline.

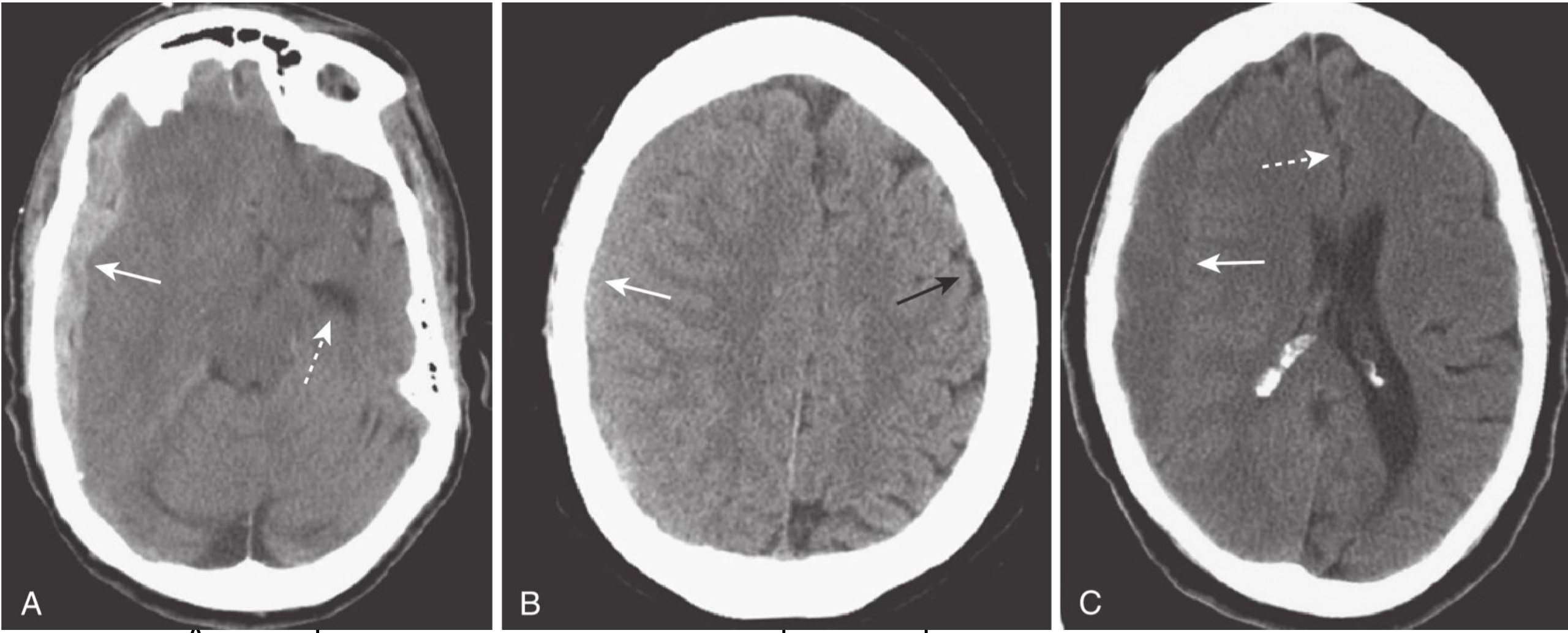

Outer Dura
Inner Dura
Arachnoid
Pia Mater
Subarachnoid space
Epidural hematoma

Epidural Hematoma




Dura
Subdural hematoma
Arachnoid
Pia Mater

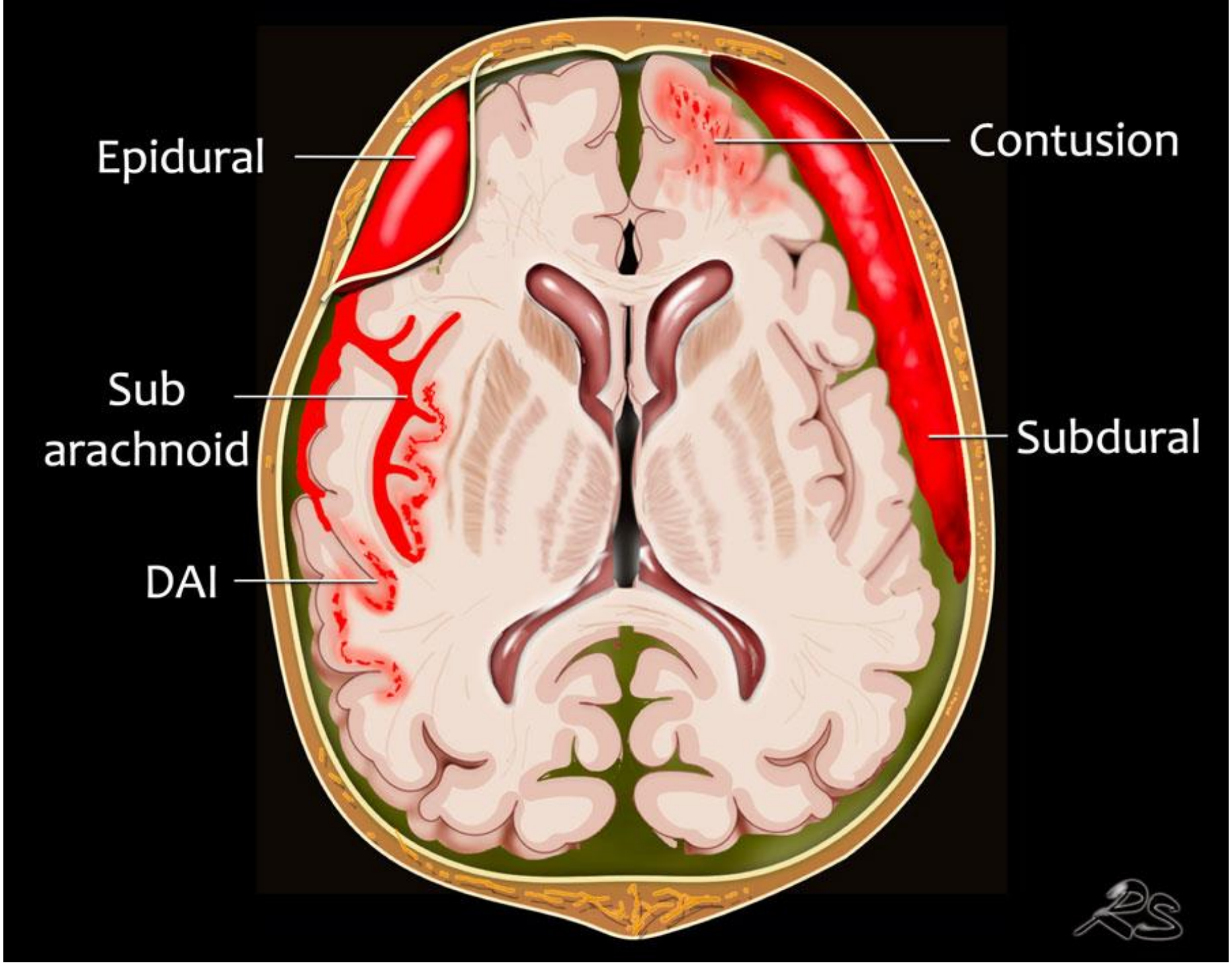
Subdural Hematoma

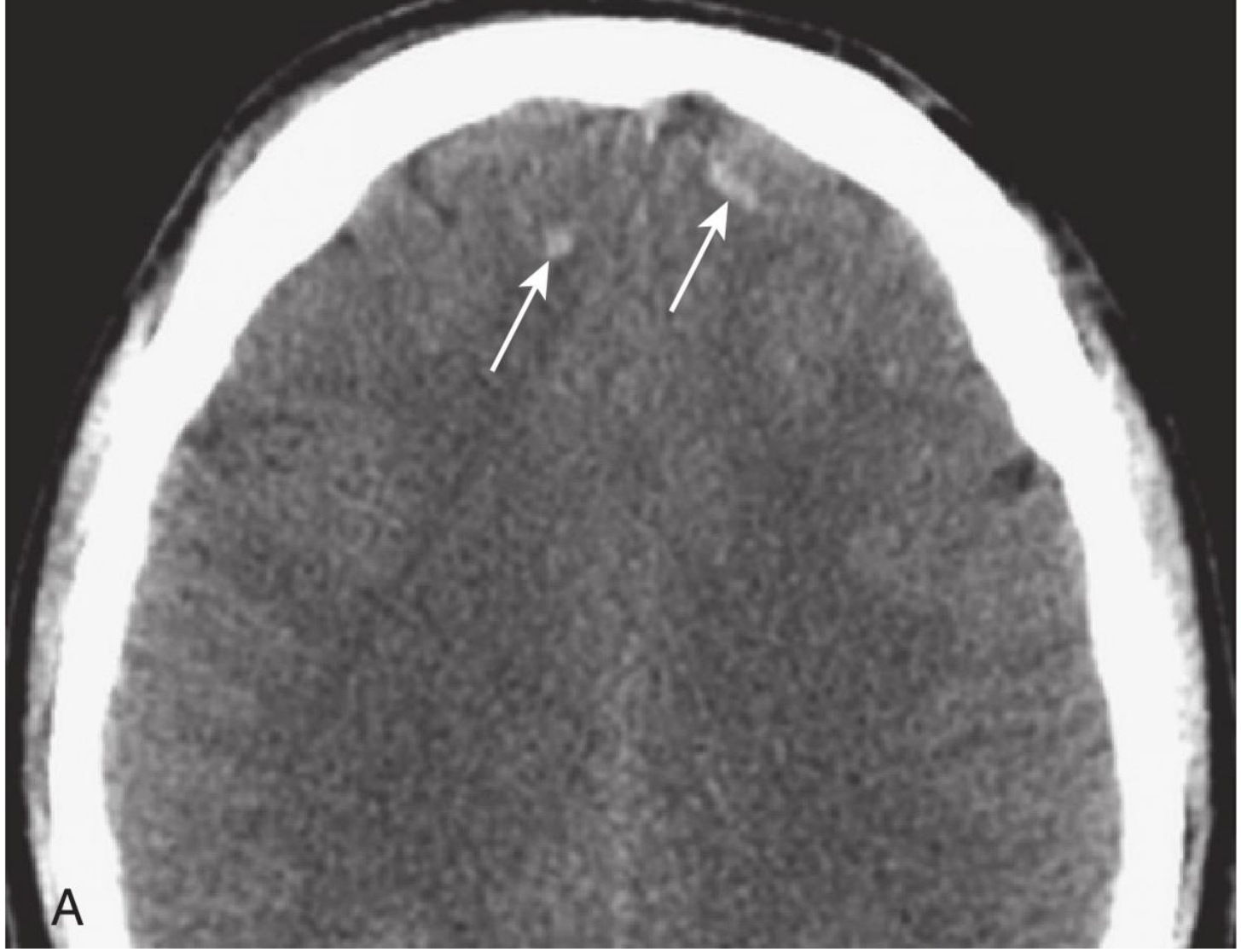


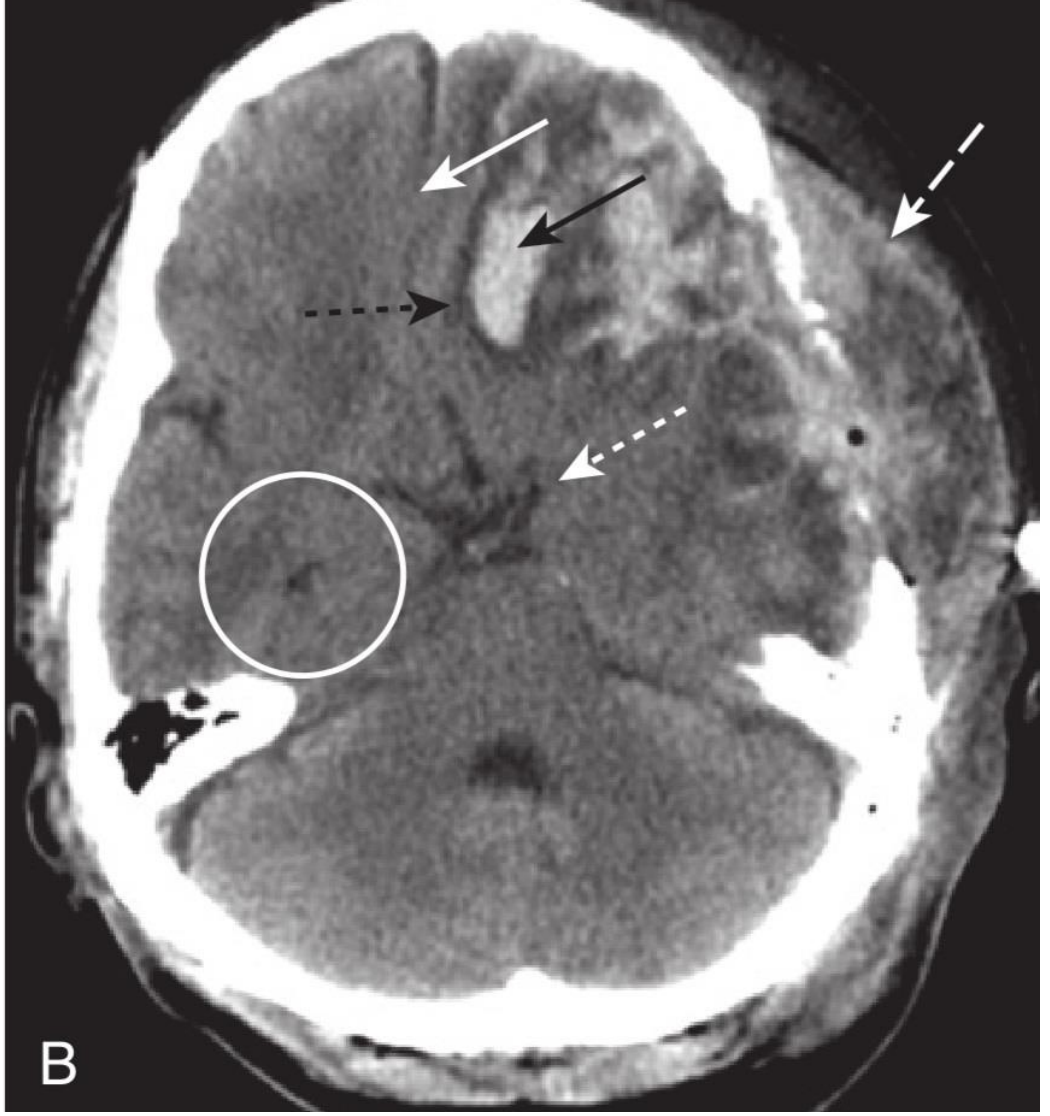
Acute

Chronic

Isodense

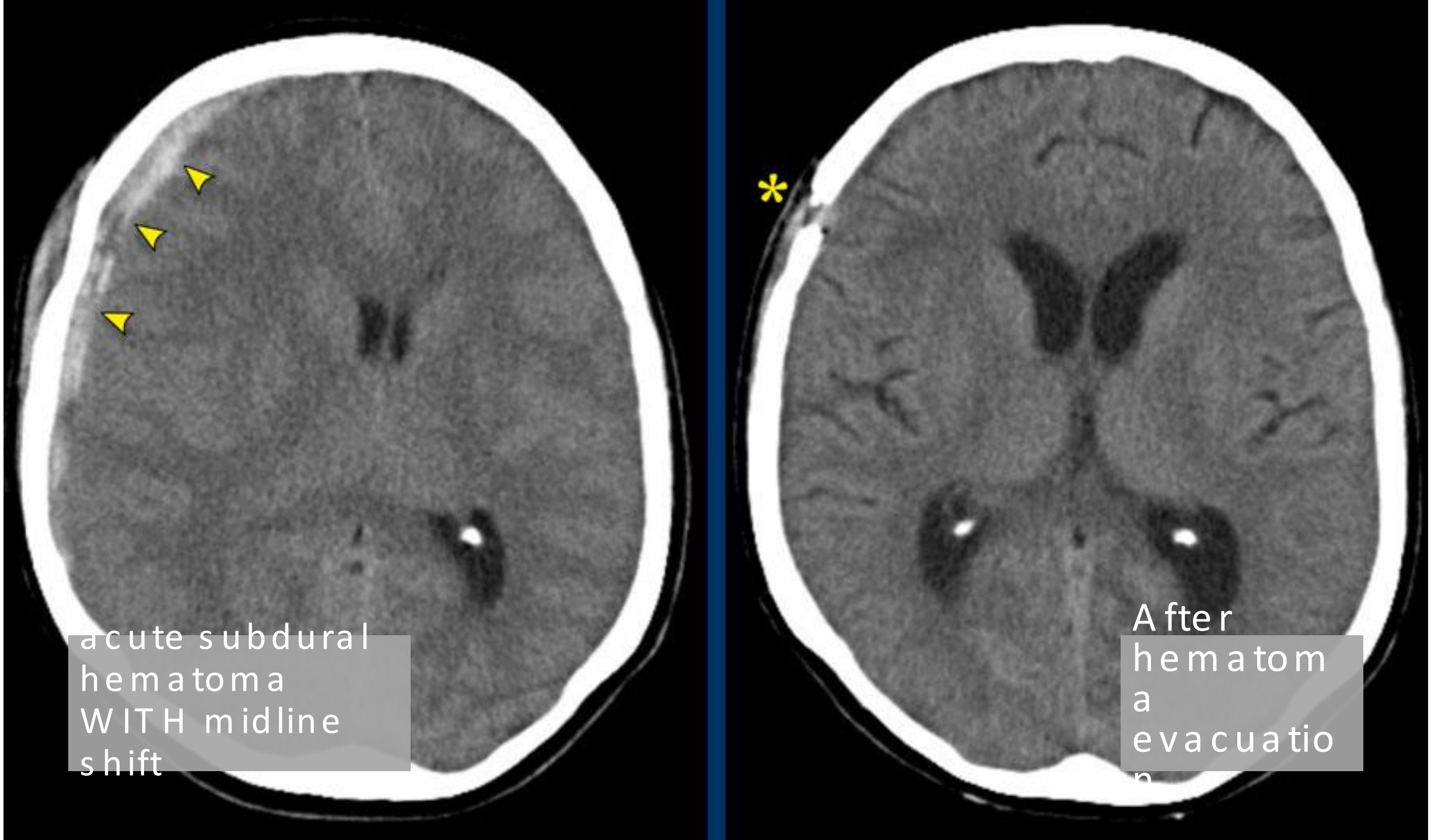

Epidural
Contusion
Sub
arachnoid
Subdural
DAI

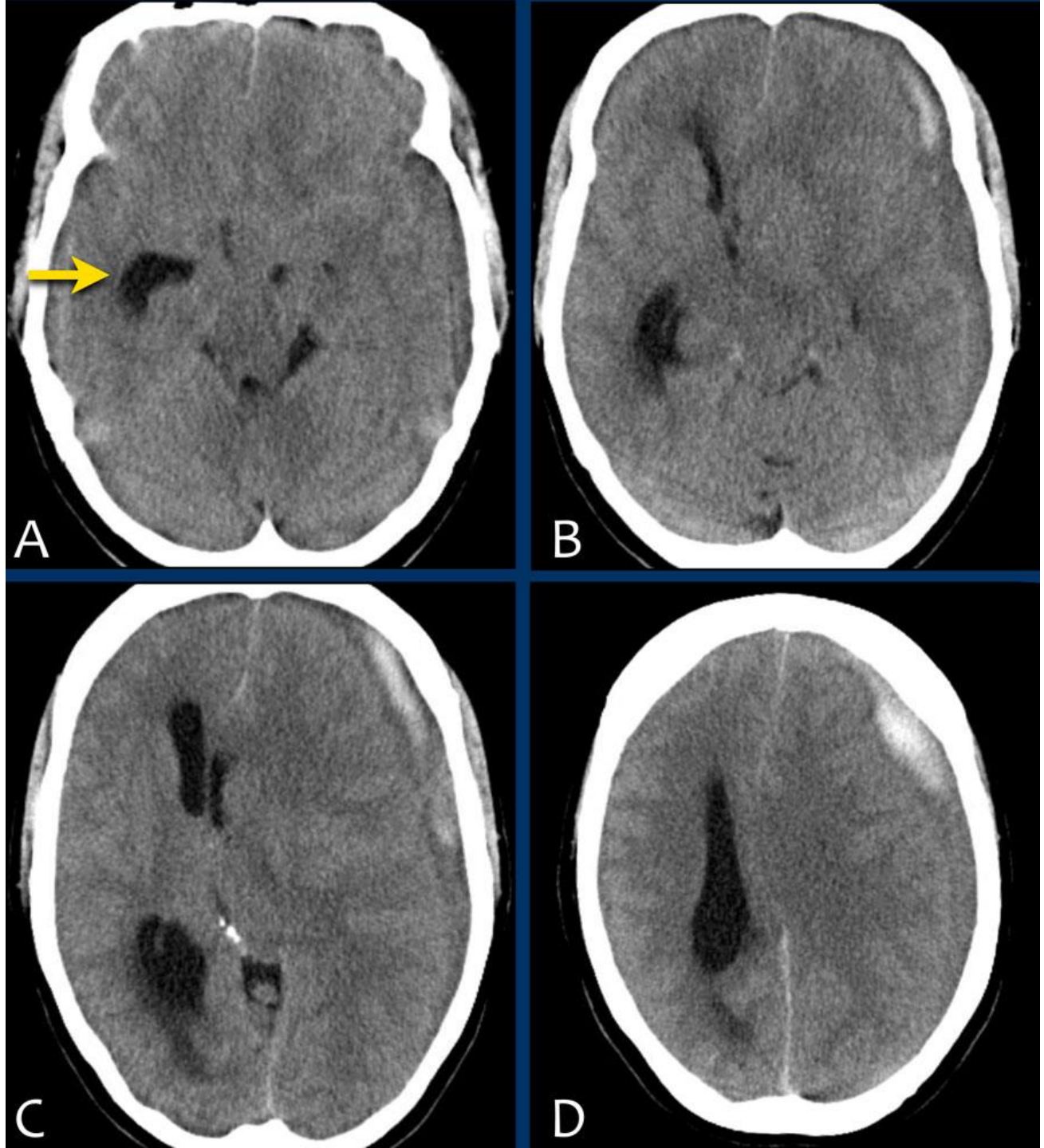




Cerebral Contusions

WITH subfalcine herniation


acute subdural hematoma WITH midline shift
After hematoma evacuation



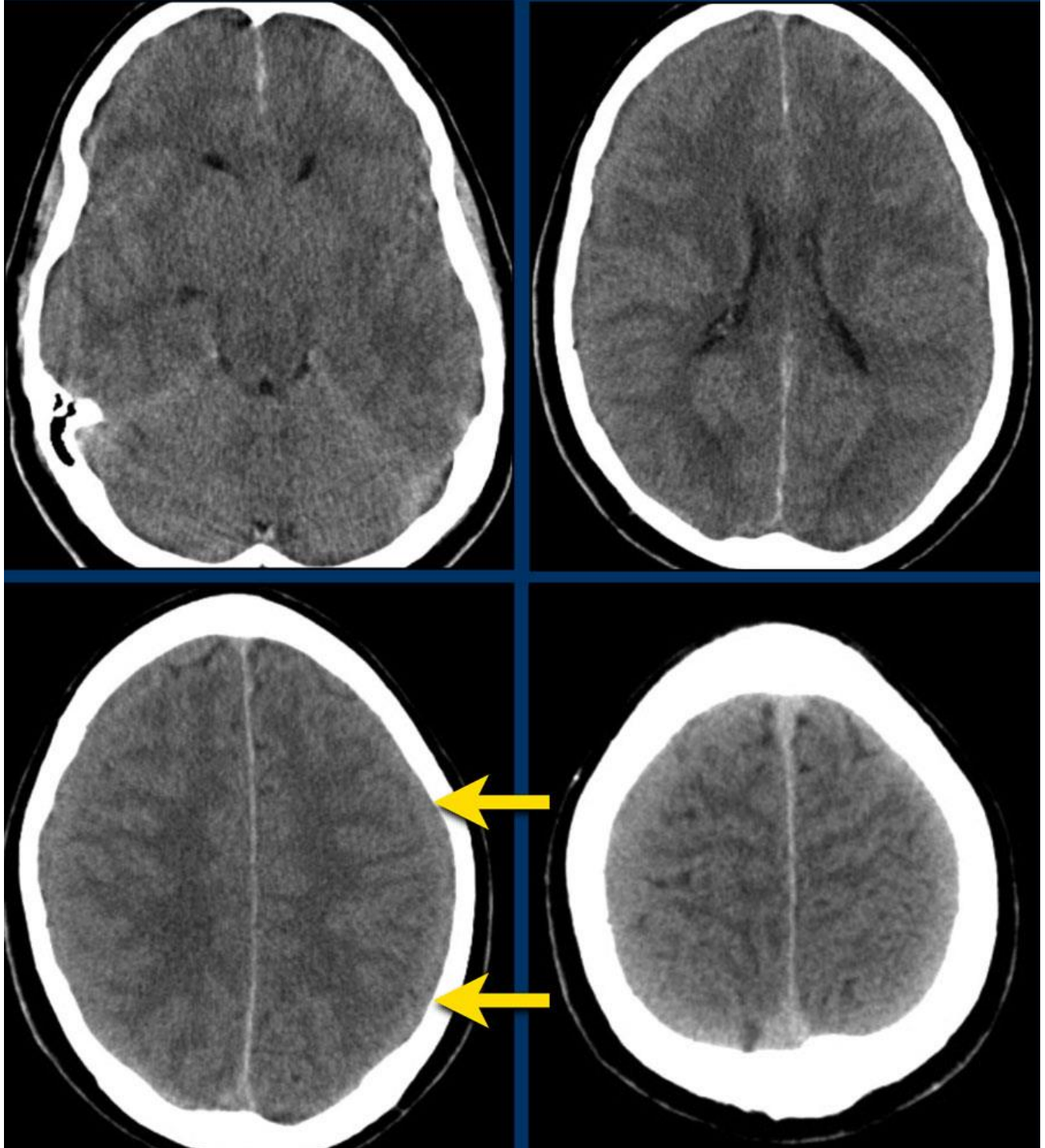
subdural hematoma

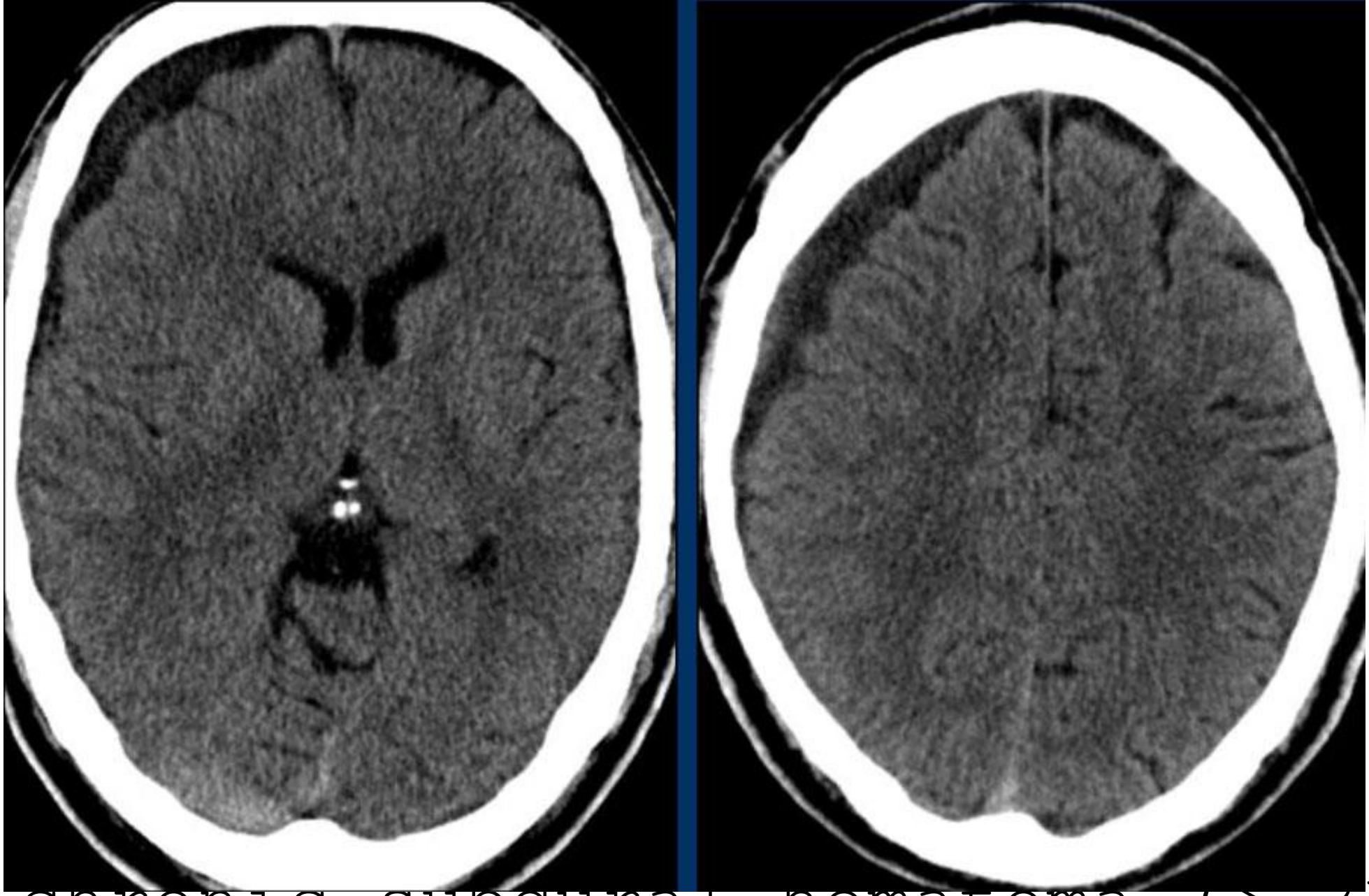
WITH both hyperdense and Isodense areas

WITH dilatation of the temporal horn of the right lateral ventricle

WITH midline shift

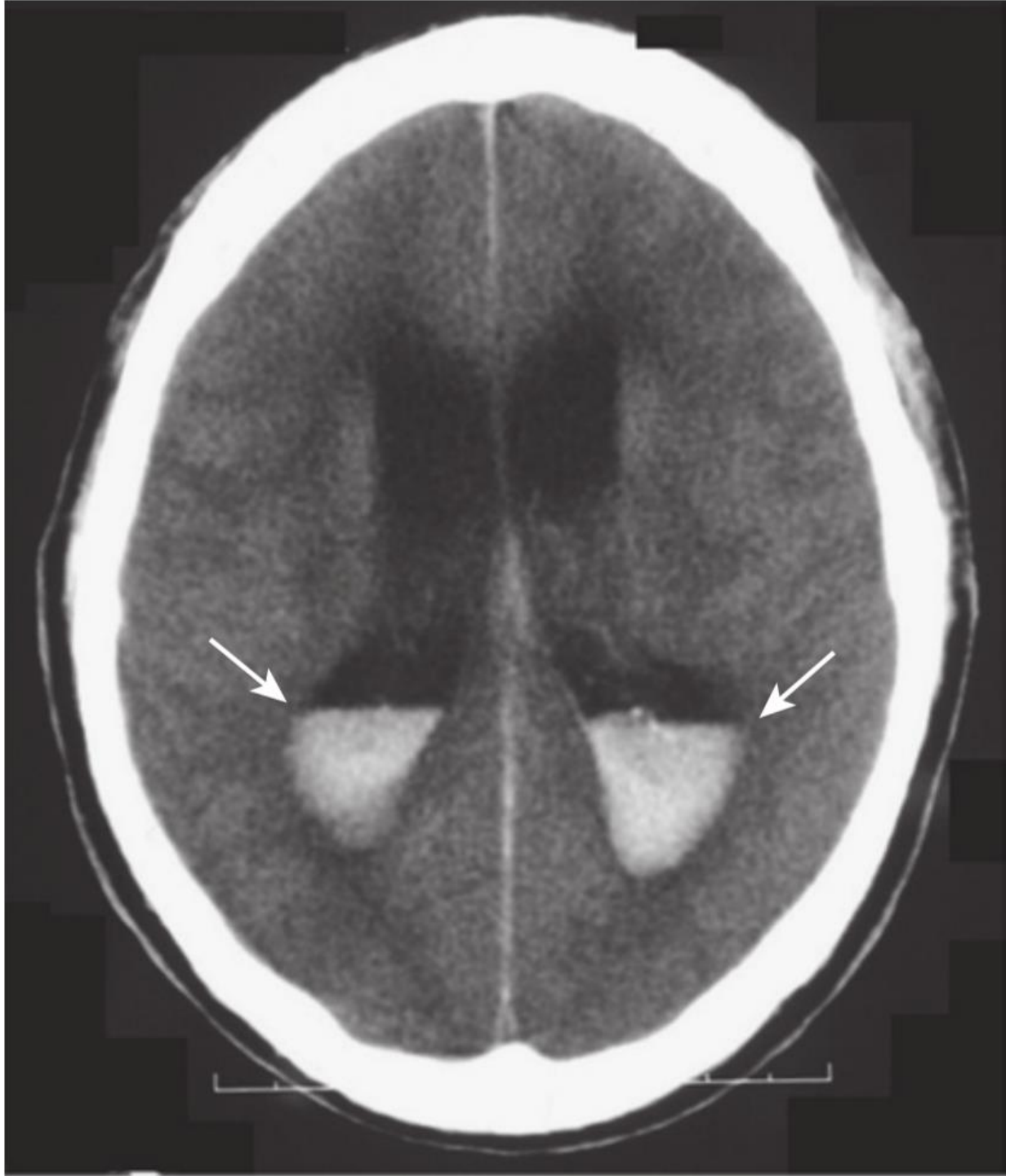
Bilateral subdural hematoma

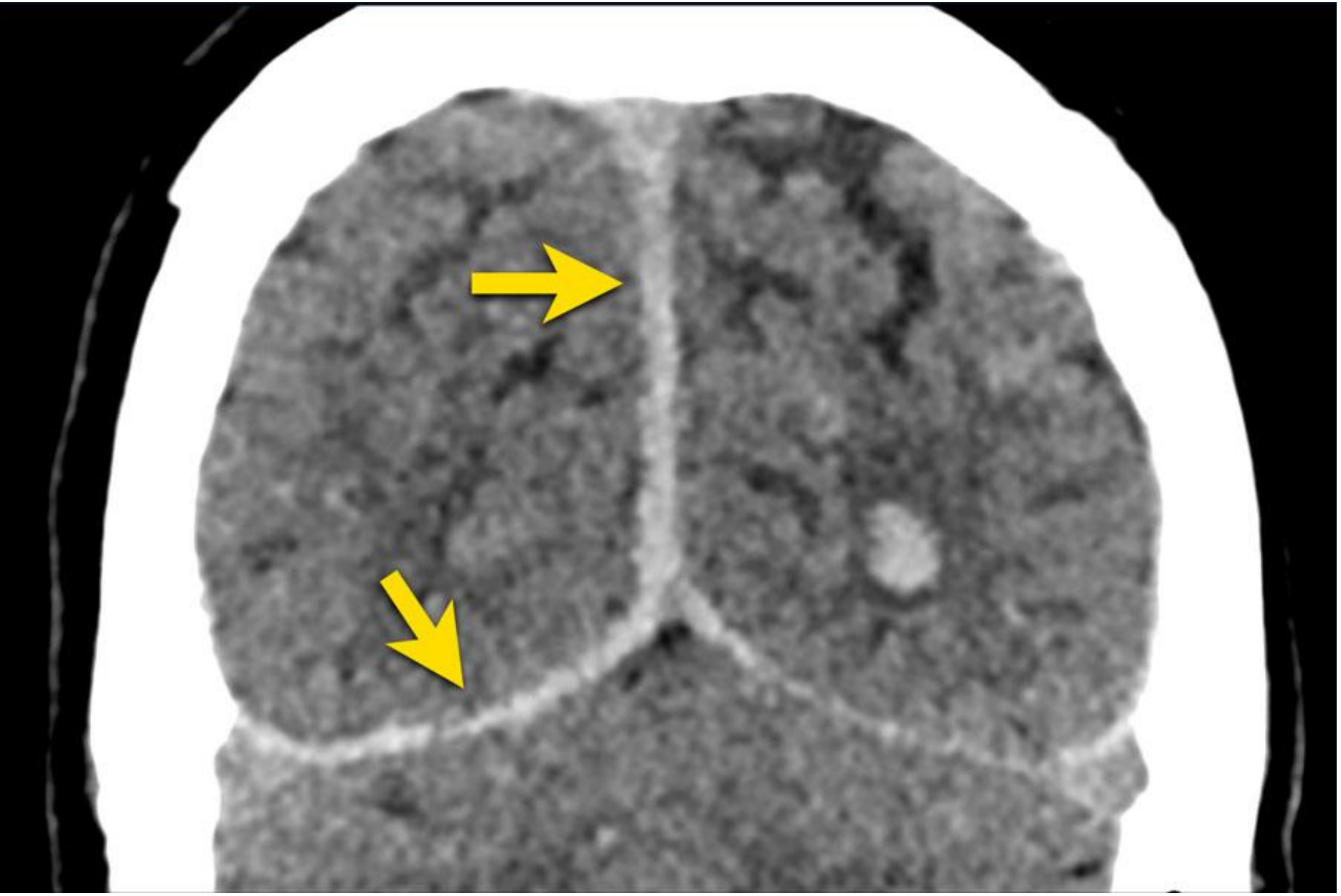




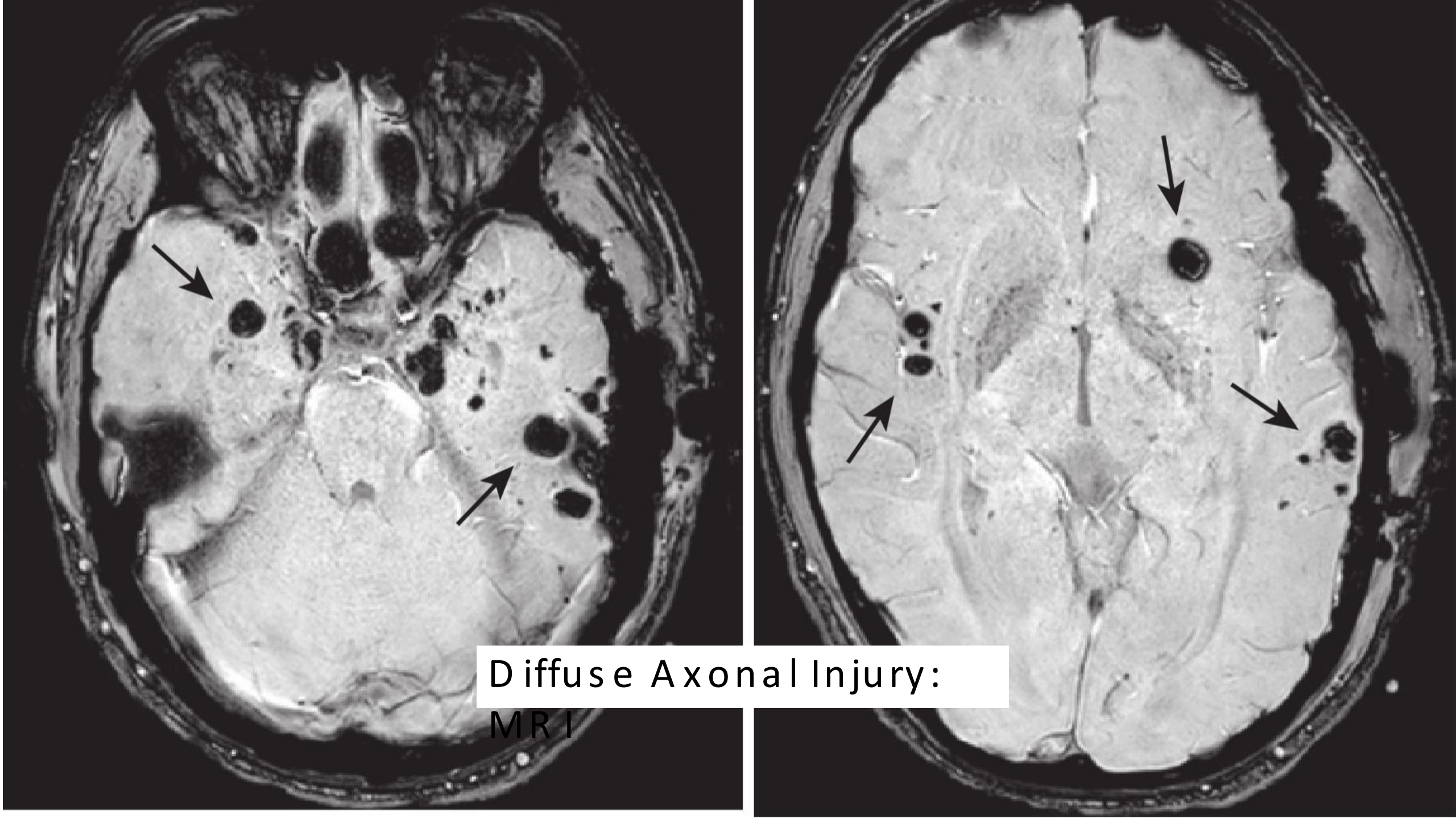
chronic subdural hematoma (> 21 days)

Intraventricular Hemorrhage





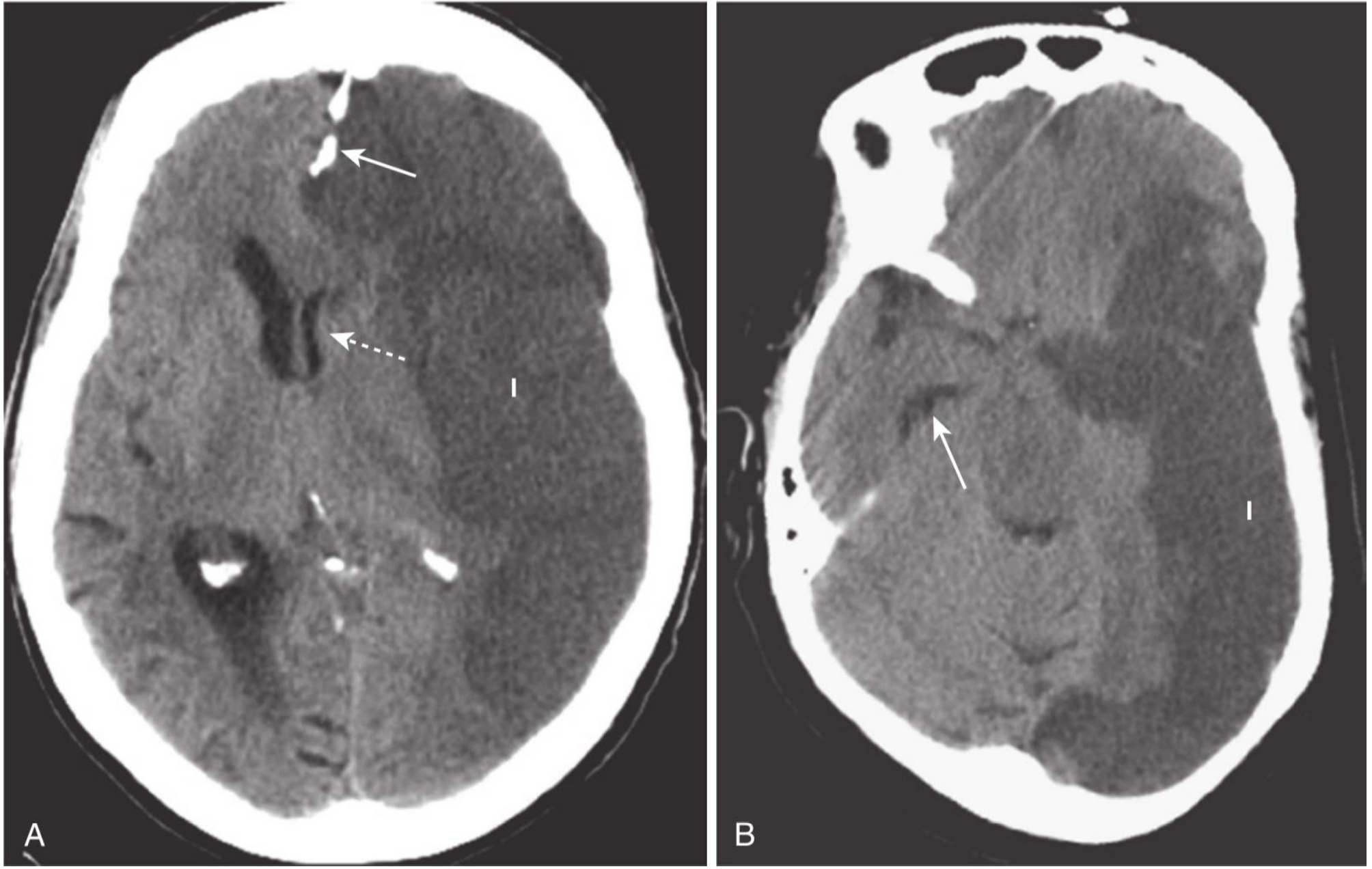
subdural hematoma
along the falx and tentorium



Diffuse Axonal Injury: MRI

TABLE 27.5 Types of Brain Herniation

Type	Remarks
Subfalcine herniation	The supratentorial brain, along with the lateral ventricle and septum pellucidum, herniates beneath the falx and shifts across the midline toward the opposite side (Fig. 27.12A).
Transtentorial herniation	Usually the cerebral hemispheres are displaced downward through the incisura beneath the tentorium compressing the ipsilateral temporal horn and causing dilatation of the contralateral temporal horn (Fig. 27.12B).
Foramen magnum/ tonsillar herniation	Infratentorial brain is displaced downward through the foramen magnum.
Sphenoid herniation	Supratentorial brain slides over the sphenoid bone either anteriorly (in the case of the temporal lobe) or posteriorly (for the frontal lobe).
Extracranial herniation	Displacement of brain through a defect in the cranium.



Subfalcine herniation & Transtentorial herniation

Pathophysiology of Cerebral Edema

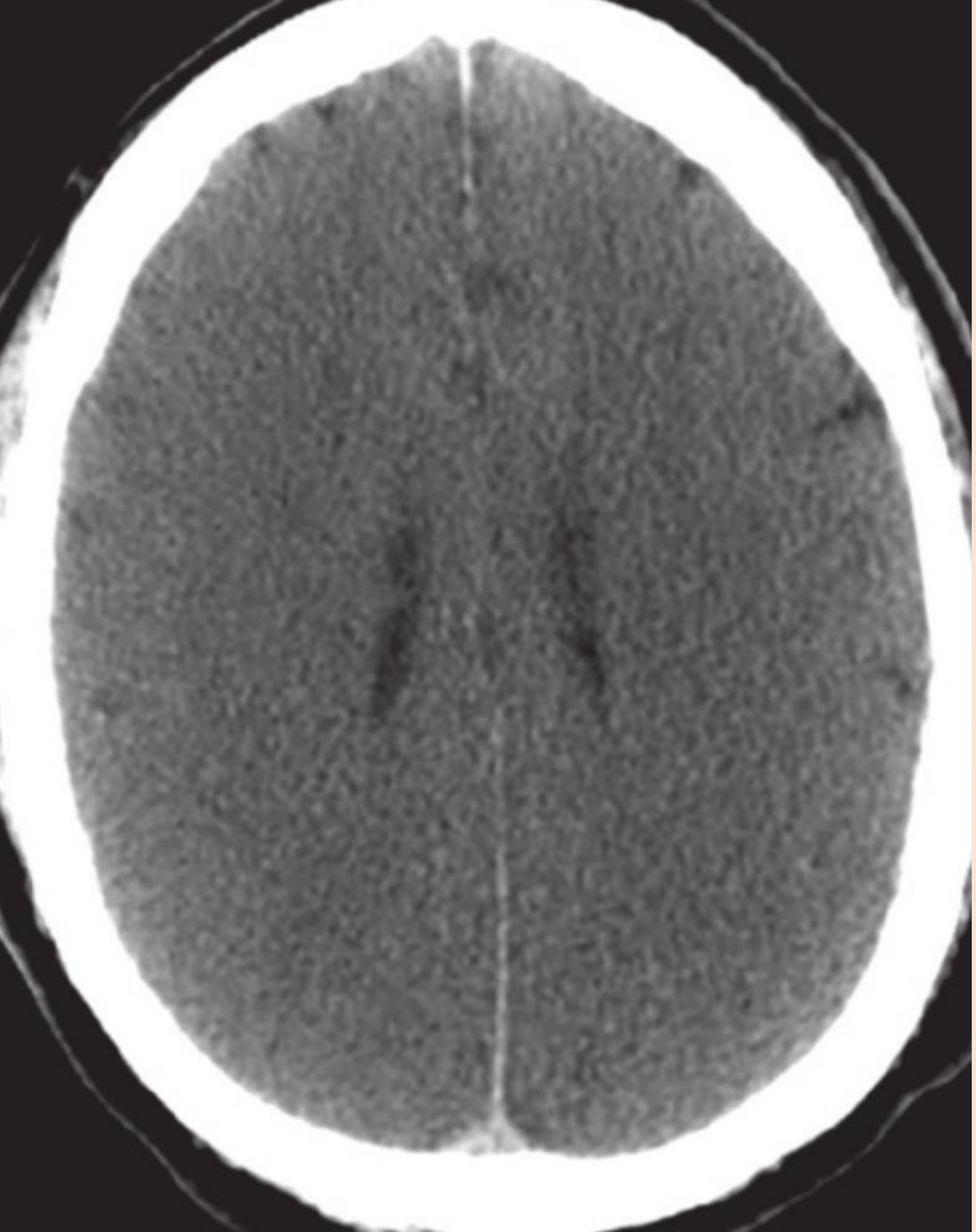
VASOGENIC EDEMA

- **Mechanism:** Abnormal permeability of the blood-brain barrier leading to extracellular fluid accumulation.
- **Tissue Affected:** Predominantly affects White Matter.
- **CT Appearance:** Normal gray-white differentiation is retained. Edema forms finger-like projections.
- **Common Causes:** Malignancy (tumors), Infection.

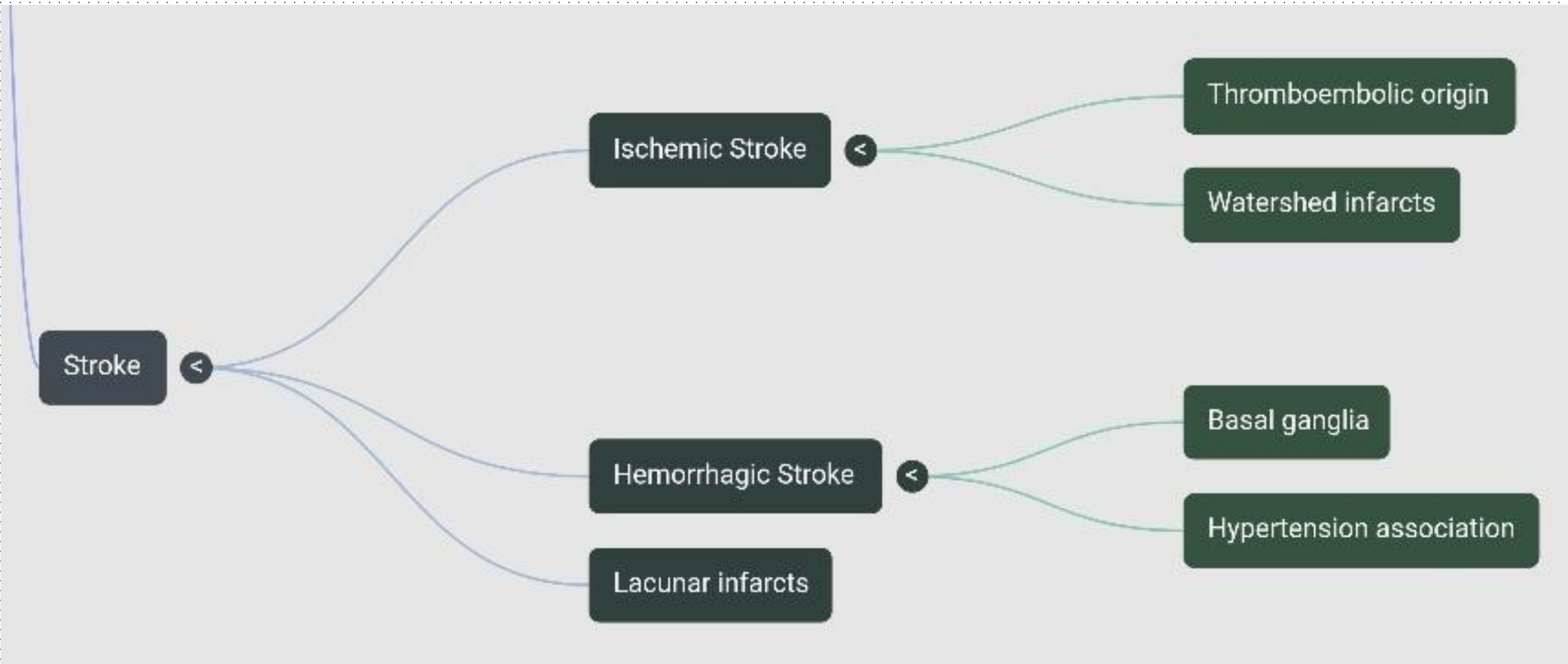
CYTOTOXIC EDEMA

- **Mechanism:** Cell death and swelling leading to intracellular fluid accumulation.
- **Tissue Affected:** Affects both Gray and White Matter.
- **CT Appearance:** Total loss of normal gray-white differentiation.
- **Common Causes:** Cerebral ischemia (Acute Stroke).

Vasogenic and Cytotoxic Edema



Diffuse Cerebral Edema


Stroke
Ischemic Stroke
Thromboembolic origin
Watershed infarcts
Hemorrhagic Stroke
Basal ganglia
Hypertension association
Lacunar infarcts

Diagnosing Acute Ischemic Stroke

< 30 Minutes

The MRI Advantage

Diffusion-Weighted MRI (DWI) is extremely sensitive to abnormalities in normal water movement. Reveals acute infarction as a bright, hyperintense signal within 20-30 minutes of onset.

0 - 24 Hours

The CT Challenge

Noncontrast CT is ordered immediately to rule out hemorrhage before administering tPA.

The most common finding of an acute ischemic stroke on CT (<24 hrs) is a **normal scan**.

12 - 24+ Hours

Delayed CT Findings

12-24 hrs: Indistinct area of low attenuation in a specific vascular distribution.

>24 hrs: Better circumscribed lesion with mass effect (peaks at 3-5 days).

CT and Diffusion-Weighted MRI in Acute Stroke

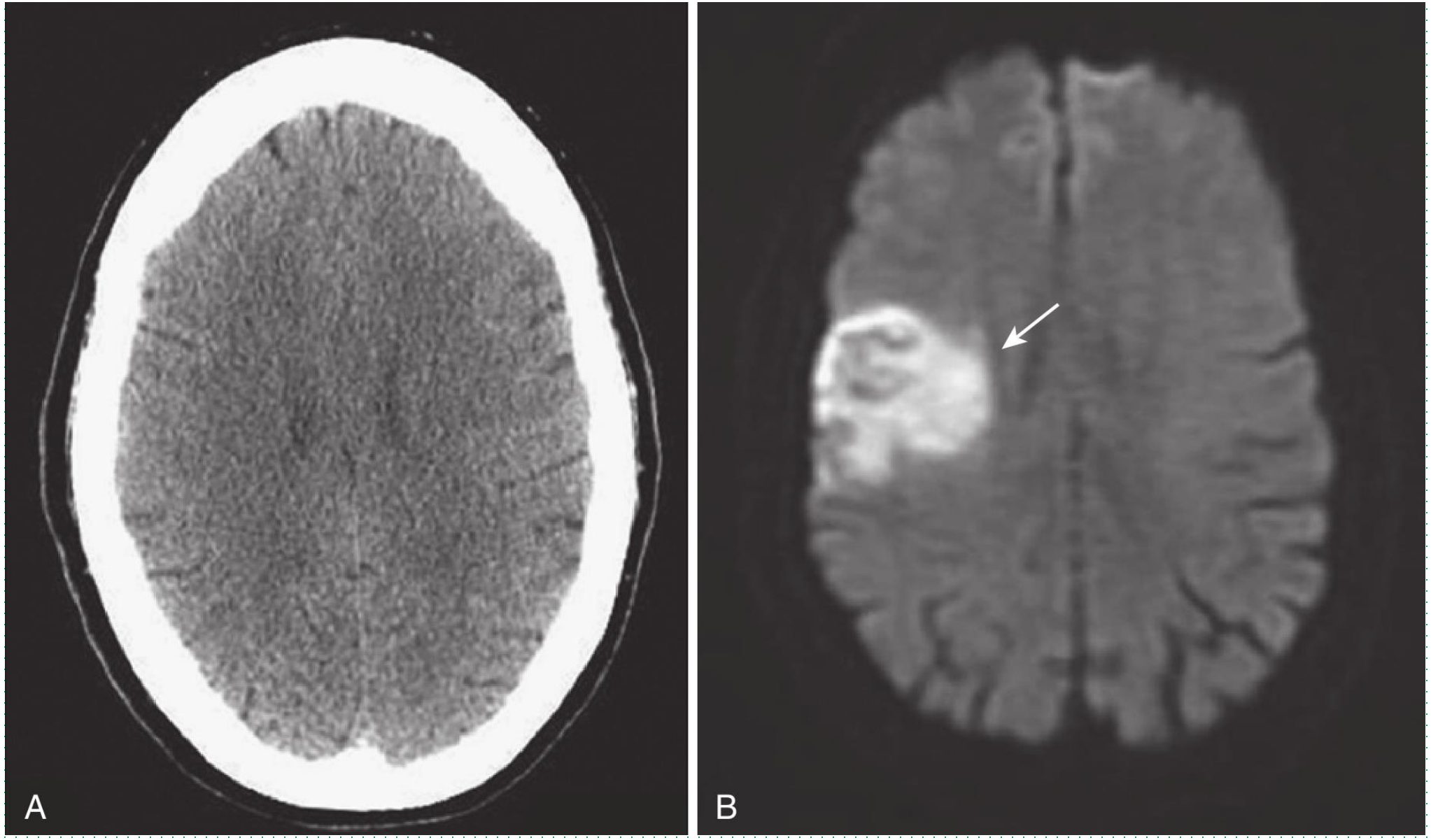
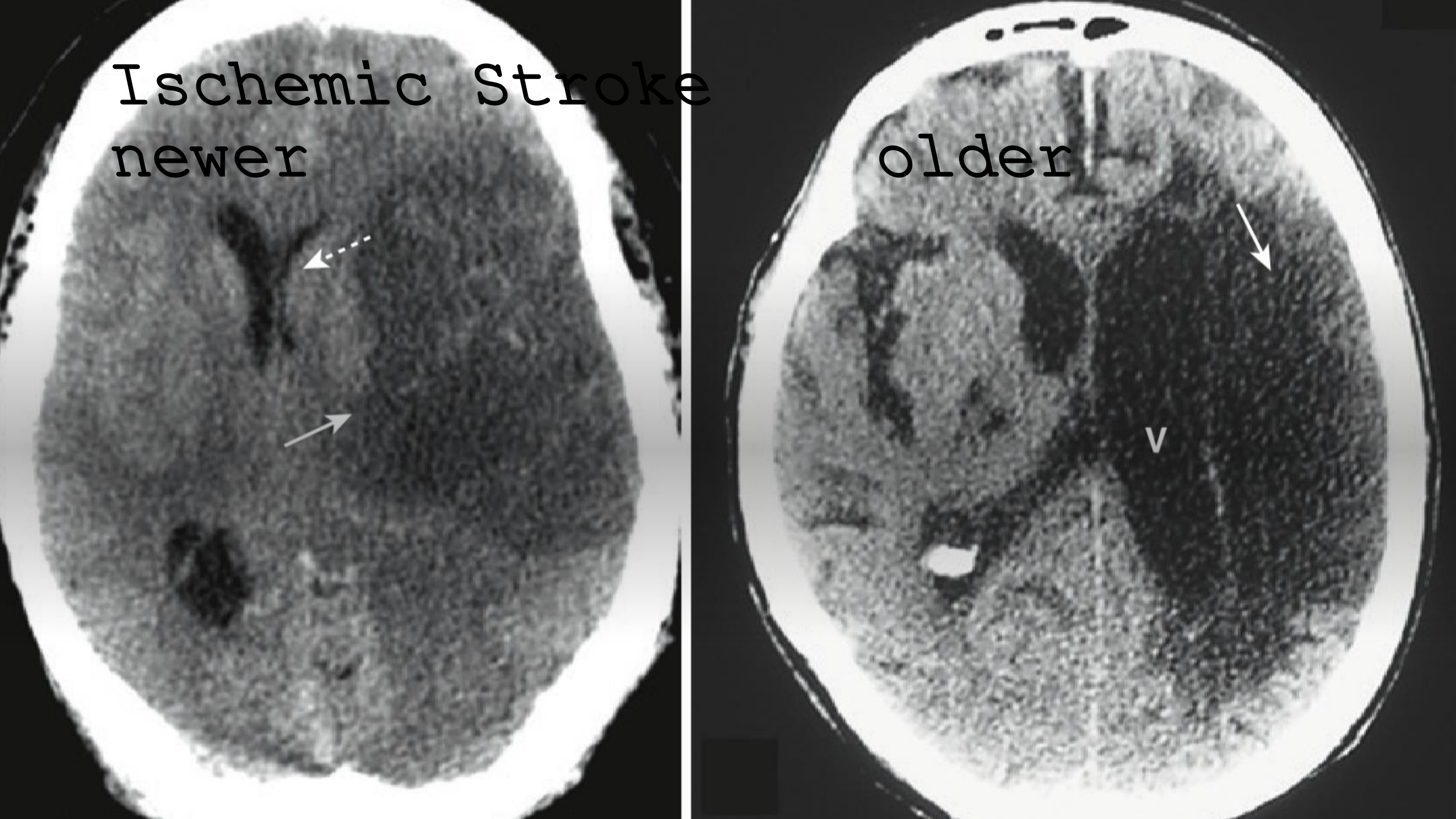
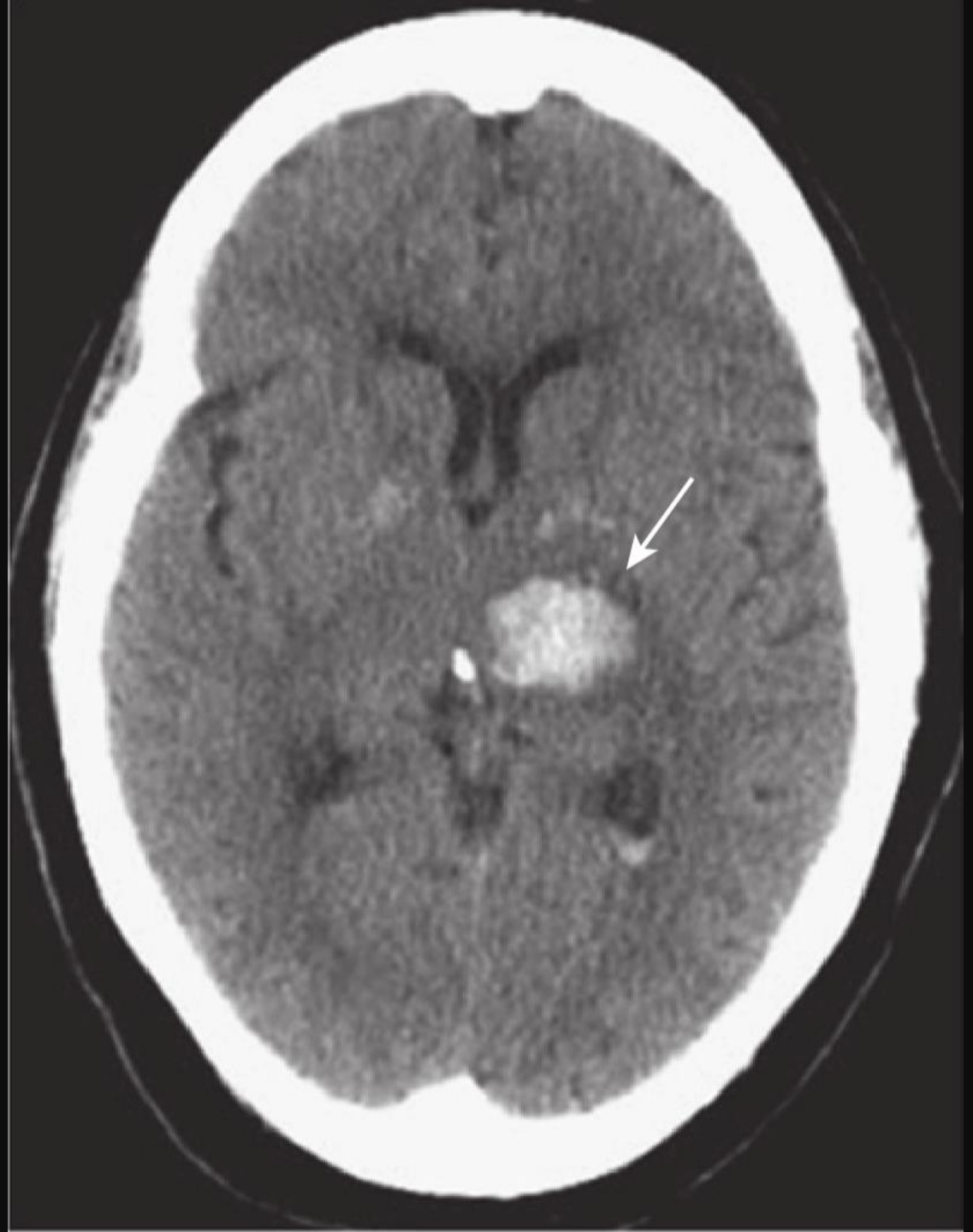


TABLE 27.6 Vascular Distribution Territories of Stroke

Circulation	Anatomy Affected	Signs and Symptoms
Anterior cerebral artery (uncommon)	Supplies all of the frontal and parietal lobes (medial surfaces), the anterior four-fifths of the corpus callosum, the frontobasal cerebral cortex, and the anterior diencephalon.	Can result in disinhibition with perseveration of speech; produces primitive reflexes (e.g., grasping or sucking), altered mental status, impaired judgment, contralateral weakness (greater in legs than arms).
Middle cerebral artery (common)	Supplies almost the entire convex surface of the brain, including the frontal, parietal, and temporal lobes (laterally), insula, claustrum, and extreme capsule. Lenticulostriate branches supply the basal ganglia, including the head of the caudate nucleus, the putamen including the lateral parts of the internal and external capsules.	Produces contralateral hemiparesis or hypesthesia, ipsilateral hemianopsia, and gaze preference toward the side of the lesion; agnosia is common; receptive or expressive aphasia may result if the lesion occurs in the dominant hemisphere; weakness of the arm and face is usually worse than that of a lower limb.
Posterior cerebral artery	Supplies portions of the midbrain, subthalamic nucleus, basal nucleus, thalamus, mesial inferior temporal lobe, and occipital and occipitoparietal cortices.	Occlusions affect vision, producing contralateral homonymous hemianopsia, cortical blindness, visual agnosia, altered mental status, and impaired memory.
Vertebrobasilar system	Perfuses the medulla, cerebellum, pons, midbrain, thalamus, and occipital cortex.	Occlusion of large vessels in this system usually leads to major disability or death; small lesions usually have a benign prognosis; may cause a wide variety of cranial nerve, cerebellar, and brainstem deficits; a hallmark of posterior circulation stroke is crossed findings: ipsilateral cranial nerve deficits and contralateral motor deficits (in contrast to an anterior circulation stroke).

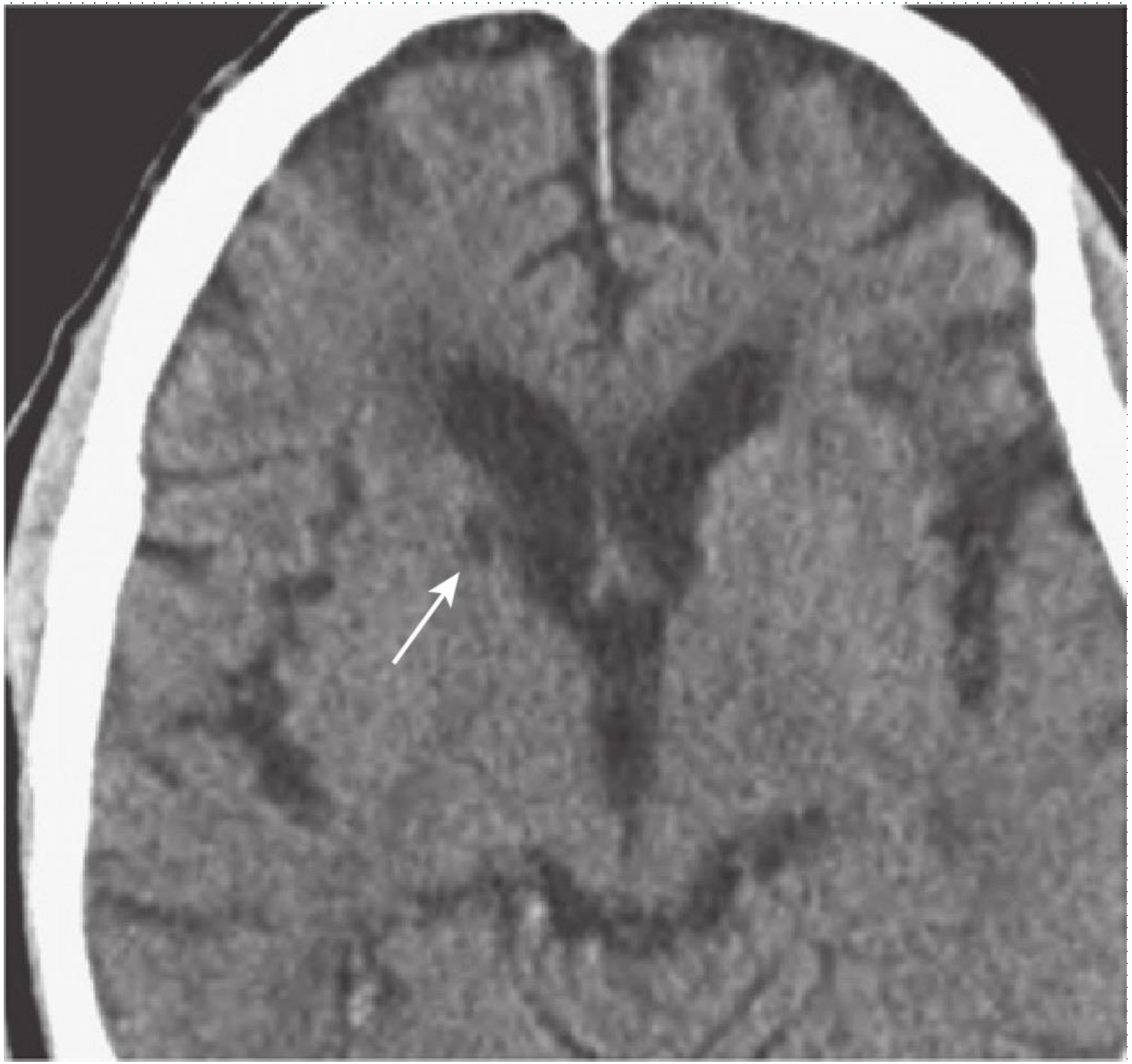

Ischemic Stroke
newer
older
V



Hemorrhagic Stroke

Intracerebral Hemorrhage: Acute

Lacunar Infarct



Ruptured Aneurysms & Subarachnoid Hemorrhage

Berry Aneurysms:

- Congenital weakenings in arterial walls, usually at branching sites in the Circle of Willis.
- 10mm is considered the critical size threshold for rupture risk.

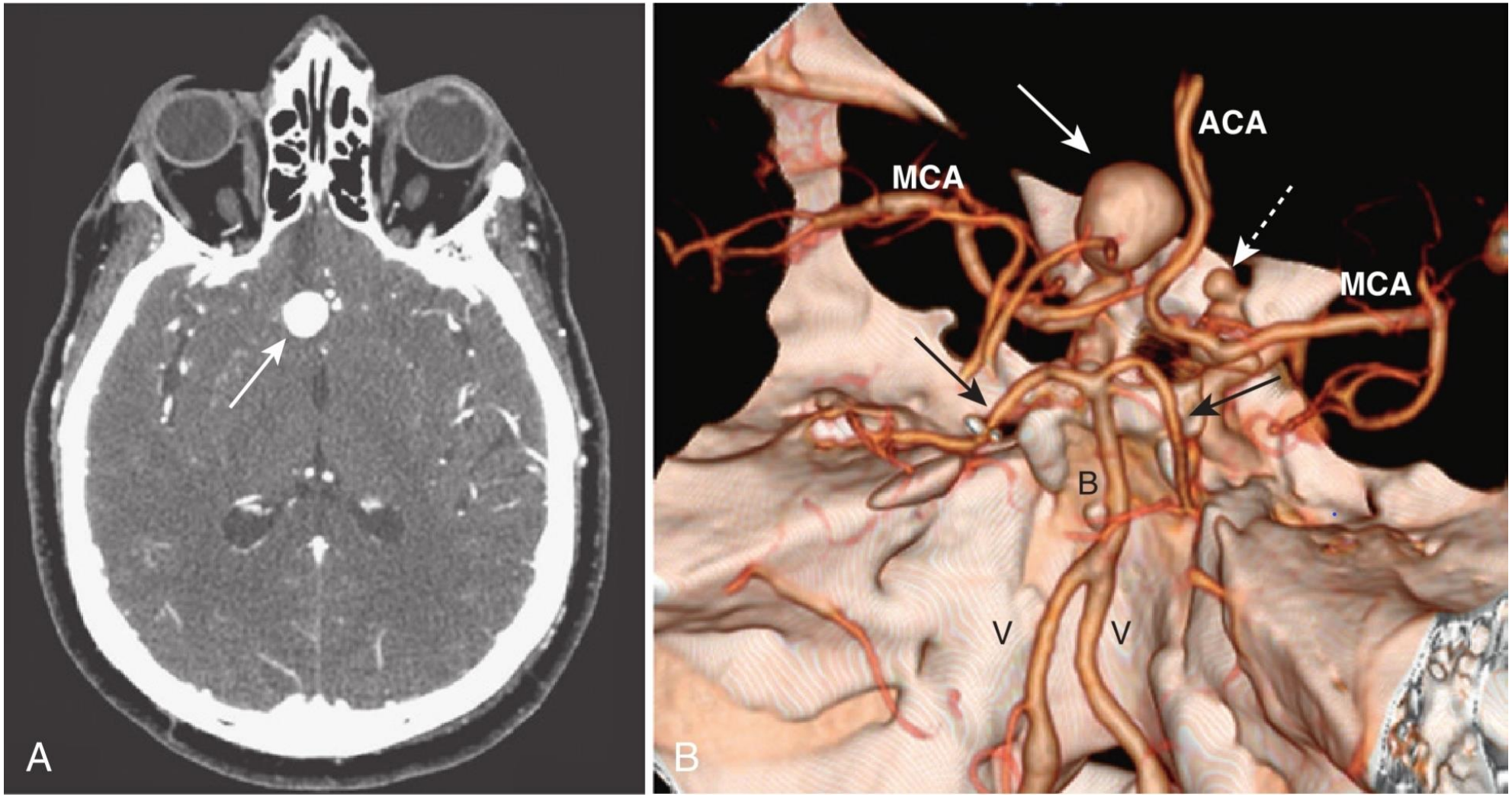
Subarachnoid Hemorrhage (SAH):

- Ruptured aneurysms are the cause of 80% of non-traumatic SAH.
- CT Findings: Acute blood is hyperdense (bright white) and fills the subarachnoid spaces—specifically the basal cisterns, sylvian fissures, and cerebral sulci.
- The falx may become hyperdense, widened, and irregularly marginated.

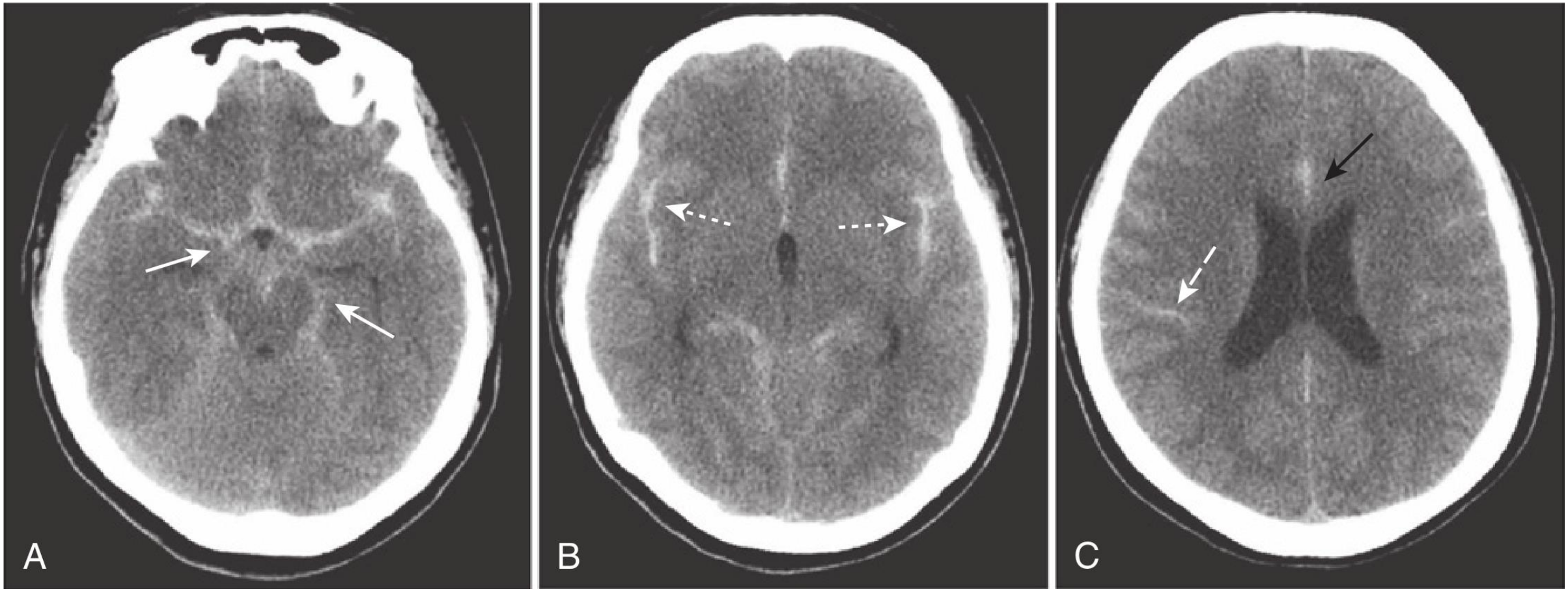
DIAGNOSTIC PEARL

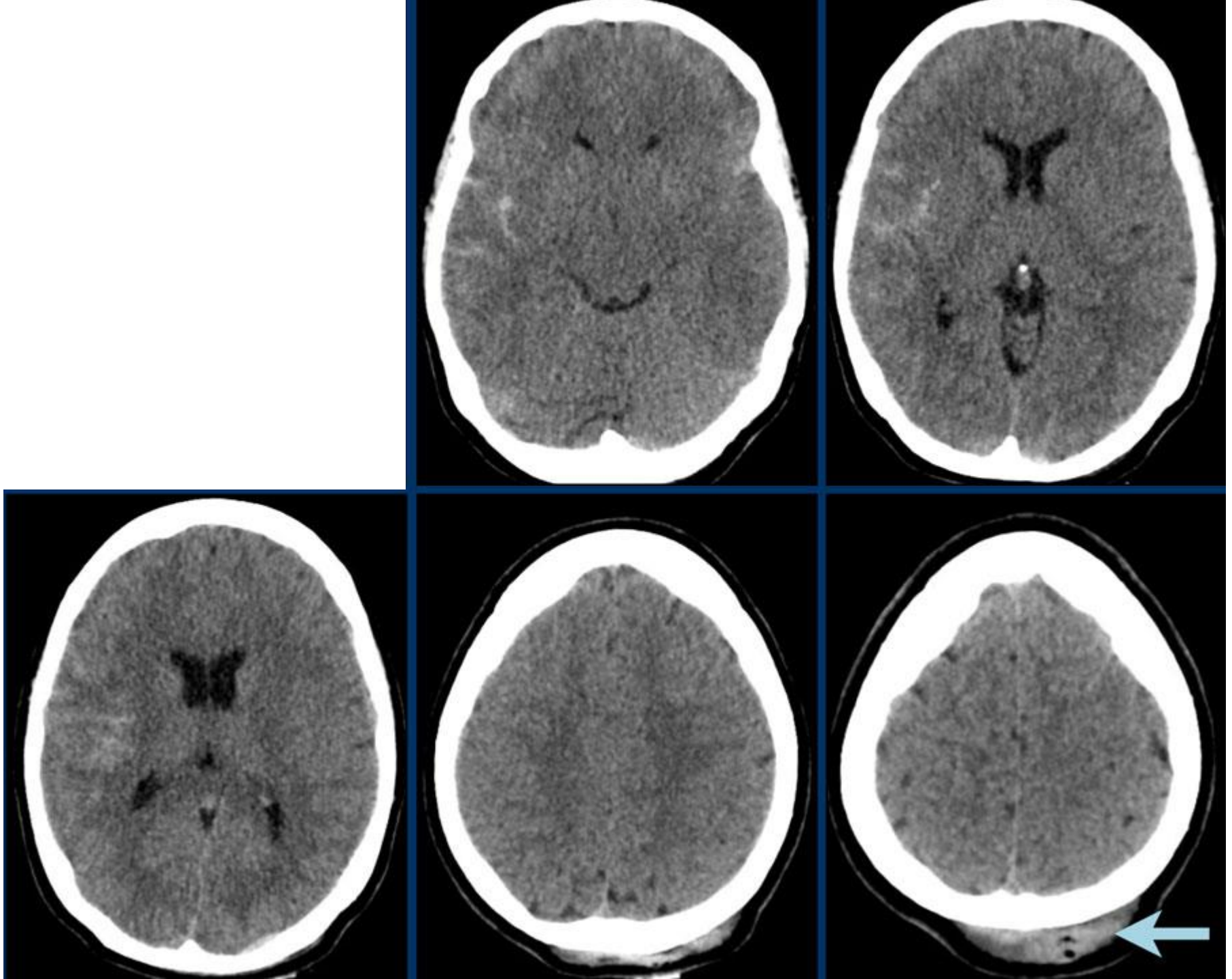
The greatest concentration of blood usually indicates the anatomical location of the ruptured aneurysm.

Berry Aneurysm: Axial CT and 3D Reconstruction



Subarachnoid Hemorrhage: Unenhanced CT Scans





Subarachnoid hemorrhage

coupe contrecoupe type of injury

subgaleal hemorrhage in the right occipital region

CSF Volume Disorders: Pressure vs. Atrophy

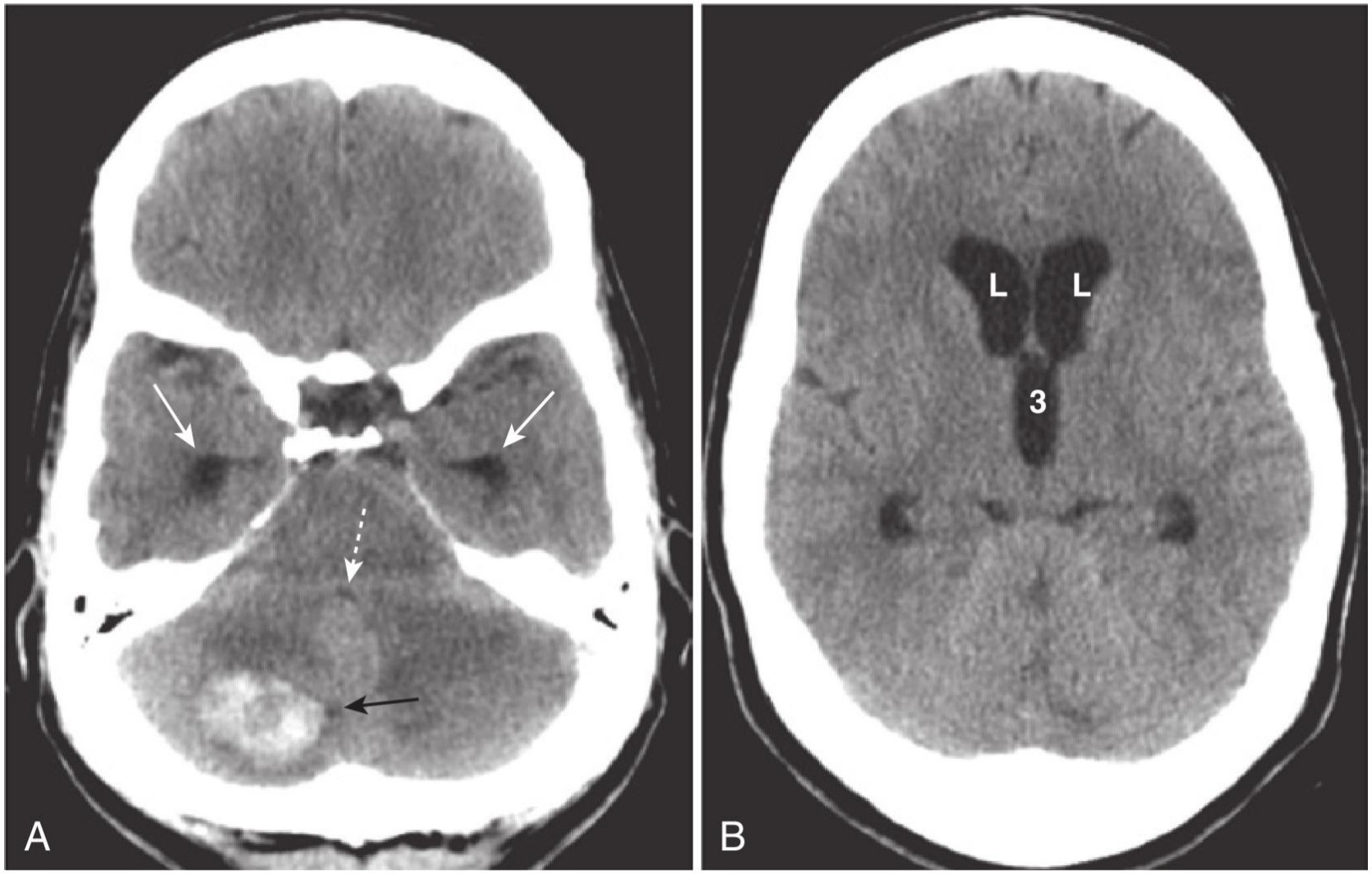
HYDROCEPHALUS (Pressure)

- Pathophysiology: Increased volume/pressure of CSF (overproduction, under-absorption, or obstruction).
- Ventricular Appearance: **Disproportionately dilated** compared to sulci.
- Sulcal Appearance: Normal, flattened, or effaced (compressed against the skull).
- Key Indicator: Temporal horns (normally barely visible) dilate to >2mm.

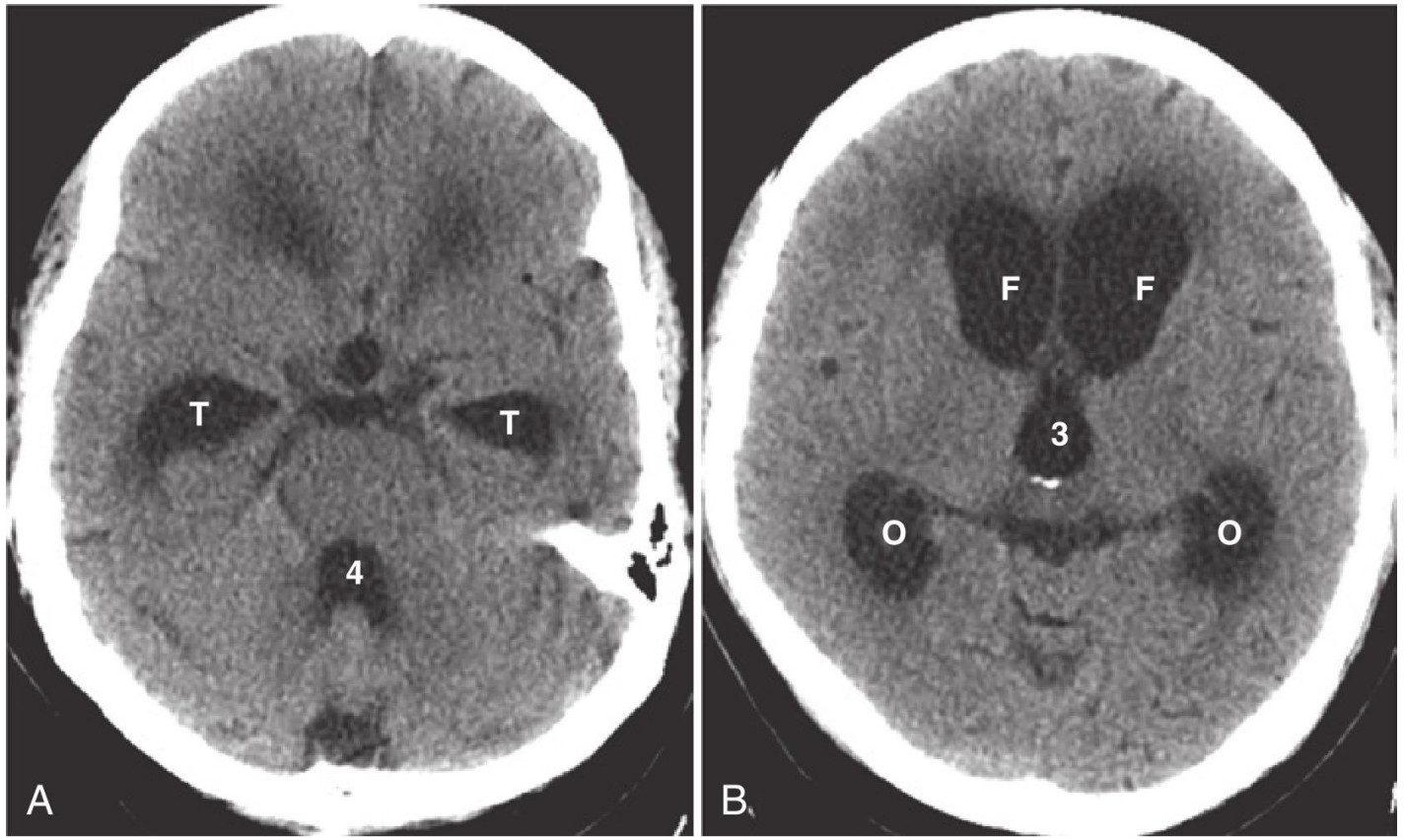
CEREBRAL ATROPHY (Ex Vacuo)

- Pathophysiology: Loss of normal brain tissue; space fills passively with CSF. Normal CSF dynamics.
- Ventricular Appearance: **Proportionately enlarged** alongside sulci.
- Sulcal Appearance: Prominent, widened sulci.

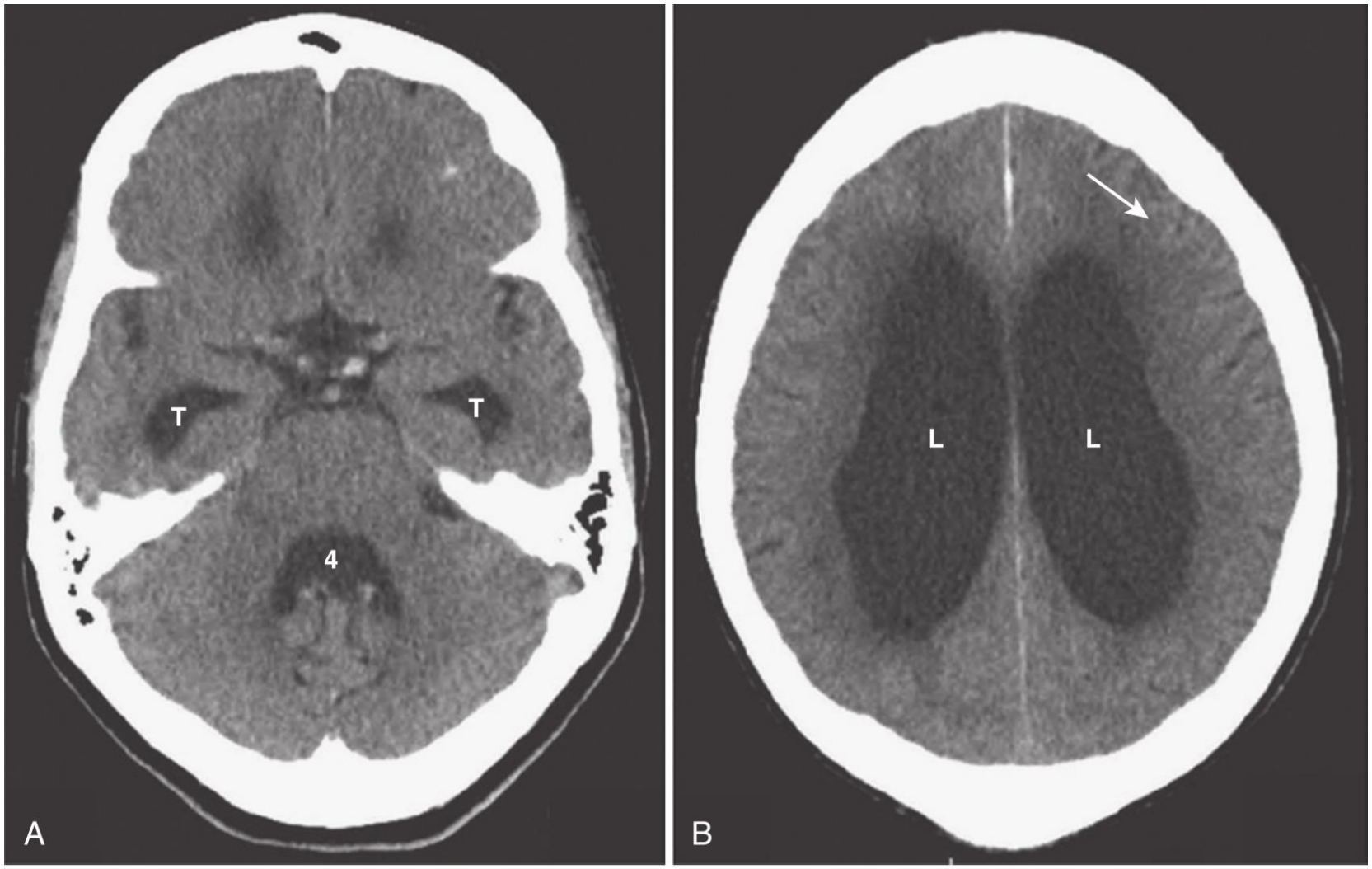
NONCOMMUNICATING HYDROCEPHALUS



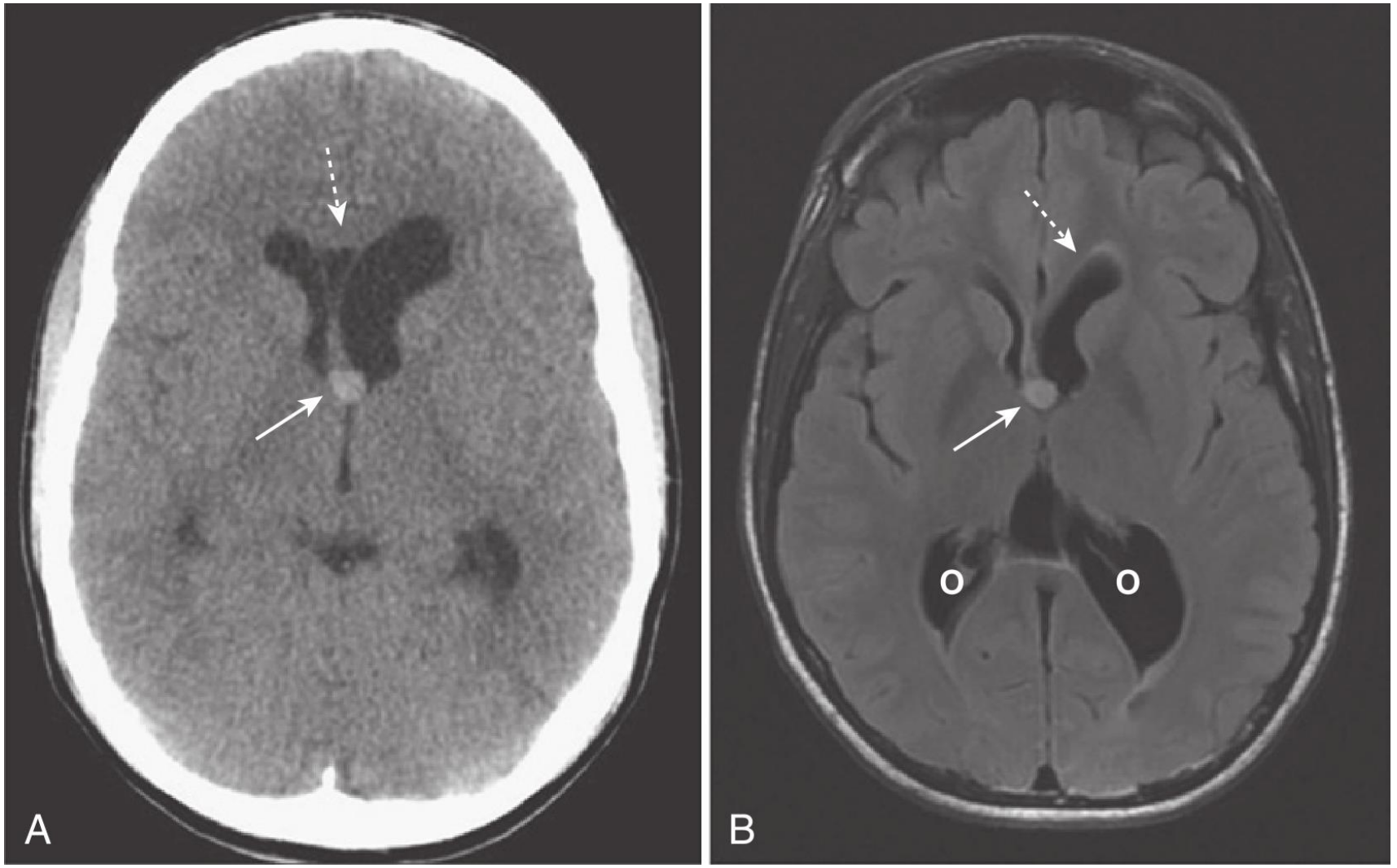
COMMUNICATING HYDROCEPHALUS



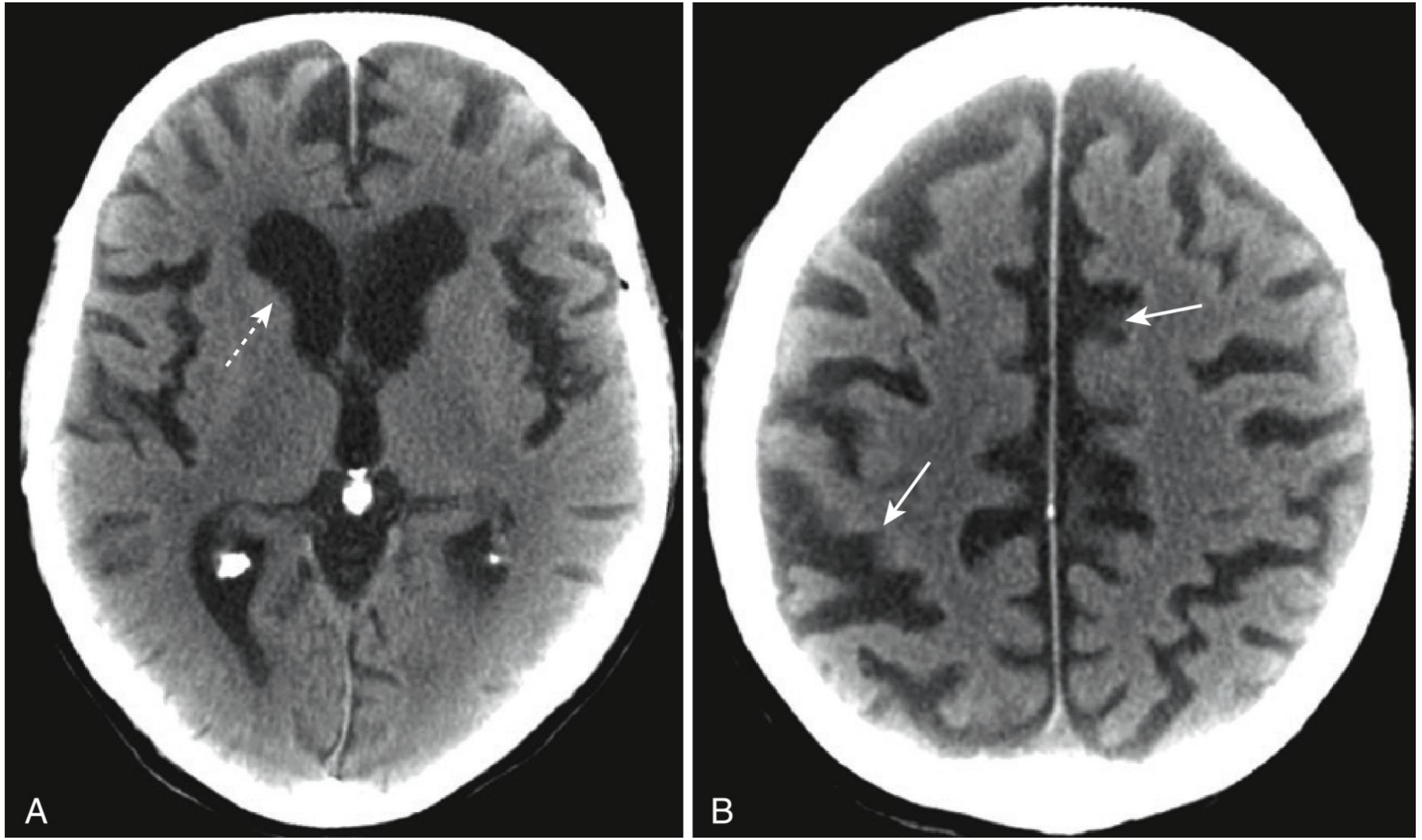
NORMAL PRESSURE HYDROCEPHALUS



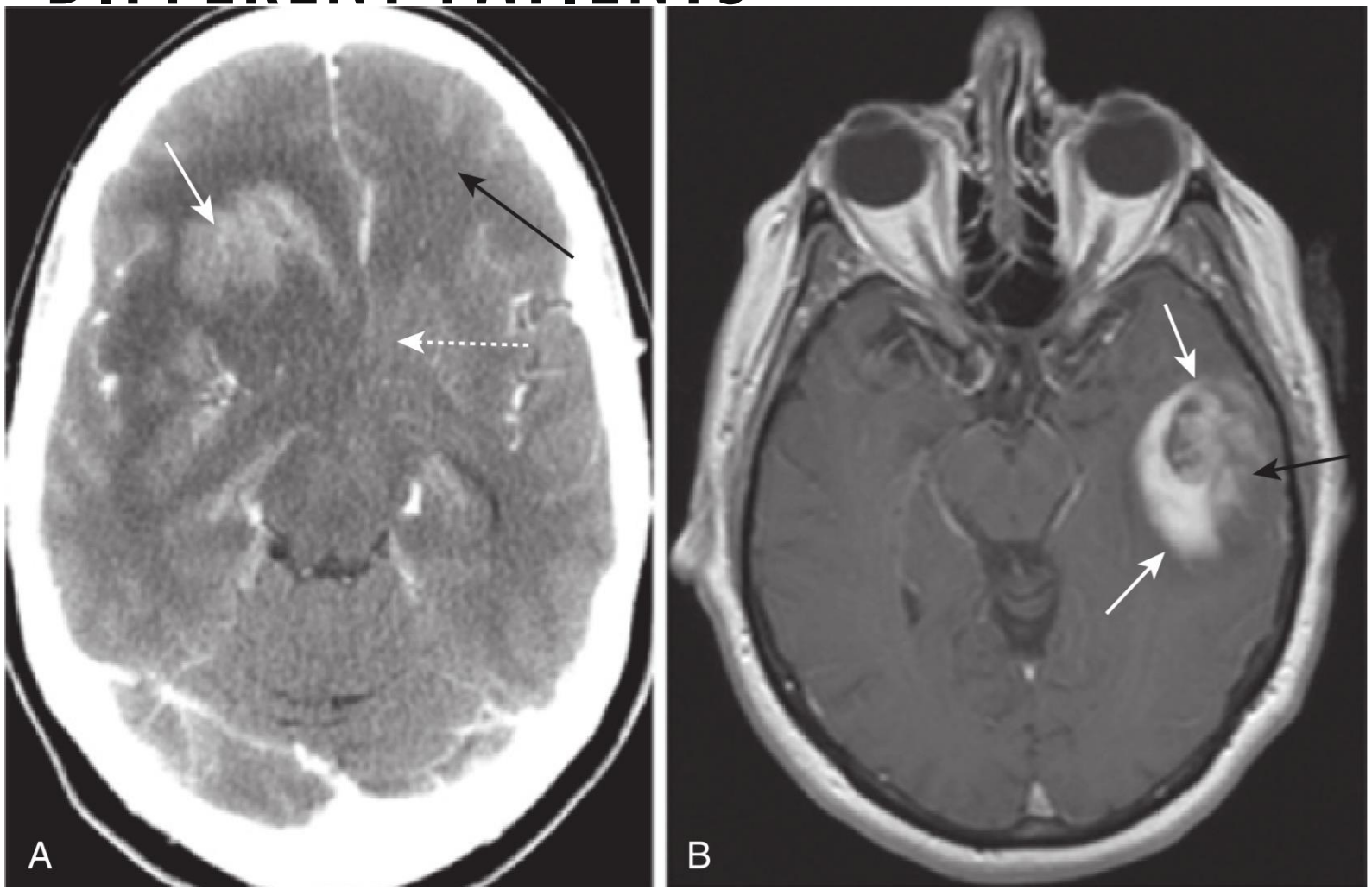
COLLOID CYST OF THE THIRD VENTRICLE: CT AND MRI



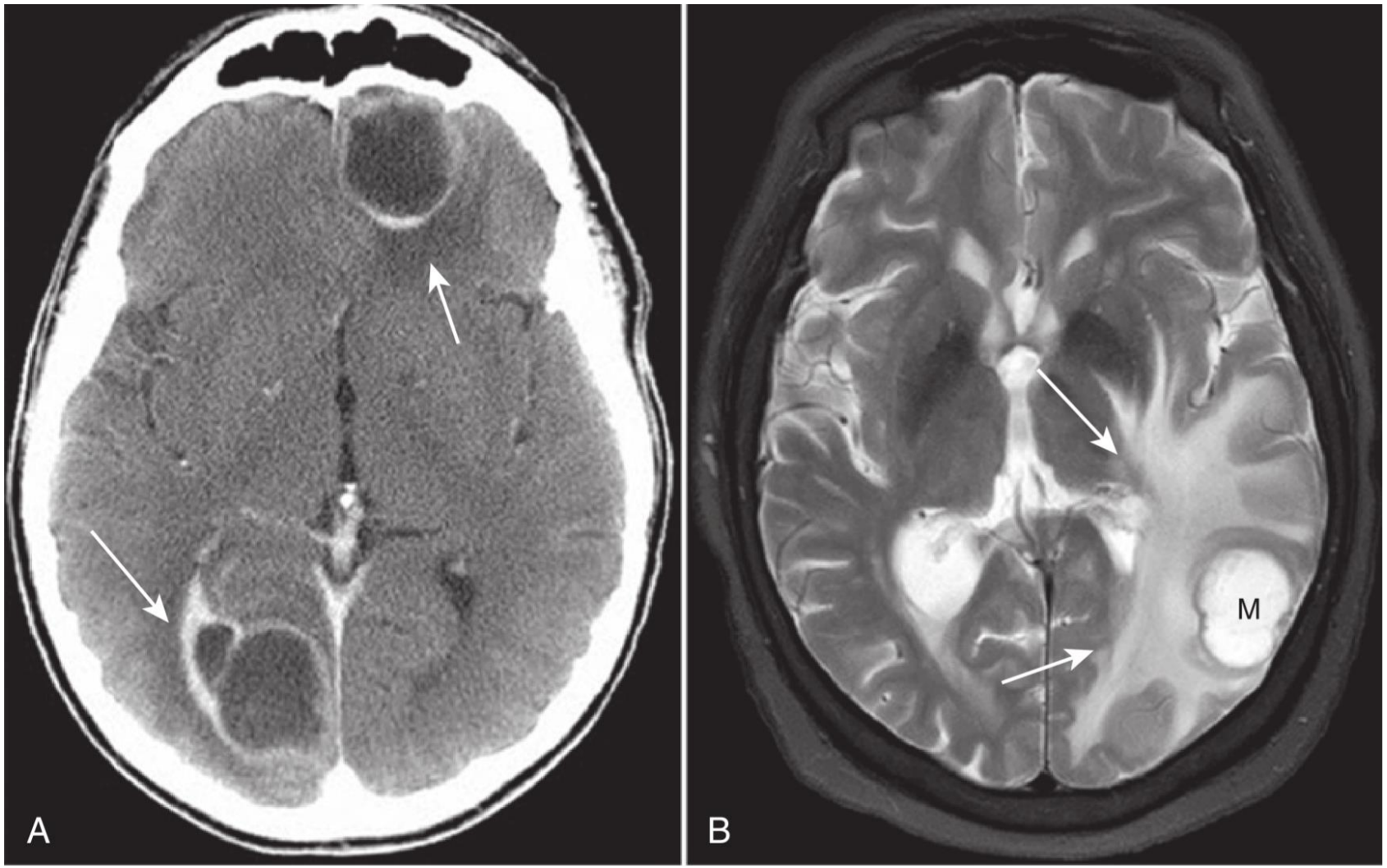
DIFFUSE CORTICAL ATROPHY



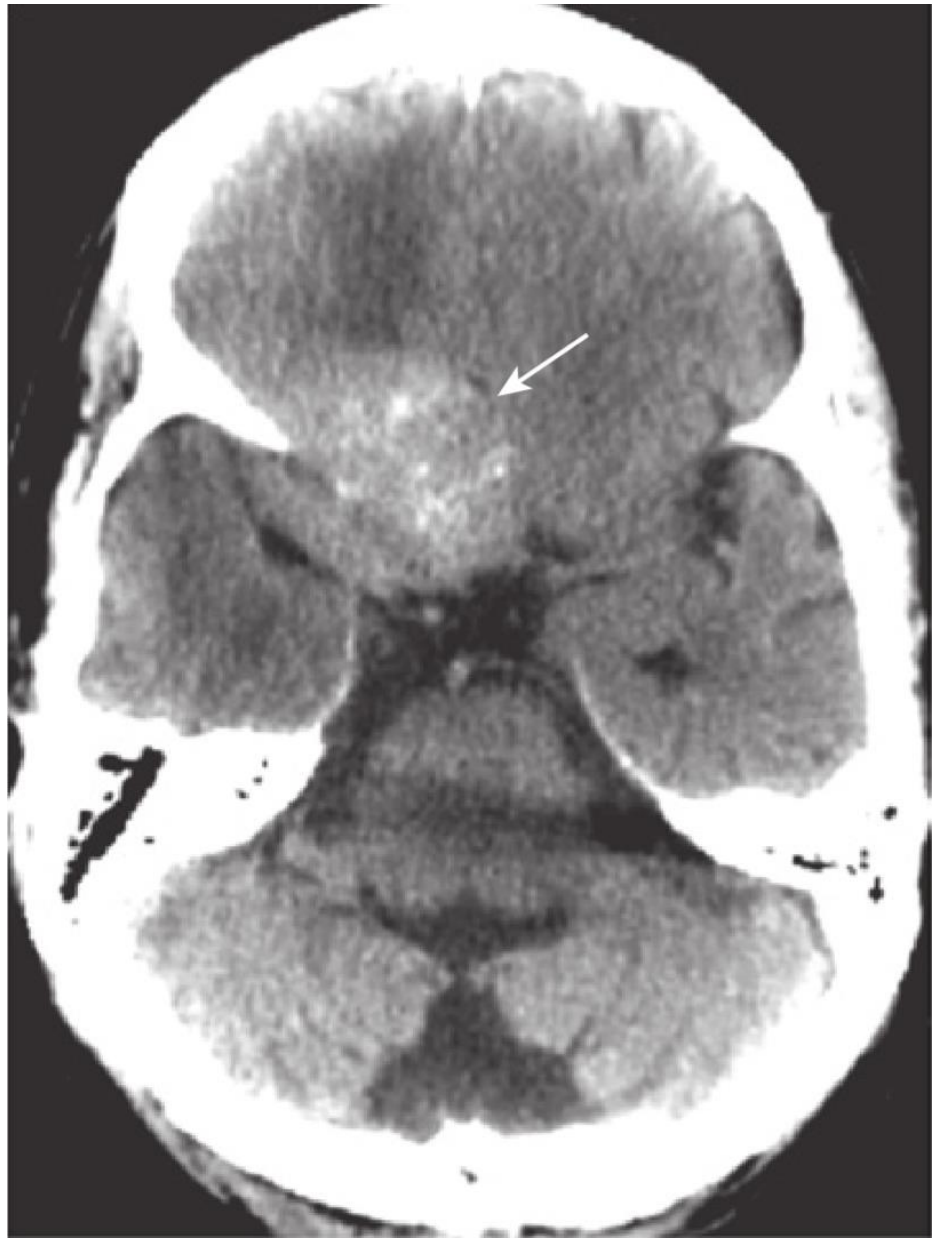
GLIOBLASTOMA MULTIFORME: CT AND MRI, TWO DIFFERENT PATIENTS



METASTASES: CONTRAST-ENHANCED CT AND MRI



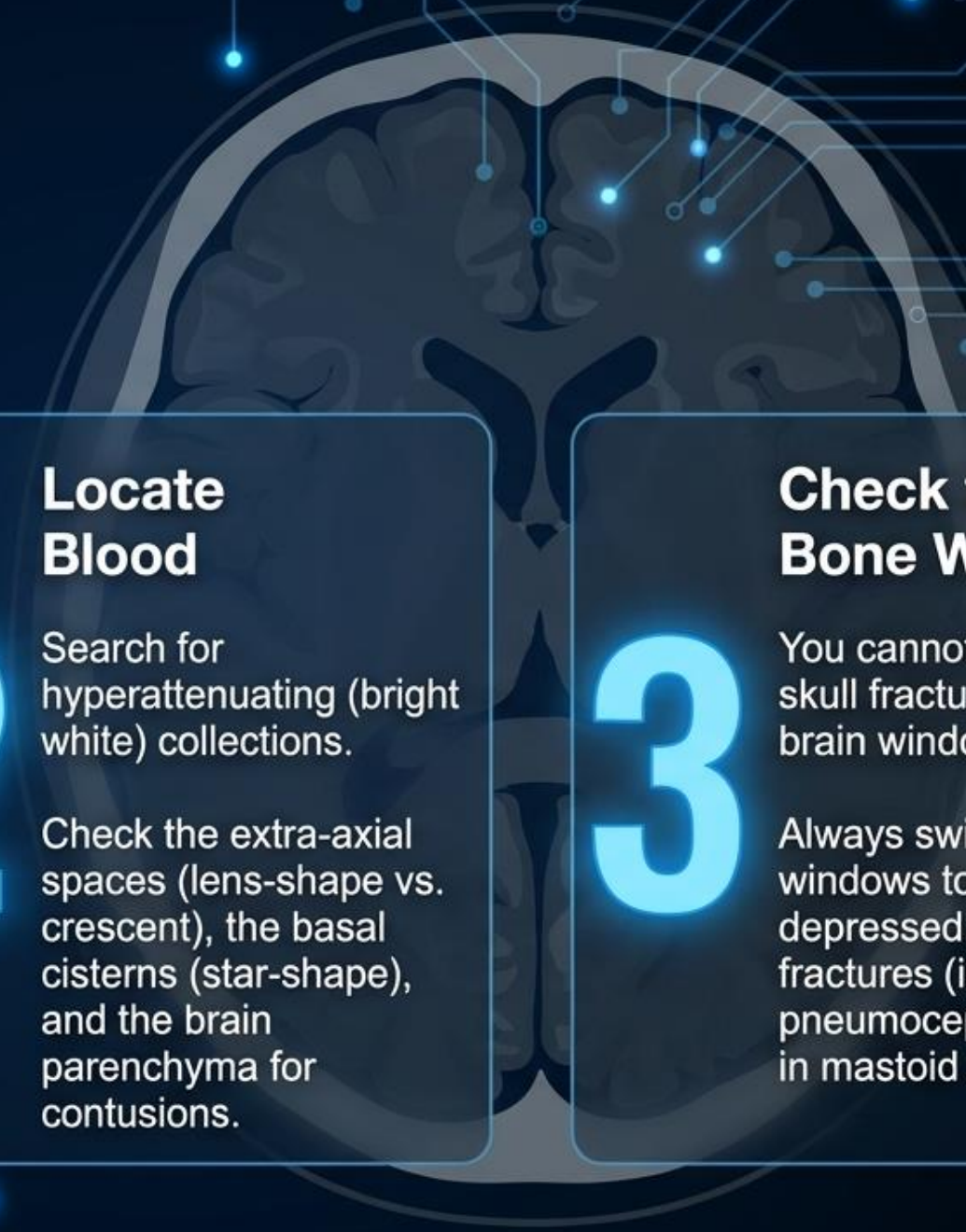
MENINGIOMA: NONENHANCED CT



VESTIBULAR SCHWANNOMA: T1-WEIGHTED MRI WITH CONTRAST

The Emergency Search Pattern

Systematic evaluation of acute head trauma on unenhanced CT.



1 Assess Mass Effect

Look for displacement or compression of key structures.

Are the ventricles symmetric? Are the basal cisterns effaced? Is there a subfalcine or transtentorial midline shift?

2 Locate Blood

Search for hyperattenuating (bright white) collections.

Check the extra-axial spaces (lens-shape vs. crescent), the basal cisterns (star-shape), and the brain parenchyma for contusions.

3 Check the Bone Windows

You cannot diagnose skull fractures on a brain window.

Always switch to bone windows to locate linear, depressed, or basilar fractures (indicated by pneumocephalus or fluid in mastoid air cells).