Pediatric Neuroradiology Pre-call Primer

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Learning Objectives

After reviewing this series of modules you should be able to:

- Sutures:
  - Name pediatric skull sutures and fontanelles.
  - Identify common accessory sutures.
  - Localize pediatric skull sutures and fontanelles.
- Skull fractures:
  - Confidently differentiate a suture from a fracture.
  - Identify when a fracture extends through a suture.
- Bleeds:
  - Differentiate between epidural, subdural, and subarachnoid bleeds.
  - Discuss the differential considerations of a hypodense region within an extraaxial hemorrhage.
  - List mimics of subarachnoid and subdural bleeds.

Learning Objectives

- Sulci & mass effect
  - Explain the “three shades of gray” approach.
  - Discuss completely effaced sulci.
  - Discuss almost completely effaced sulci.
  - Discuss normal appearing sulci.
- Cisterns:
  - Name the major cisterns.
  - List the contents of the cisterns.
  - Discuss complications of cisternal compression.
- Herniations:
  - Describe major types of brain herniations.
  - Discuss the consequences of brain herniation.

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Pediatric Neuroradiology Precall Primer

Module 1: Sutures

Relevance

- In the pediatric population, sutures and non-displaced fractures can easily be confused. This can have significant impact on clinical management for victims of **abusive head trauma**.

- Besides emergency indications, knowledge of pediatric sutures is also important in the accurate diagnosis and treatment monitoring of patients with **craniosynostosis**.

- Adult fracture signs (fracture edges that are not corticated, fractures are linear compared to normal squiggly sutures) **may not apply in the immature skull**.

- **In children**, a decision of suture versus fracture is frequently based on:
  - **Symmetry (favors suture)**
  - **Knowledge of sutures and accessory sutures**

Learning Objectives

After reviewing this module you should be able to:

- Name pediatric skull sutures and fontanelles
- Identify common accessory sutures
- Localize pediatric skull sutures and fontanelles

Larger Sutures

Major sutures:

- Coronal (Corona means crown- think of a tiara)
- Sagittal (Sagitta means arrow)
- Lambdoid (Lamdoid is a letter from the Greek alphabet with a peculiar shape that matches the configuration of the lambdoid suture).

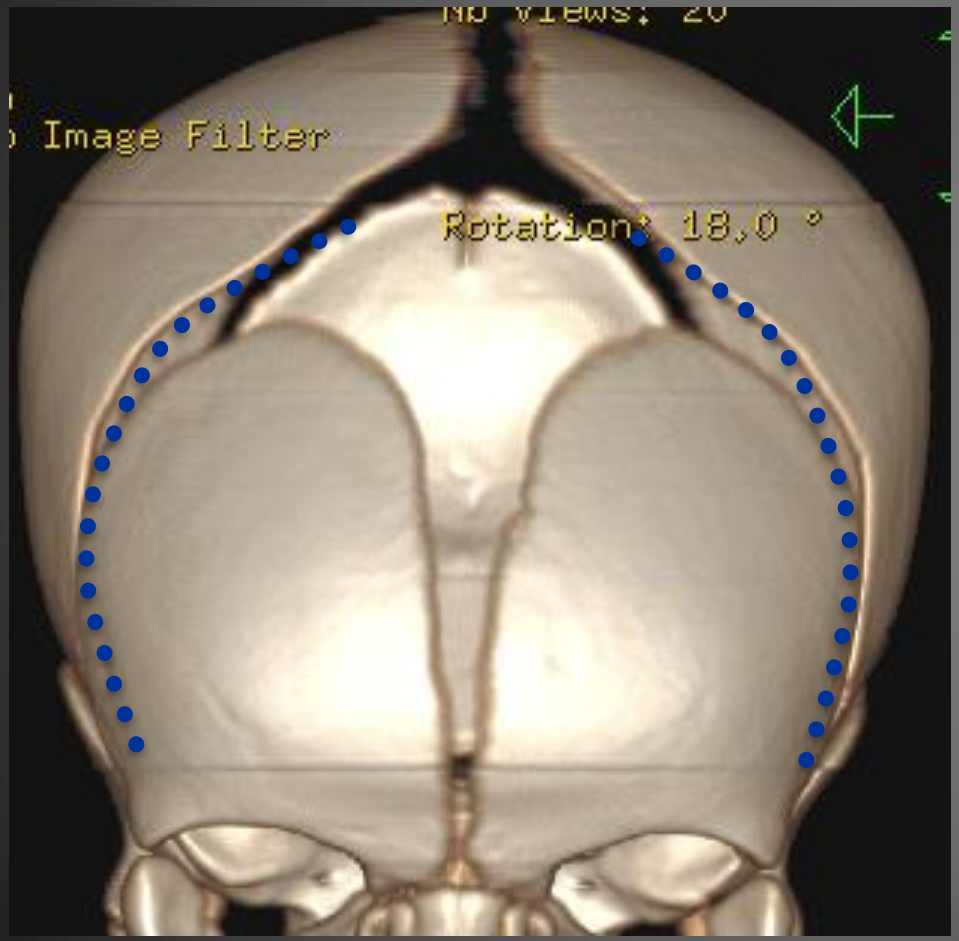
Other sutures:

- Squamosal (Squama is Latin for scale and relates to the shape of this part of the temporal bone).
- Metopic and mendosal sutures also have names that refer to their anatomical location and make them more memorable (metopic=frontal; Mendosal =posterior intraoccipital)
- The remaining sutures are named after the neighboring bones adjacent to them.

3D Volume Rendered Images

- Head CT imaging in pediatric patients is commonly done for head trauma, and skull fractures or suture diastasis are a common finding.
- 3D volume rendered images can increase detection of fracture and diastatsis and are routinely done at our institution. These images require minimal post-processing, and do not increase radiation dose.
- It is prudent to familiarize yourself with creating these images if they are not routinely done at your institution.

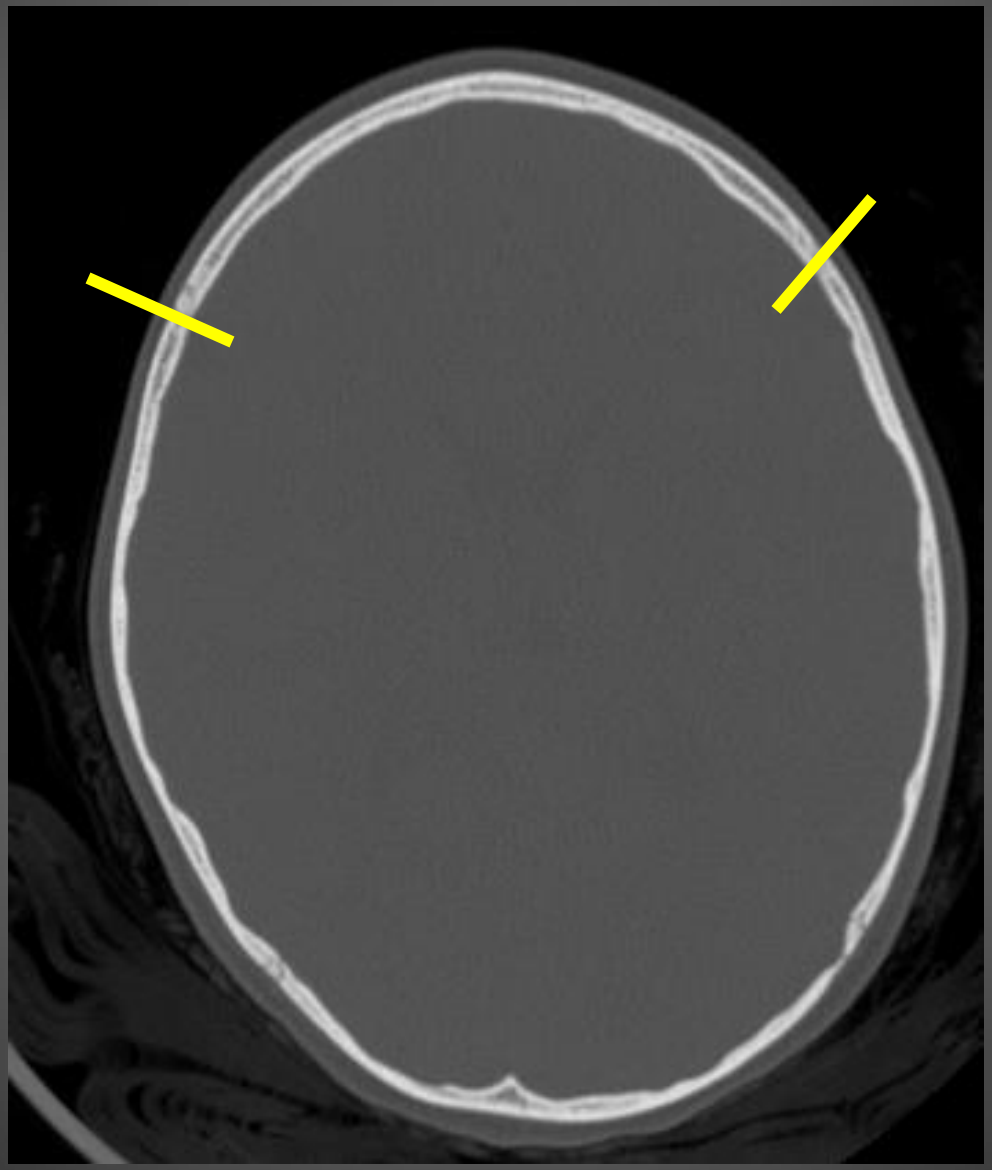
Blue dots mark the **coronal suture**
as seen from the front (left) and as seen from the top (right)



Frontal

Occipital

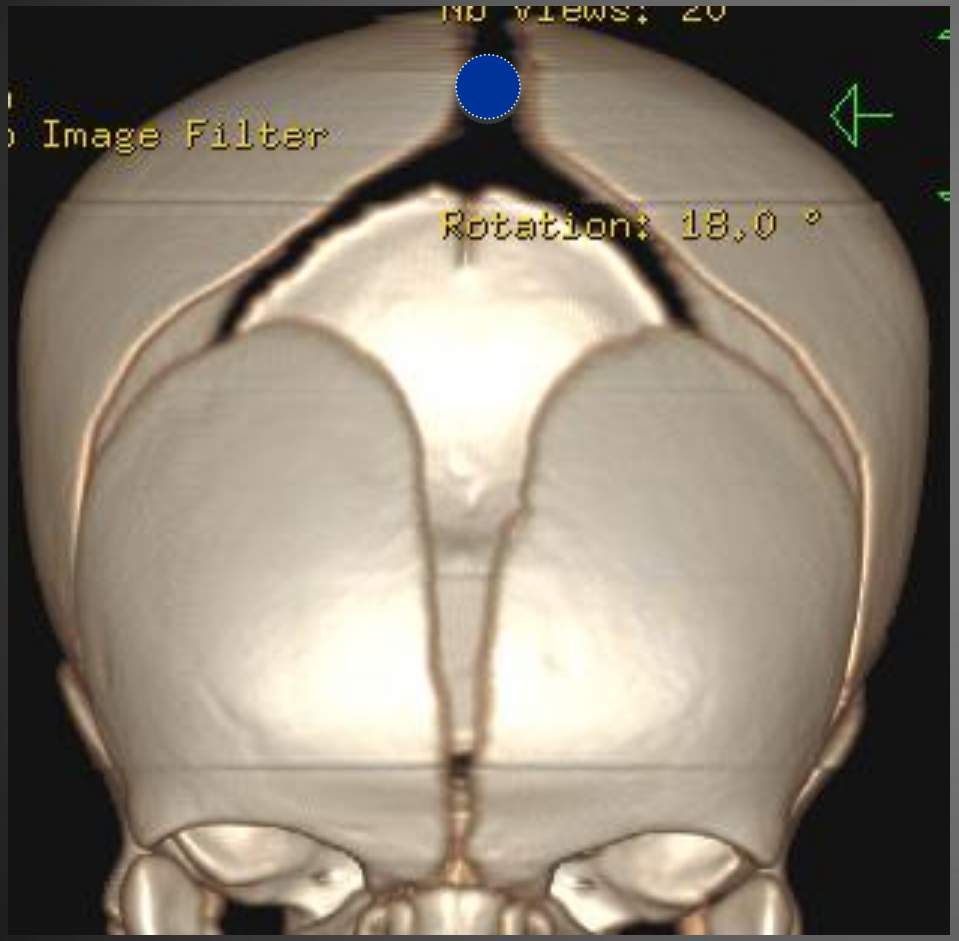
Yellow lines mark the **coronal suture**



Blue dots mark the **sagittal suture**

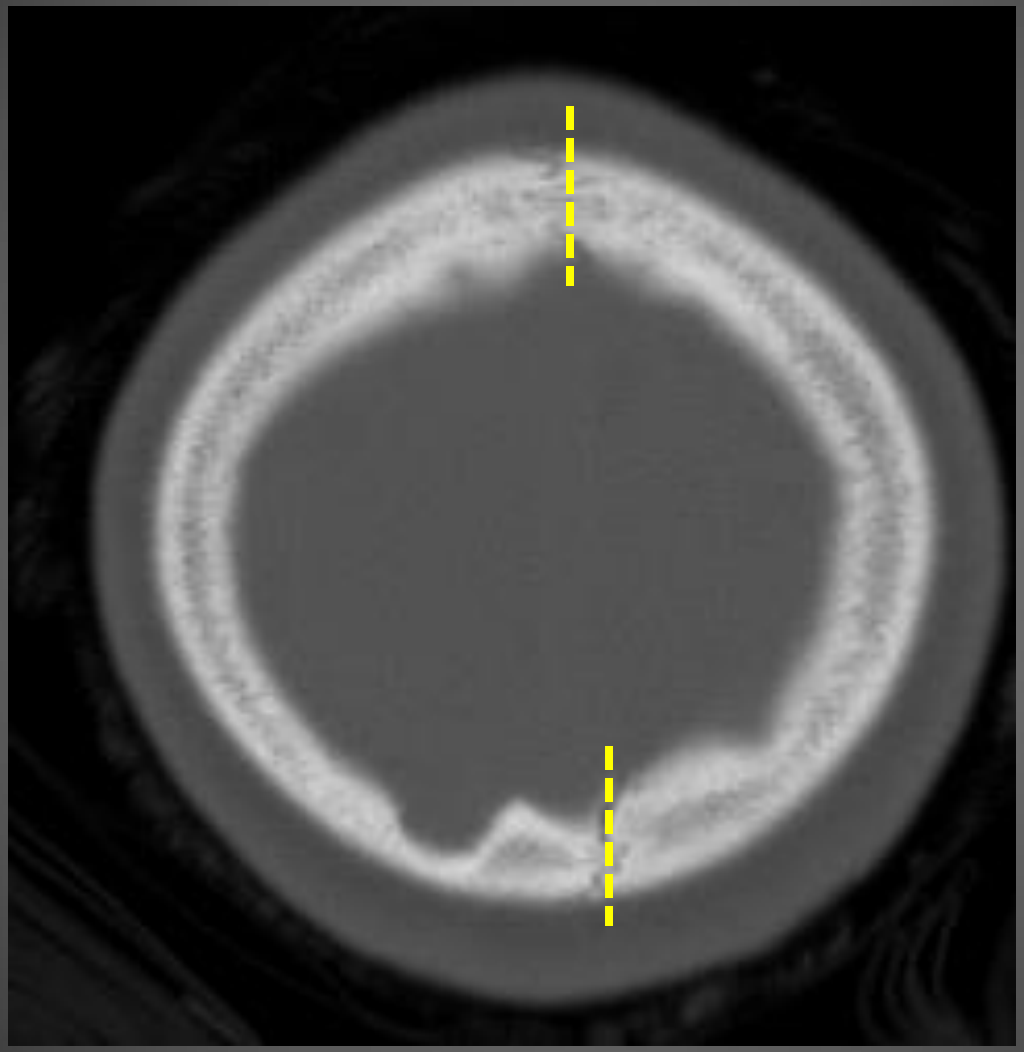
as seen from the front (left) and as seen from the top (right).

Front

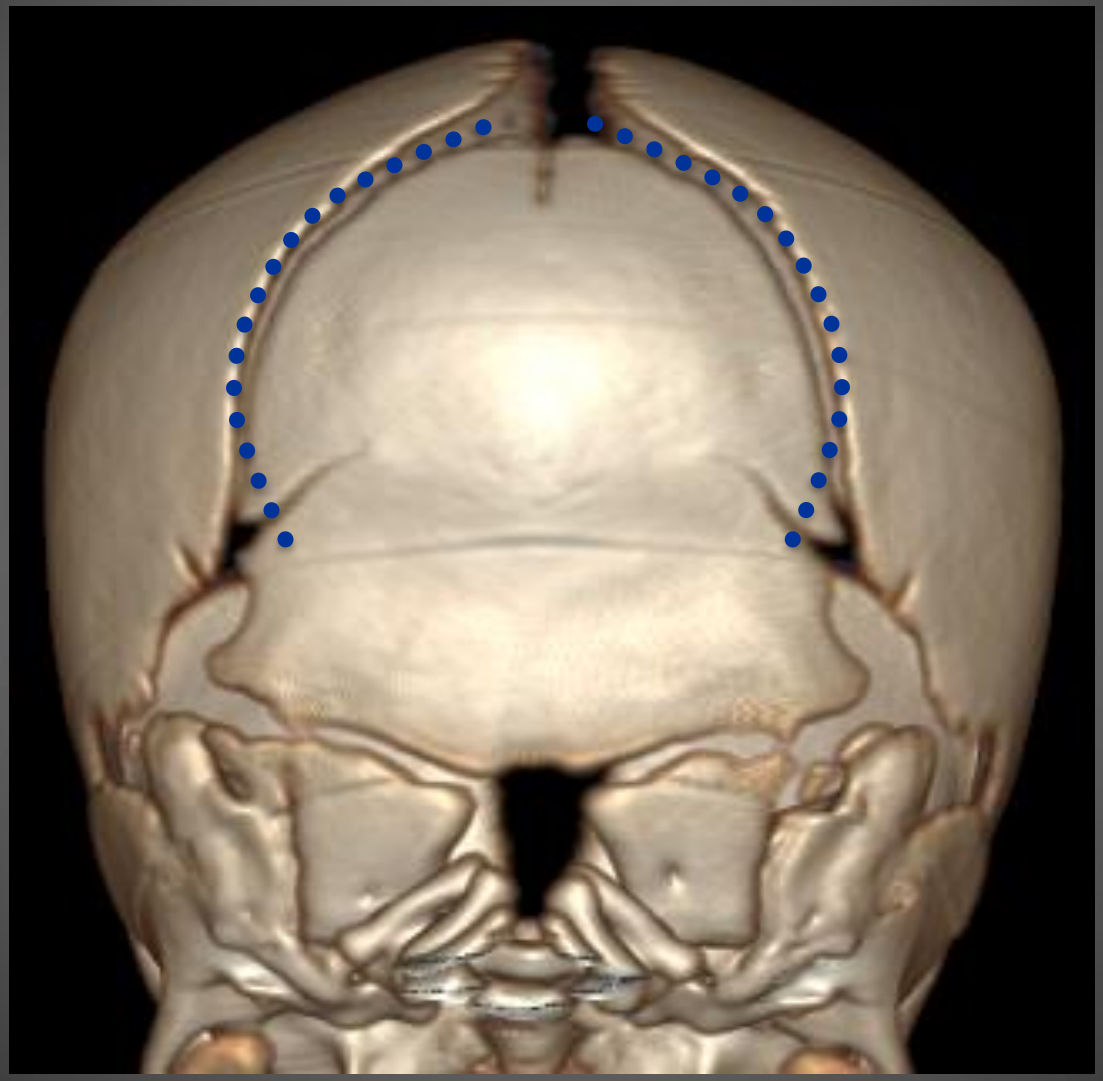


Back

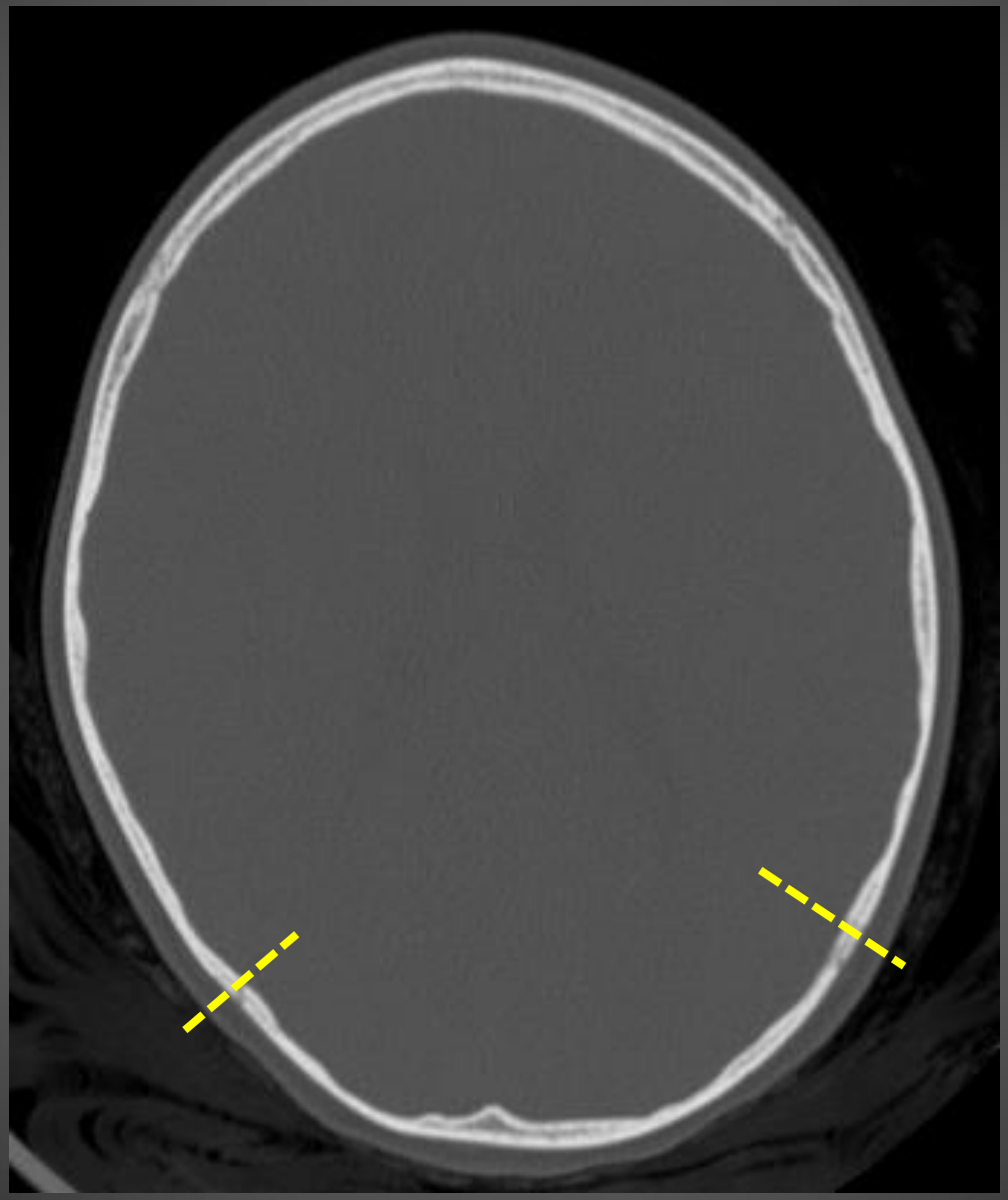
Yellow lines the **sagittal suture**



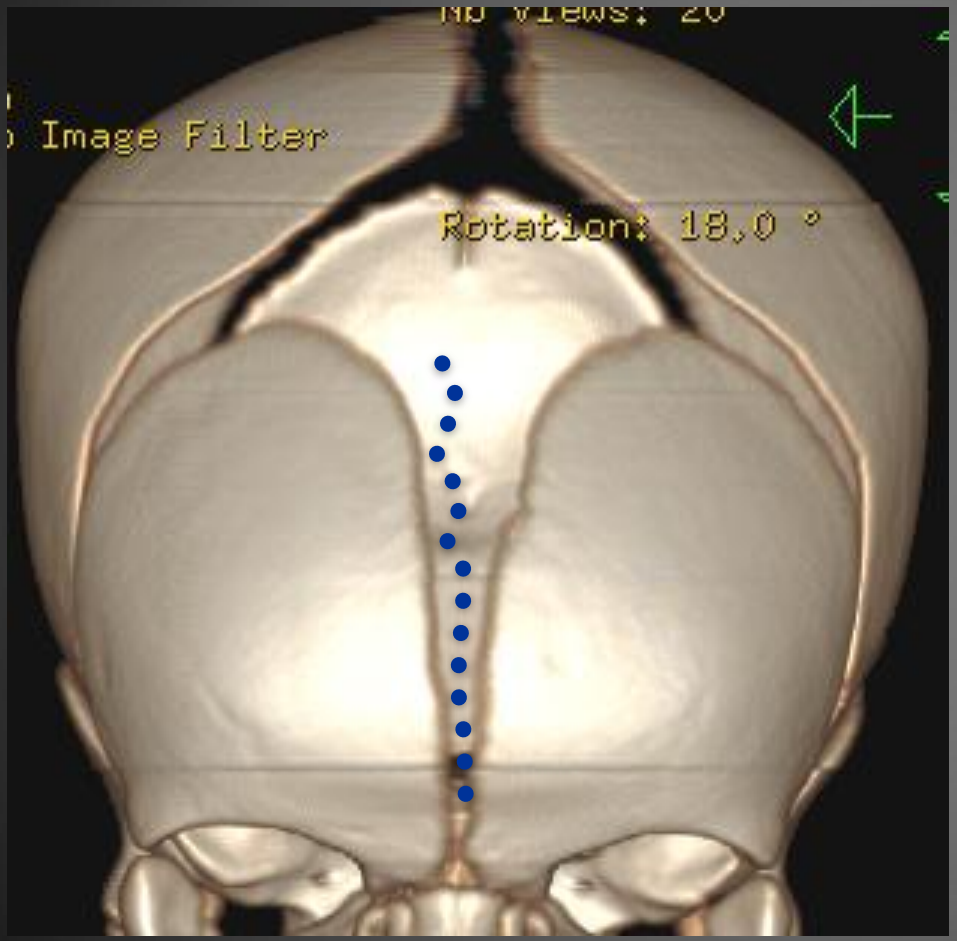
On this occipital view we see the **lambdoid suture** (blue dots).



Yellow lines mark the **lambdoid suture**.



Here, blue dots mark the **metopic or frontal suture**,
seen from the front (left) and from the top (right).

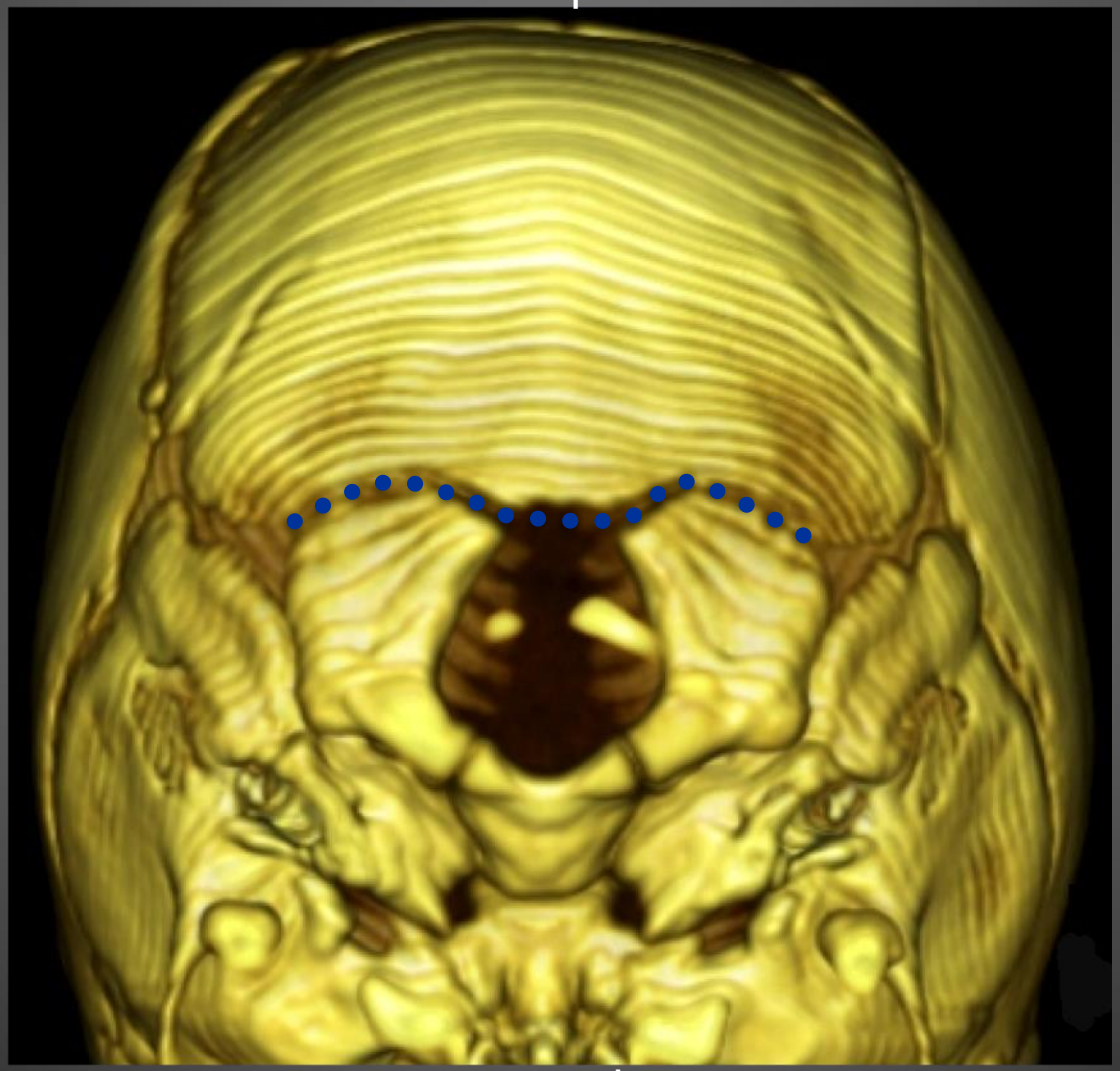


Frontal

Occipital

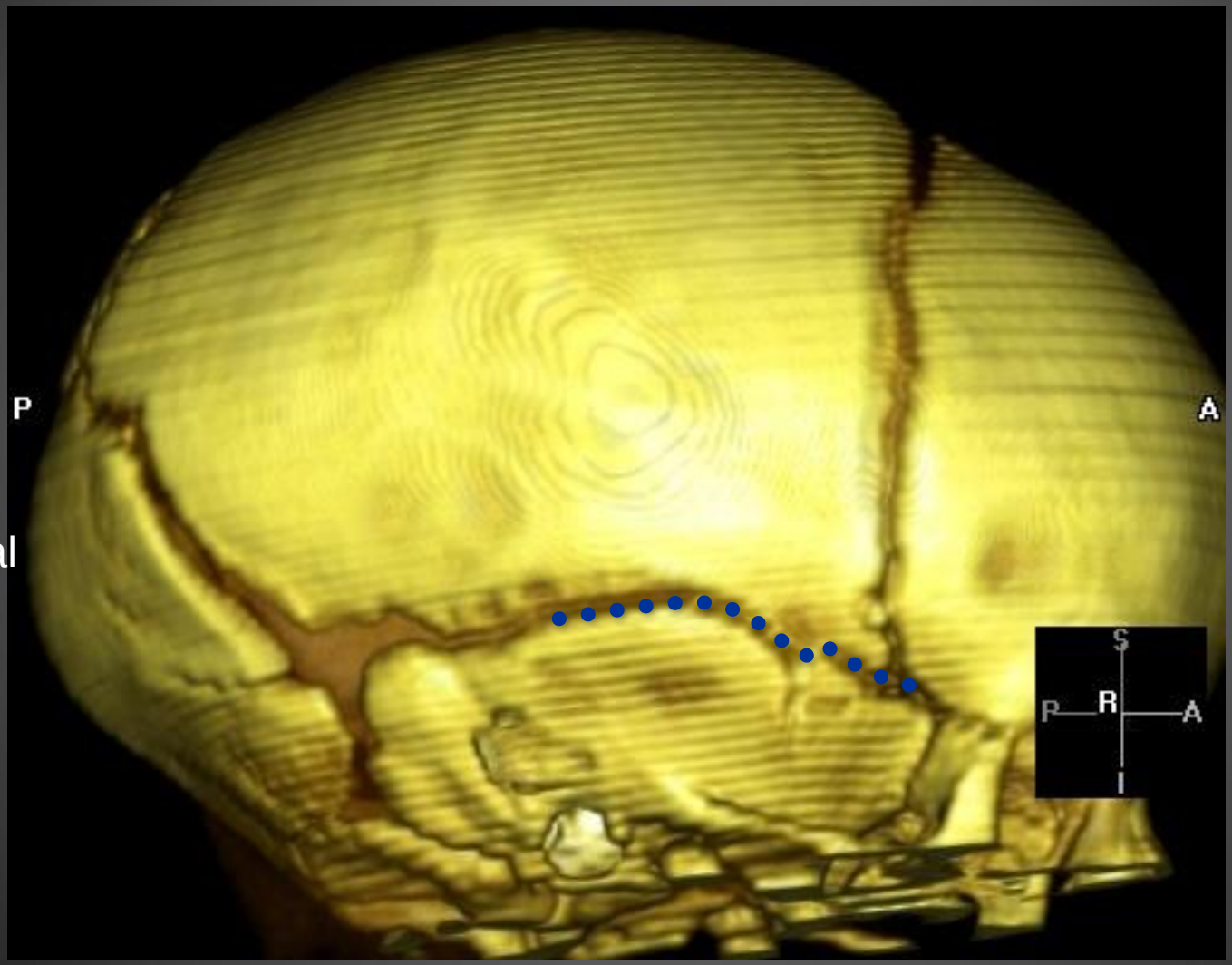
Here, we are looking at the foramen magnum from below and outlined with blue dots is the **posterior intraoccipital suture**.

Occipital



Frontal

Here is the **squamosal suture** with blue dots.



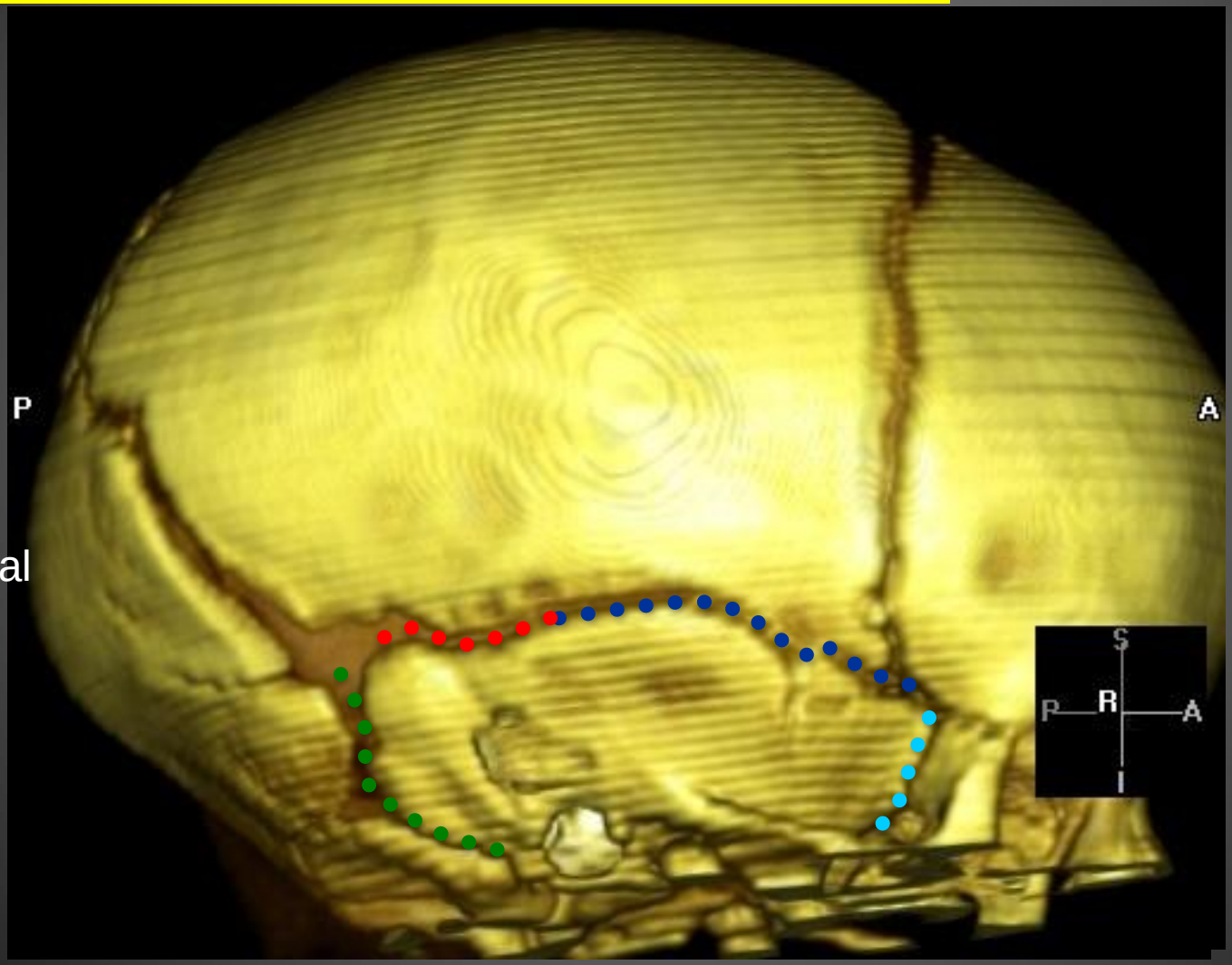
Occipital

Frontal

Minor Sutures

- These smaller sutures are named after the neighboring bones adjacent to them:
  - Spheno-frontal
  - Spheno-parietal
  - Spheno-squamosal
  - Parieto-mastoid
  - Occipito-mastoid

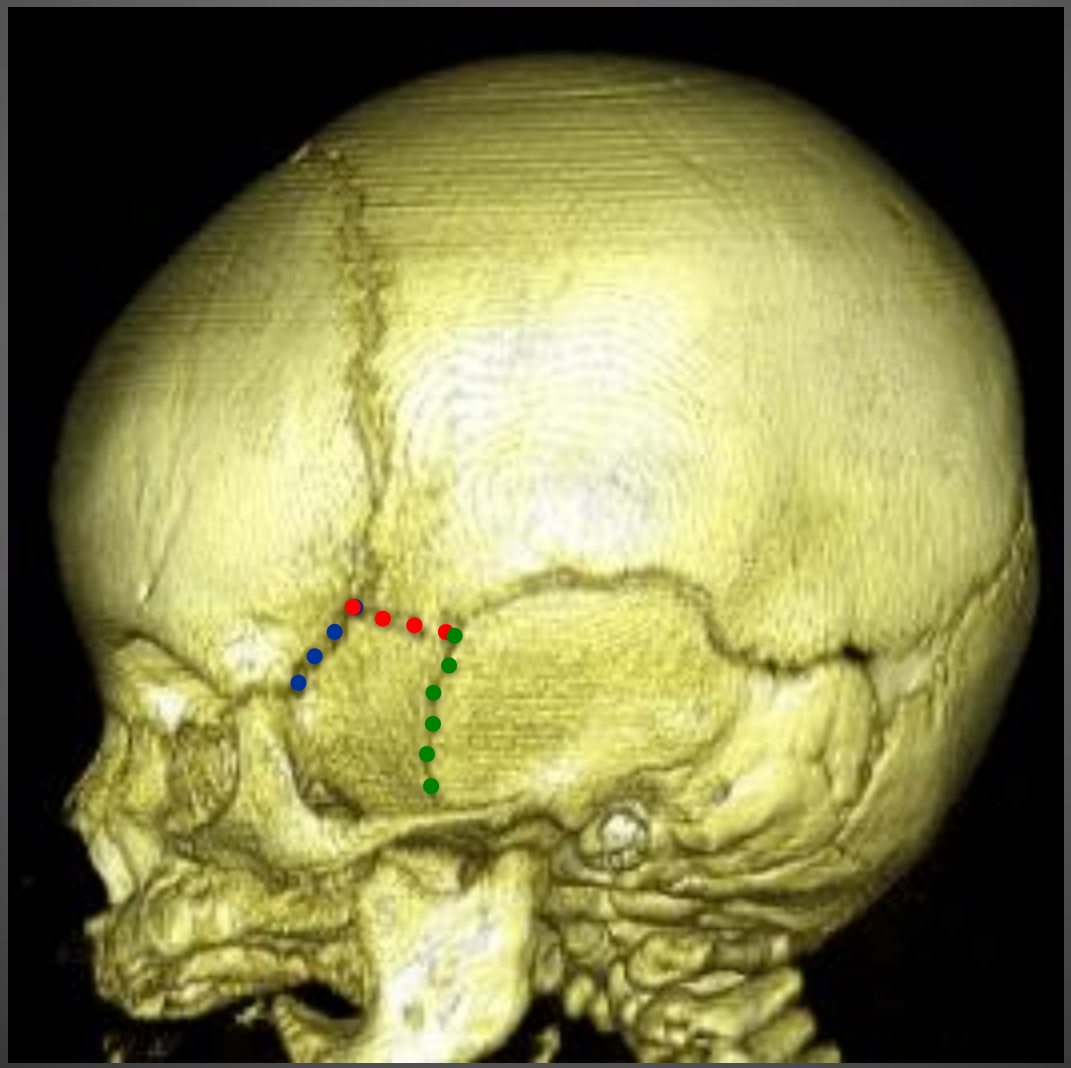
The **squamosal suture** is in dark blue.
The **parieto-mastoid** suture in red.
The **occipito-mastoid** suture in green,
And the **spheno-temporal** suture in.light blue



Occipital

Frontal

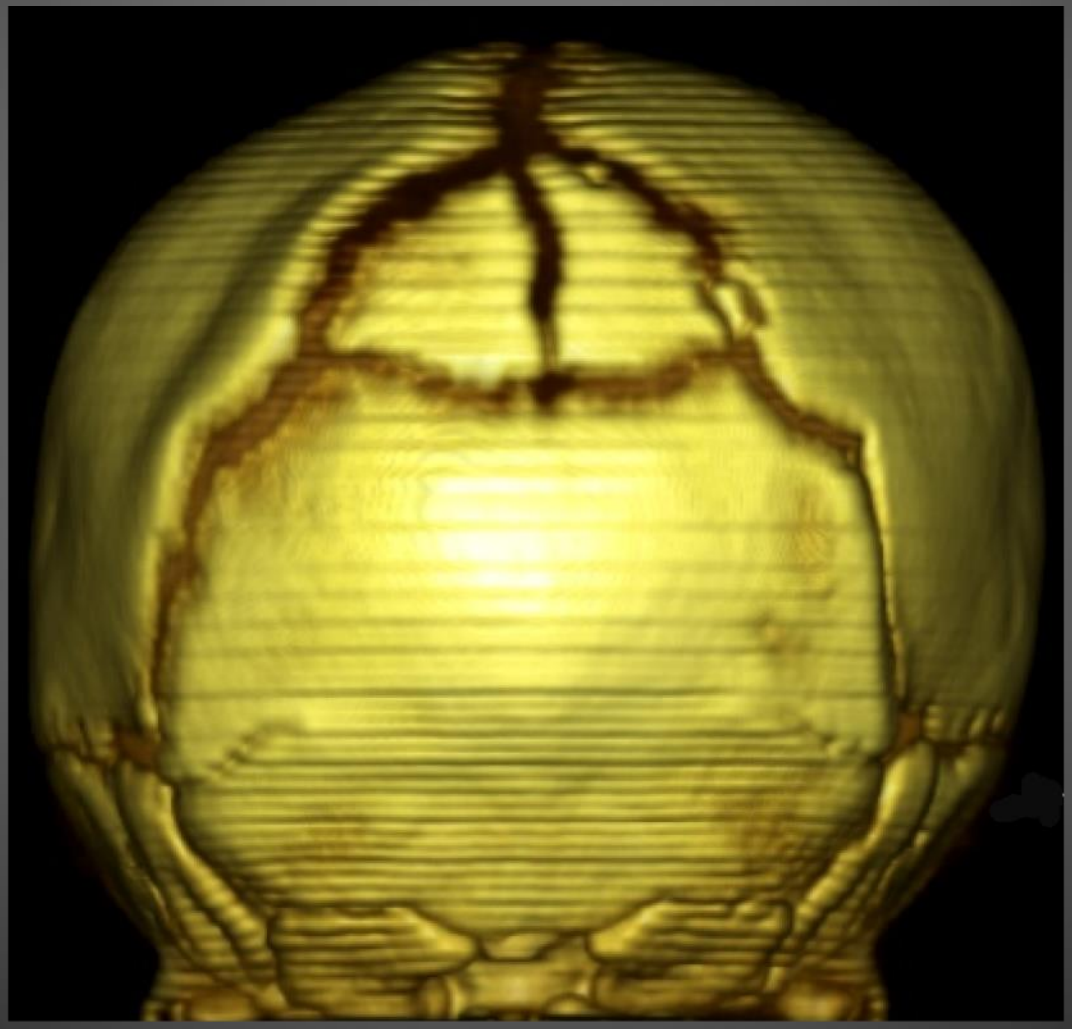
This is the **spheno-frontal** suture in blue,
The **spheno-parietal** suture in red,
Again the **spheno-temporal** suture- this time in green.



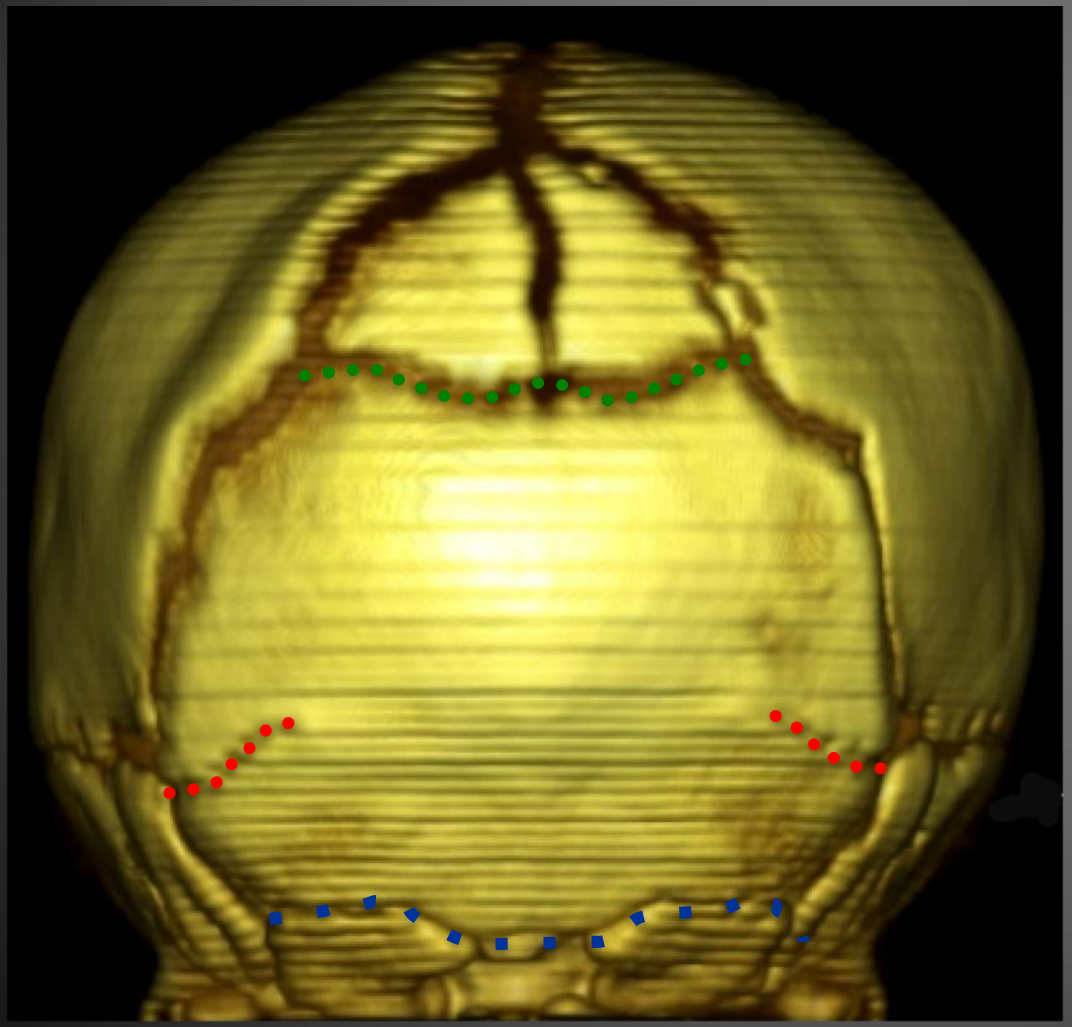
Accessory Sutures

Accessory sutures mostly occur in the parietal and occipital bones.

These could particularly be confused with fractures.



Accessory Sutures

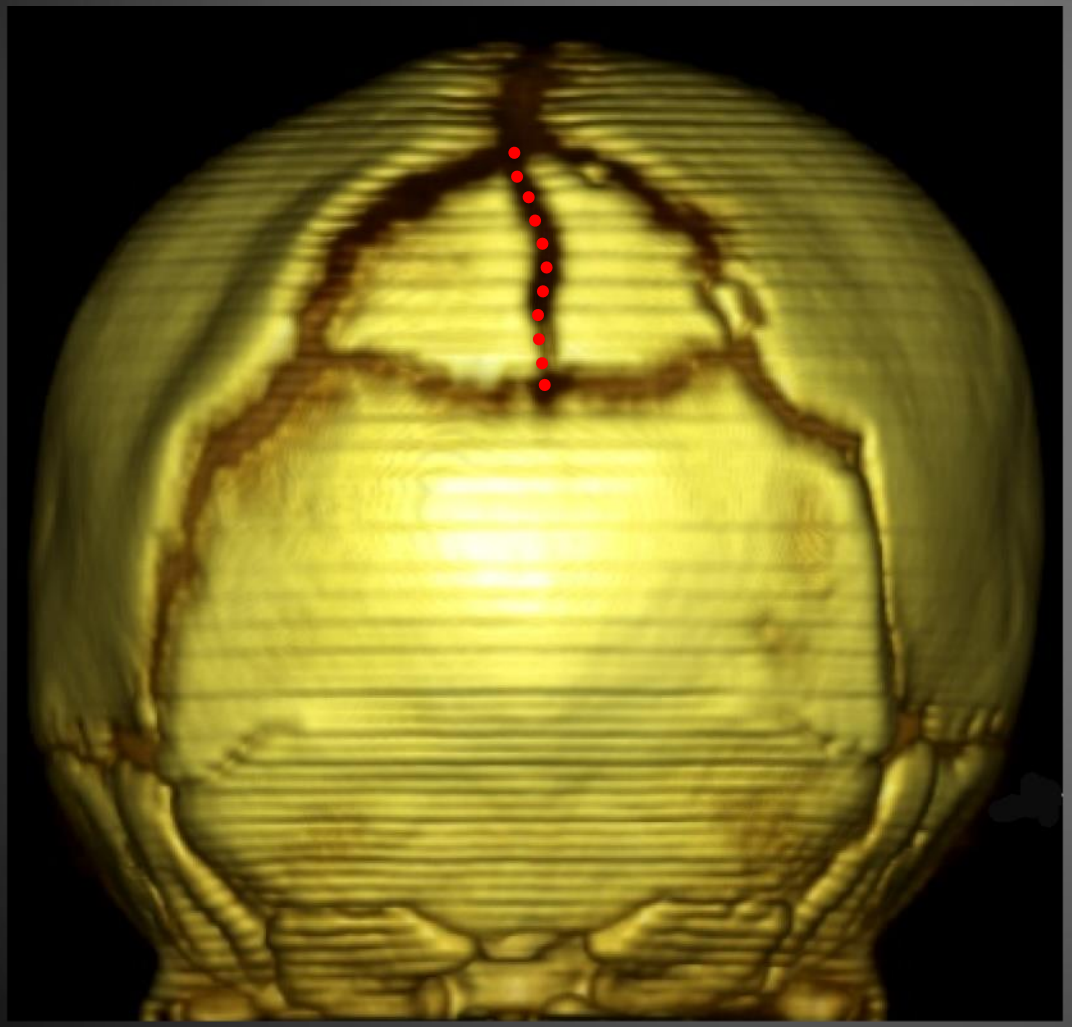


The **Mendosal sutures** (red) do not extend across the midline…….

…..unlike the **transverse occipital suture** (green)

….. and the **posterior intraoccipital suture** (blue).

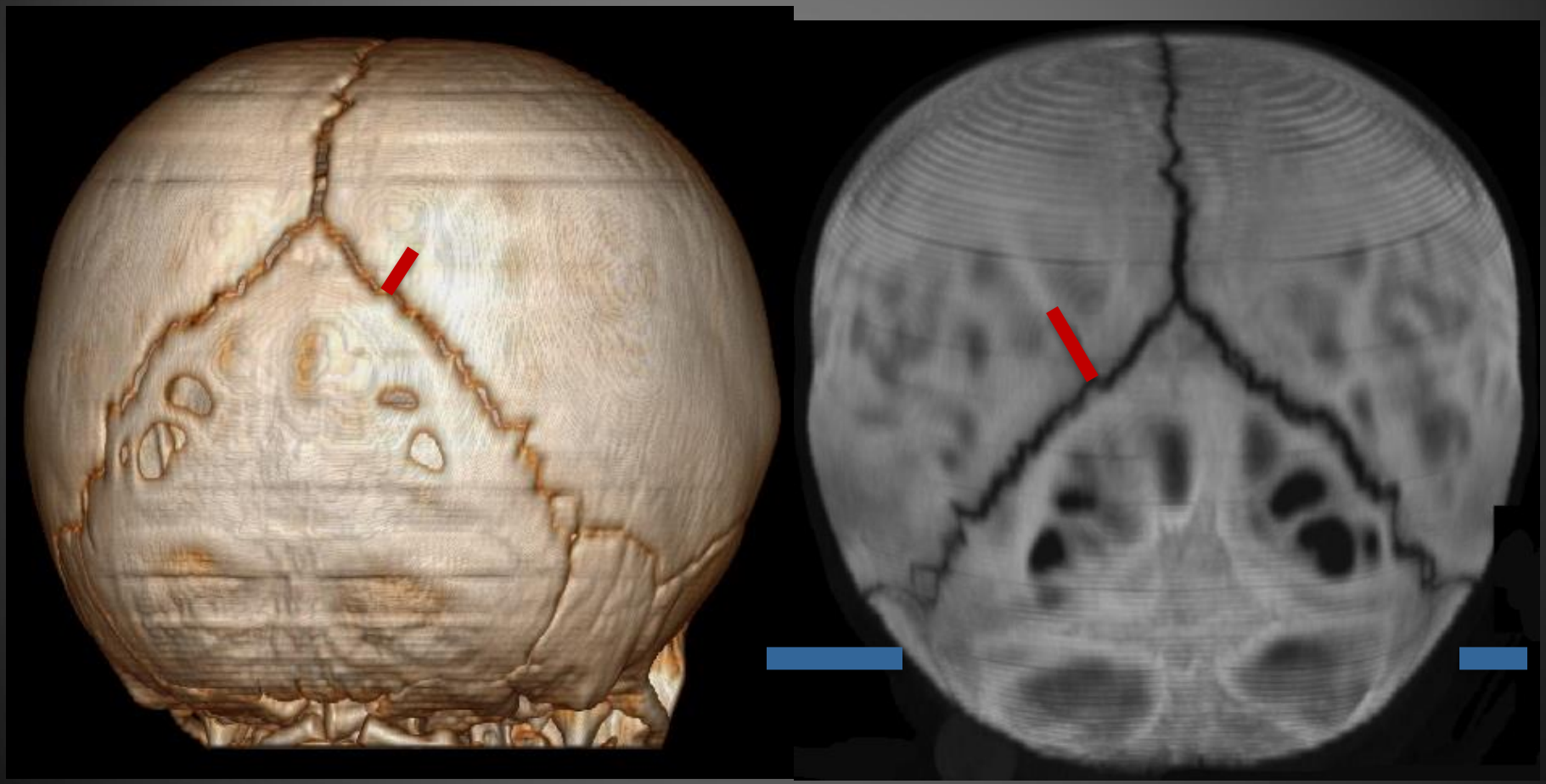
Accessory Sutures



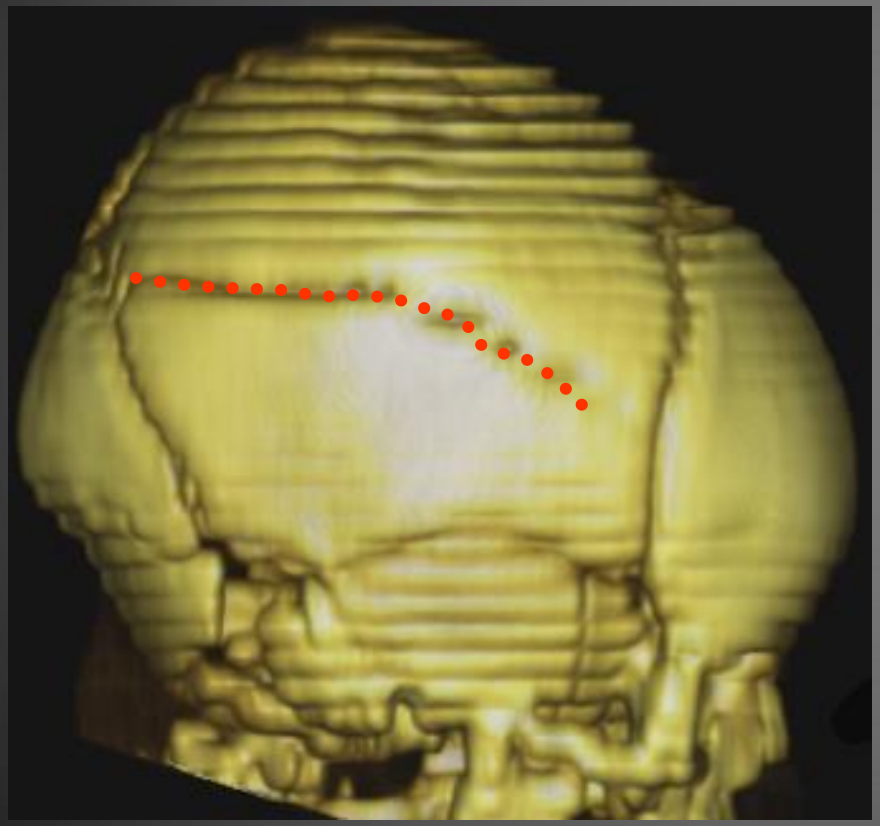
The interparietal suture (red) is an accessory suture of the upper part of the occipital bone that wedges between the parietal bones – hence its name!

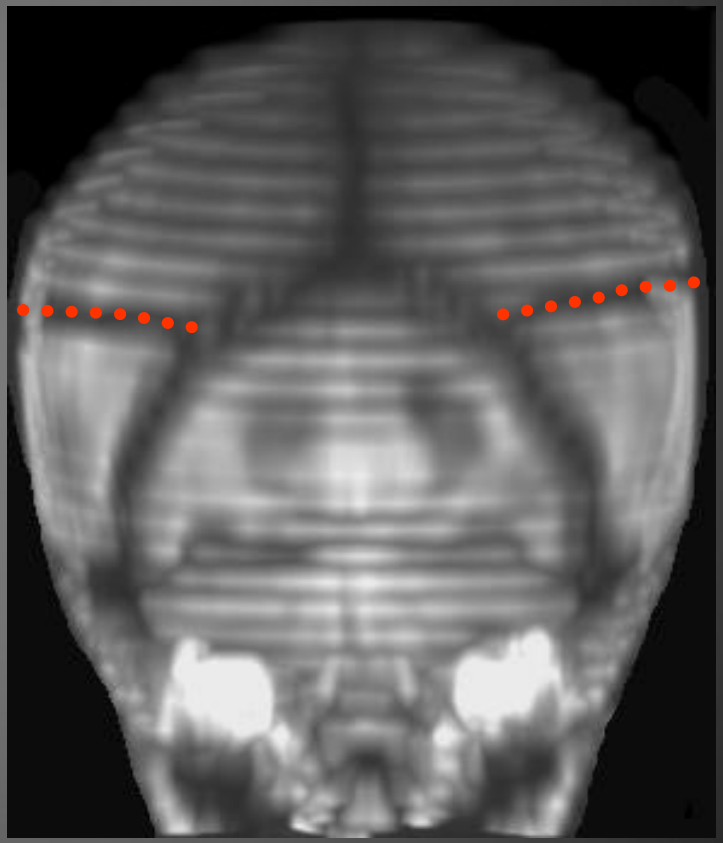
Accessory parietal suture

Frequently confused with a fracture, especially when asymmetrical!
3D bone renderings (left) and MIP (maximum intensity projections, right) can help in visualizing sutures and fractures.

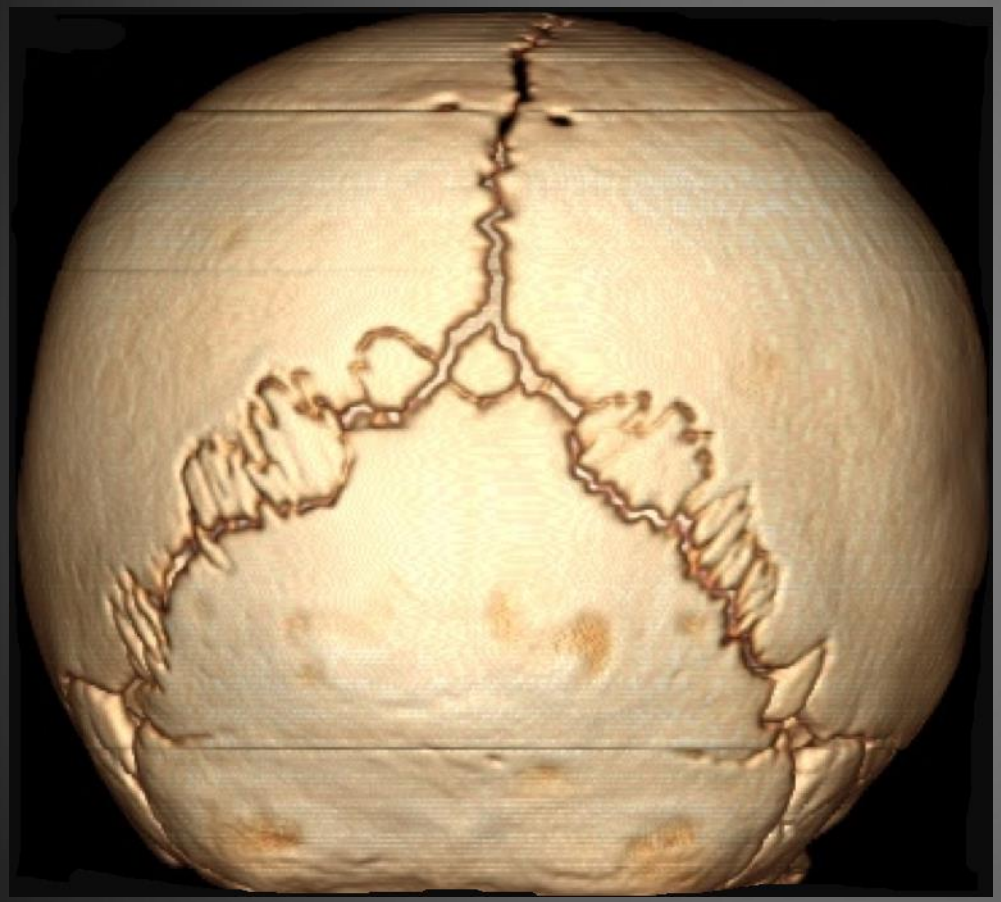


Accessory parietal suture





Wormian bones



- Wormian bones are intra-sutural bones
- They vary in size and can be found on either side of the skull and are usually an anatomical variation
- Some genetic diseases are associated with Wormian bones, best remembered by the mnemonic **PORKCHOPS**

P - Pyknodysostosis
O - Osteogenesis imperfecta
R - Rickets
K - Kinky hair syndrome
C - Cleidocranial dysostosis
H - Hypothyroidism/hypophosphatasia
O - Otopalatodigital syndrome
P - Primary acroosteolysis/ pachydermoperiostosis/Progeria
S - Syndrome of Downs

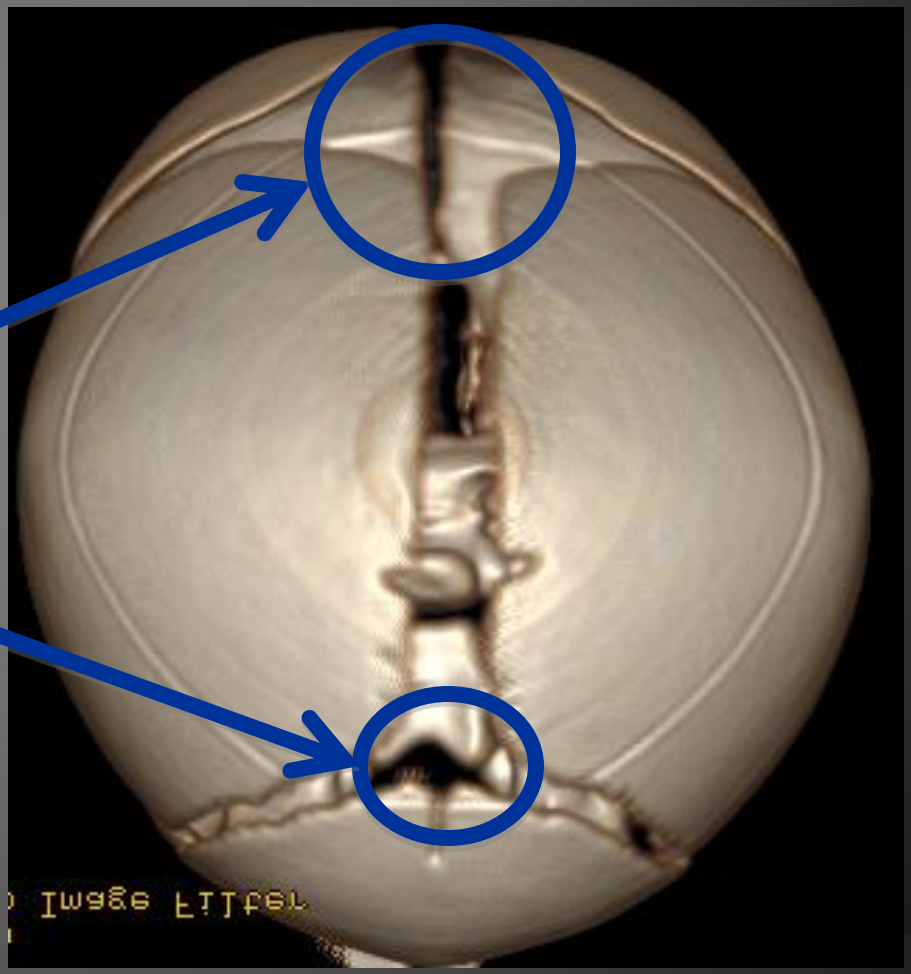
Suture Closures

Structure	Closure
Posterior fontanelle	by 3 mo
Sphenoidal fontanelle	by 6 mo
Metopic suture	by 3-9 mo
Mastoid fontanelle	by 6-18 mo
Anterior fontanelle	by 1-3 yrs
Posterior intraoccipital suture	by 1-3 yrs
Coronal, lambdoid and sagittal sutures	by teenage years

Any suture can persist into adulthood as a developmental variant.

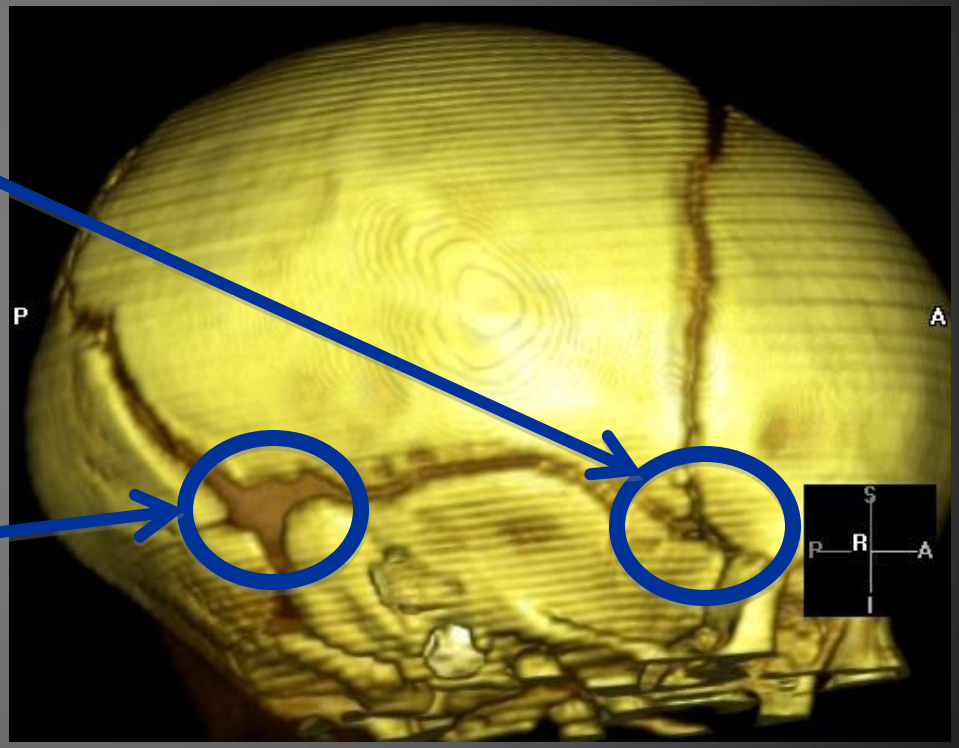
Fontanelles

- As the fontanelles close they form important landmarks of the skull. These landmarks have been given special names.
- When the anterior fontanelle closes this landmark is called the **Bregma**.
- After closure of the posterior fontanelle the landmark is called **Lambda.**



Fontanelles

- The sphenoid fontanel is anterior and the landmark of the skull after closure is called **Pterion**.
- The mastoid fontanelle is posterior and when it closes the landmark is called **Asterion**.



END OF MODULE #1

- Continue to the next slide for references.

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- Sanchez T, Stewart D, Walvick M, Swischuk L. Skull fracture vs. accessory sutures: how can we tell the difference? Emerg Radiol. 2010 Sep;17(5):413-8. doi: 10.1007/s10140-010-0877-8. Epub 2010 May 23. PubMed PMID: 20496093; PubMed Central PMCID: PMC2914264.

Pediatric Neuroradiology Precall Primer

Module 2: Skull Fractures

Relevance

Non-displaced skull fractures usually do not require surgical intervention unless associated with large hemorrhages and/or mass effect.

The presence of a skull fracture could indicate an **abusive head trauma** and is therefore important to detect.

Differentiating non-displaced skull fractures from immature sutures can be very **challenging**.

Learning Objectives

After reviewing this module you should be able to:

- Confidently differentiate a suture from a fracture
- Identify when a fracture extends through a suture

Fracture versus Suture signs

Adults

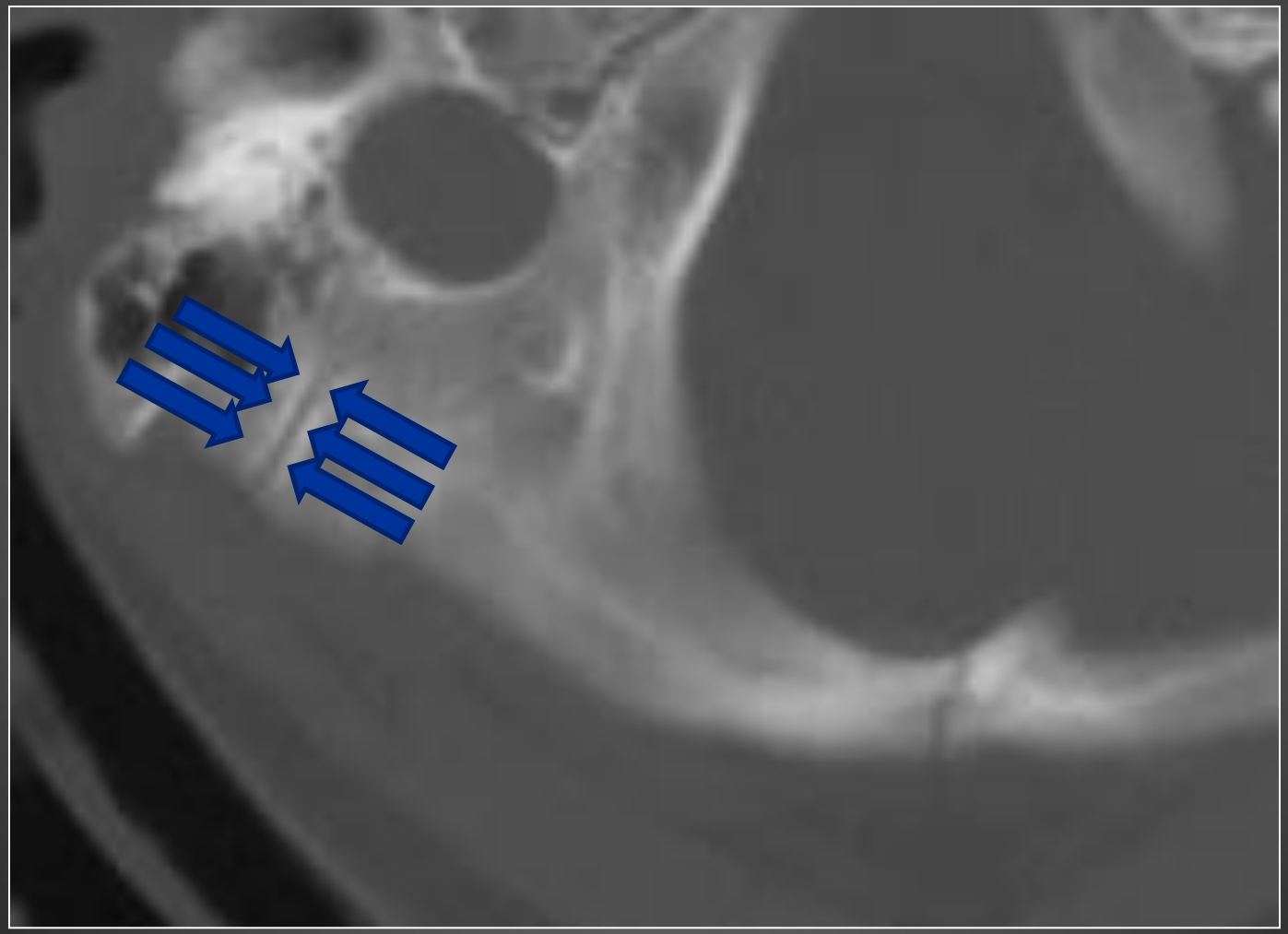
- Fracture edges not corticated, suture edges corticated
- Fracture squiggly, suture linear
- Fracture asymmetrical, only sagittal suture is midline
- Overlying scalp hematoma

Children

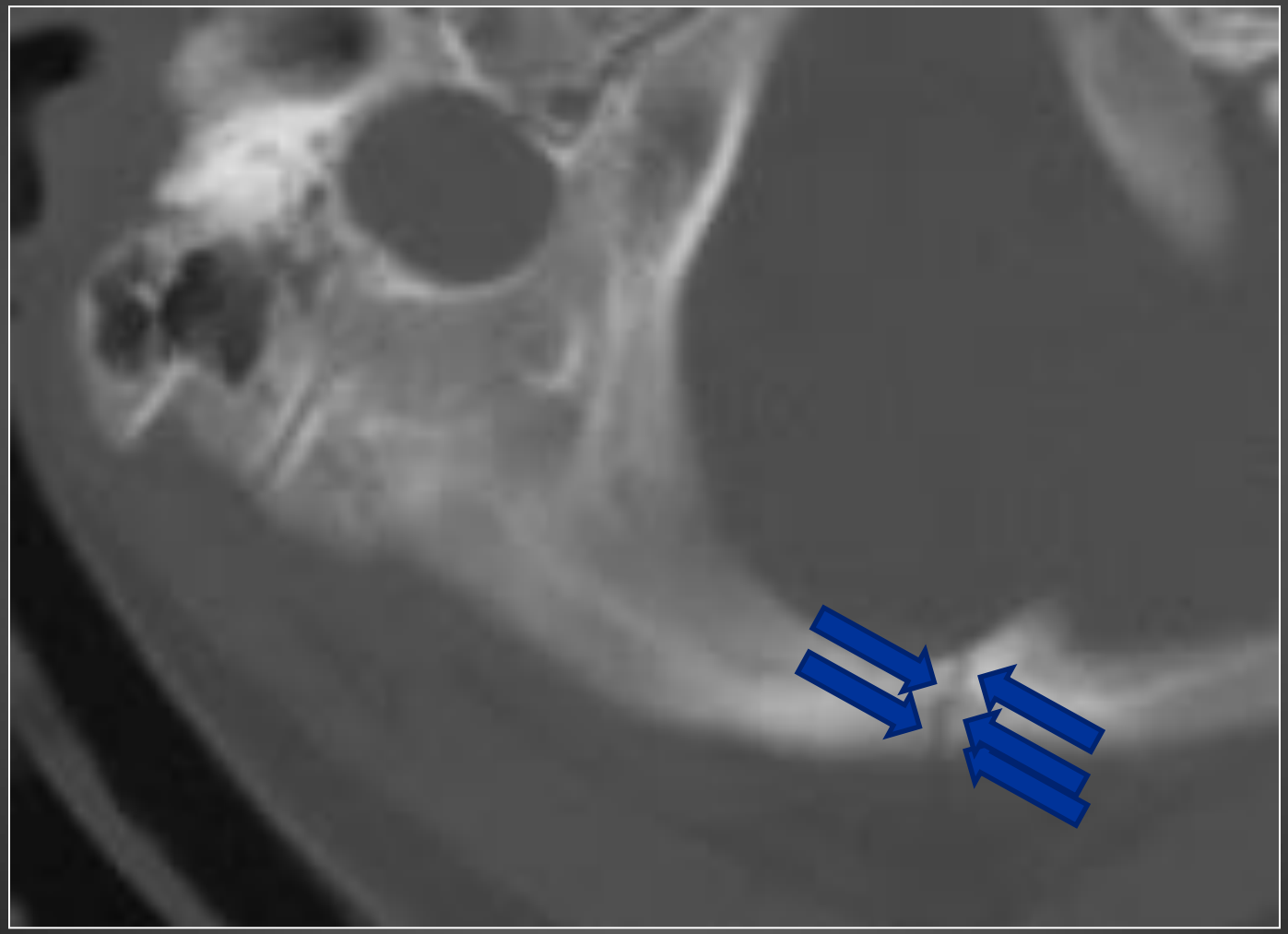
- Fracture and immature suture edges **both not corticated**
- Fracture and immature suture **both linear**
- Fracture asymmetrical, sagittal and metopic are **both midline sutures**
- **Scalp hematoma can be delayed** up to 24 h in infants

Cortication

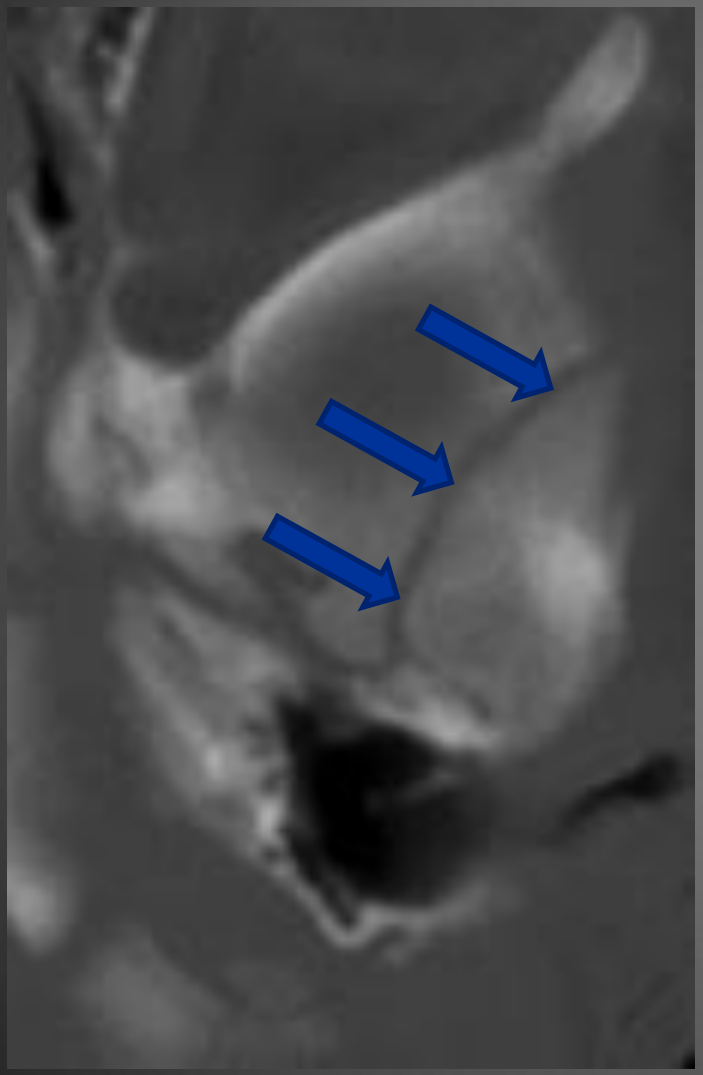
Corticated right mastoid-occipital suture



Non-corticated right occiptal fracture



Immature suture, not corticated



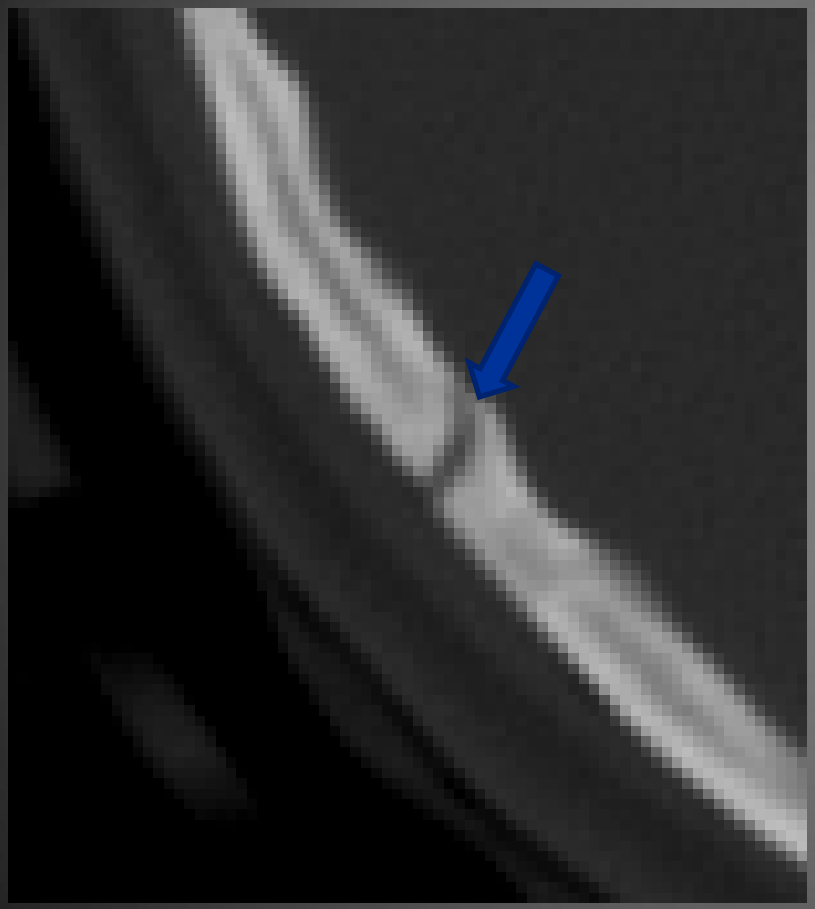
17 day old girl
Left sphenotemporal suture

Pearl

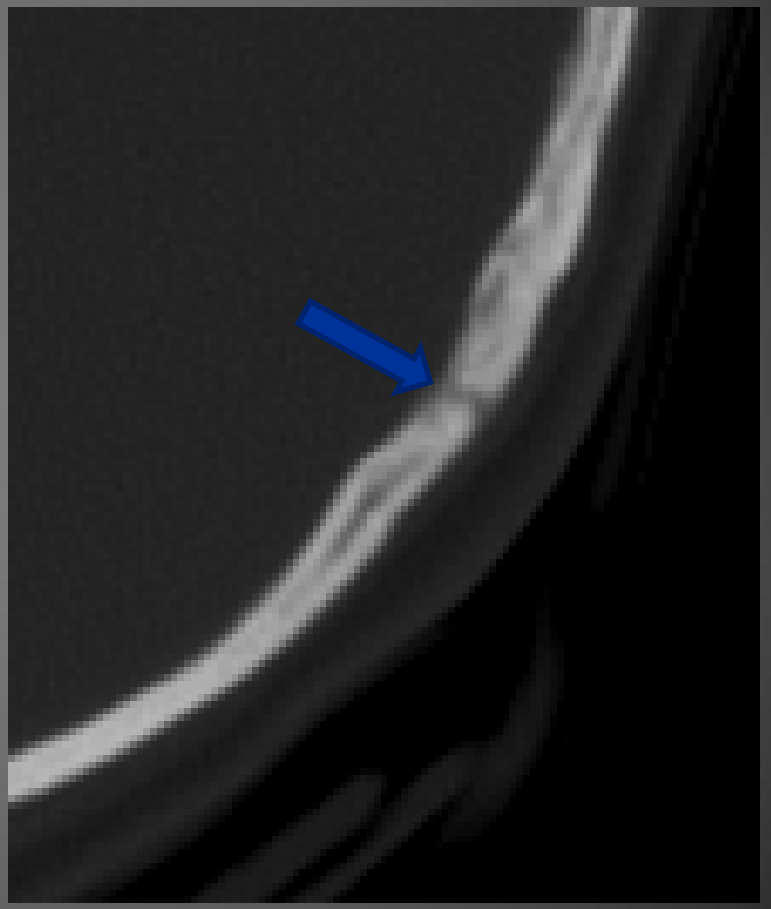
- Trauma can cause suture dehiscence
- So, after differentiating a suture from a fracture, still look for evidence of trauma to that suture

Suture dehiscence

12 year old boy, lambdoid sutures



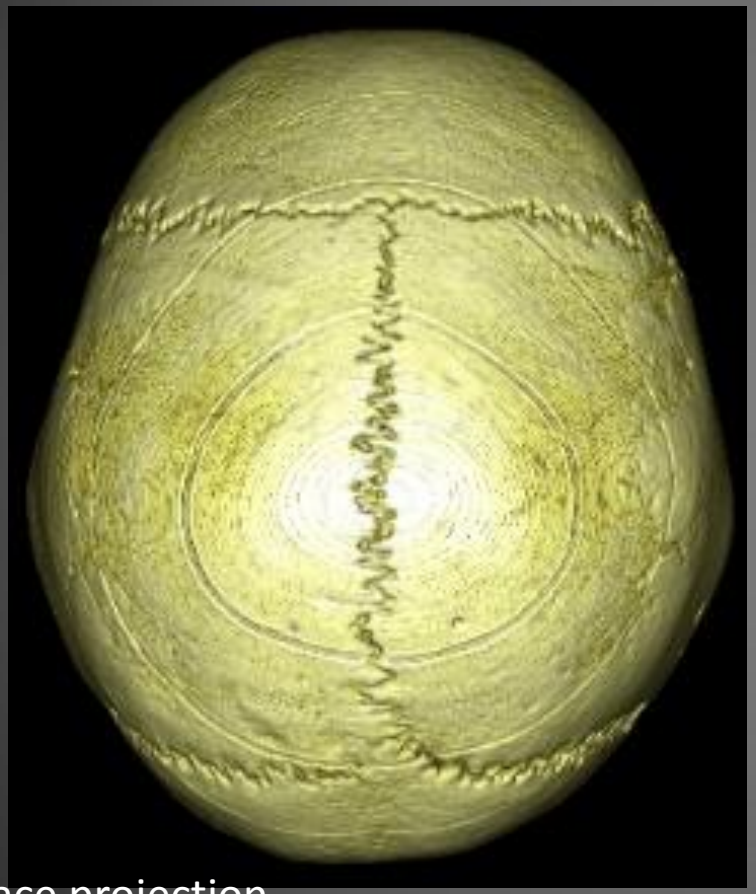
Traumatic dehiscence right



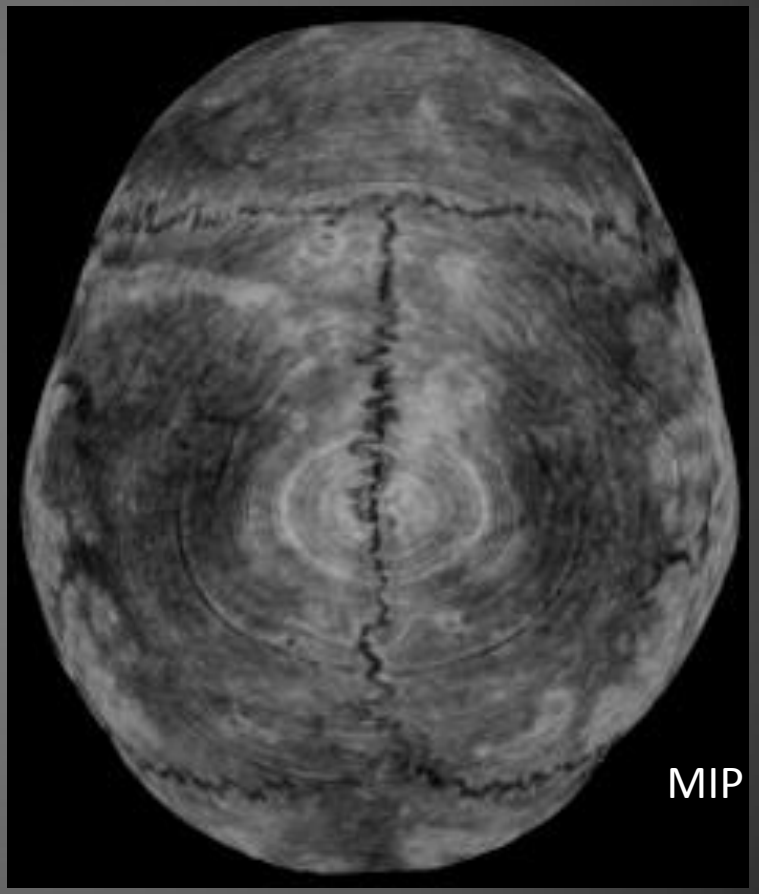
Normal left

Squiggly vs. Linear

Squiggly mature sutures

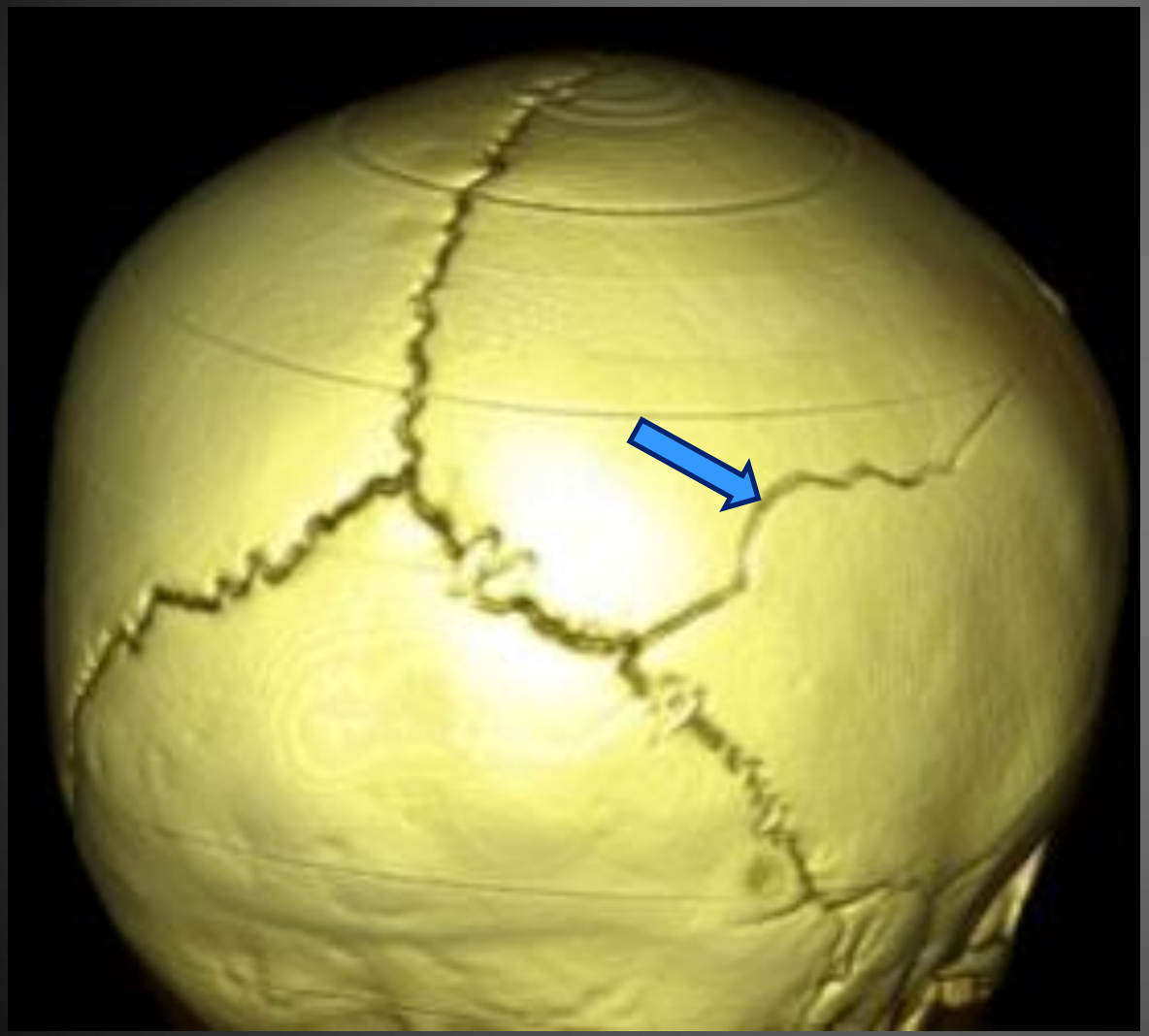


3D surface projection



14 year old girl

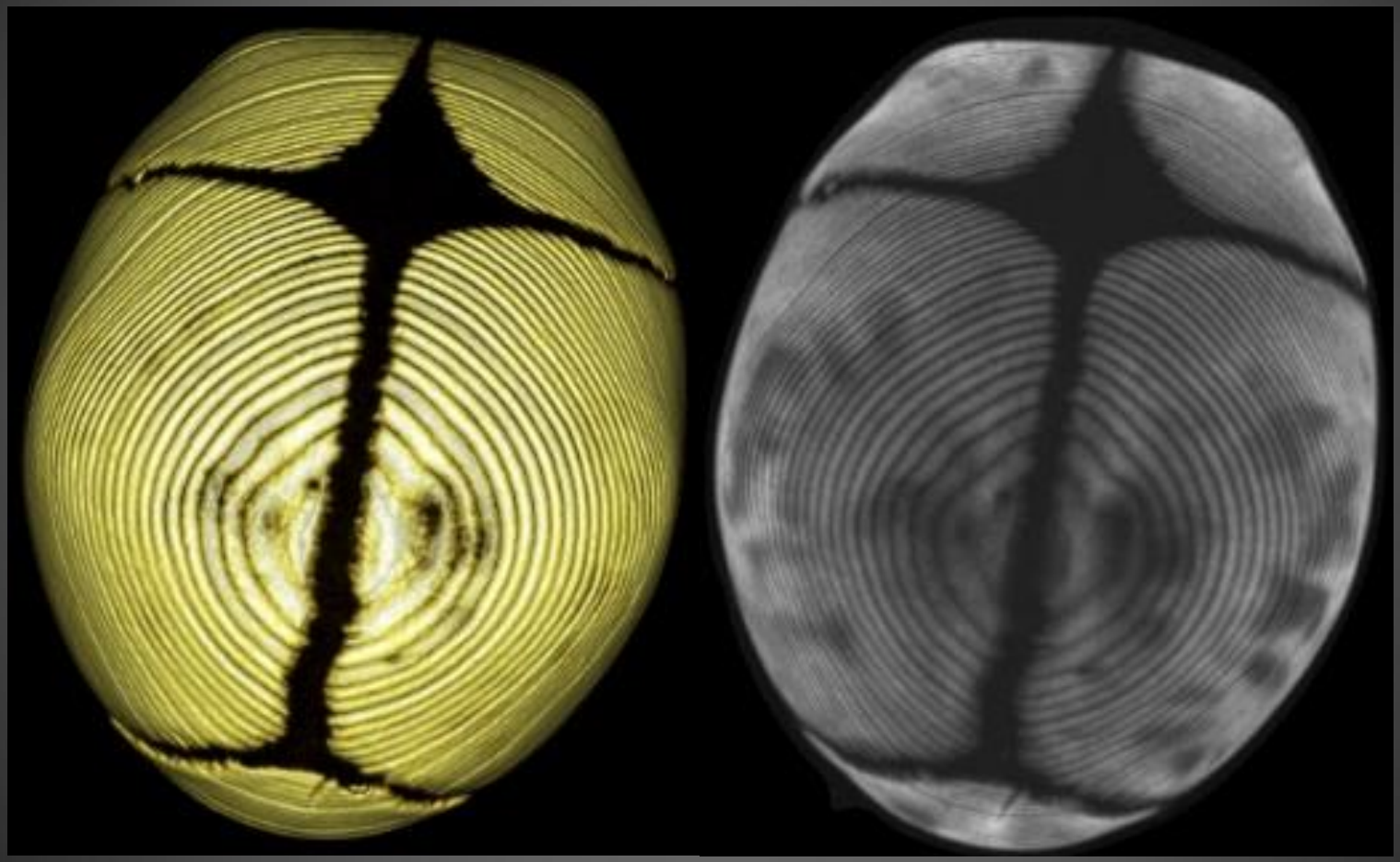
Right parietal skull fracture



Skull fracture (blue arrow) more linear (but curved course) than sagittal and lambdoid sutures.

10 month old girl, right parietal fracture

Linear immature sutures

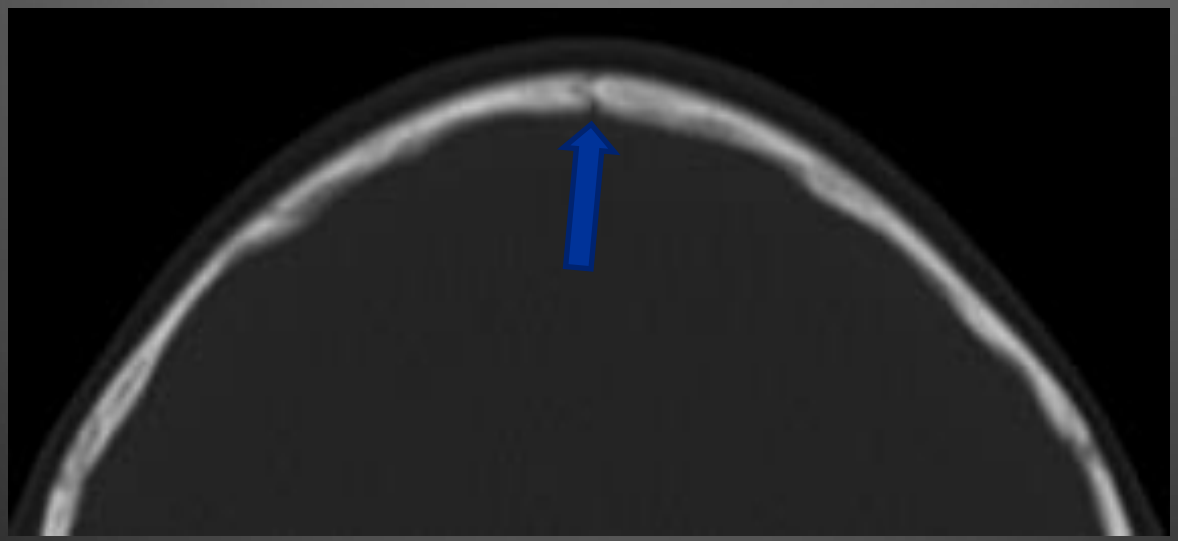


3D surface projection MIP

17 day old girl

Metopic suture

- Do not mistake for fracture
- Closes by 3-9 months
- Can persist into adulthood

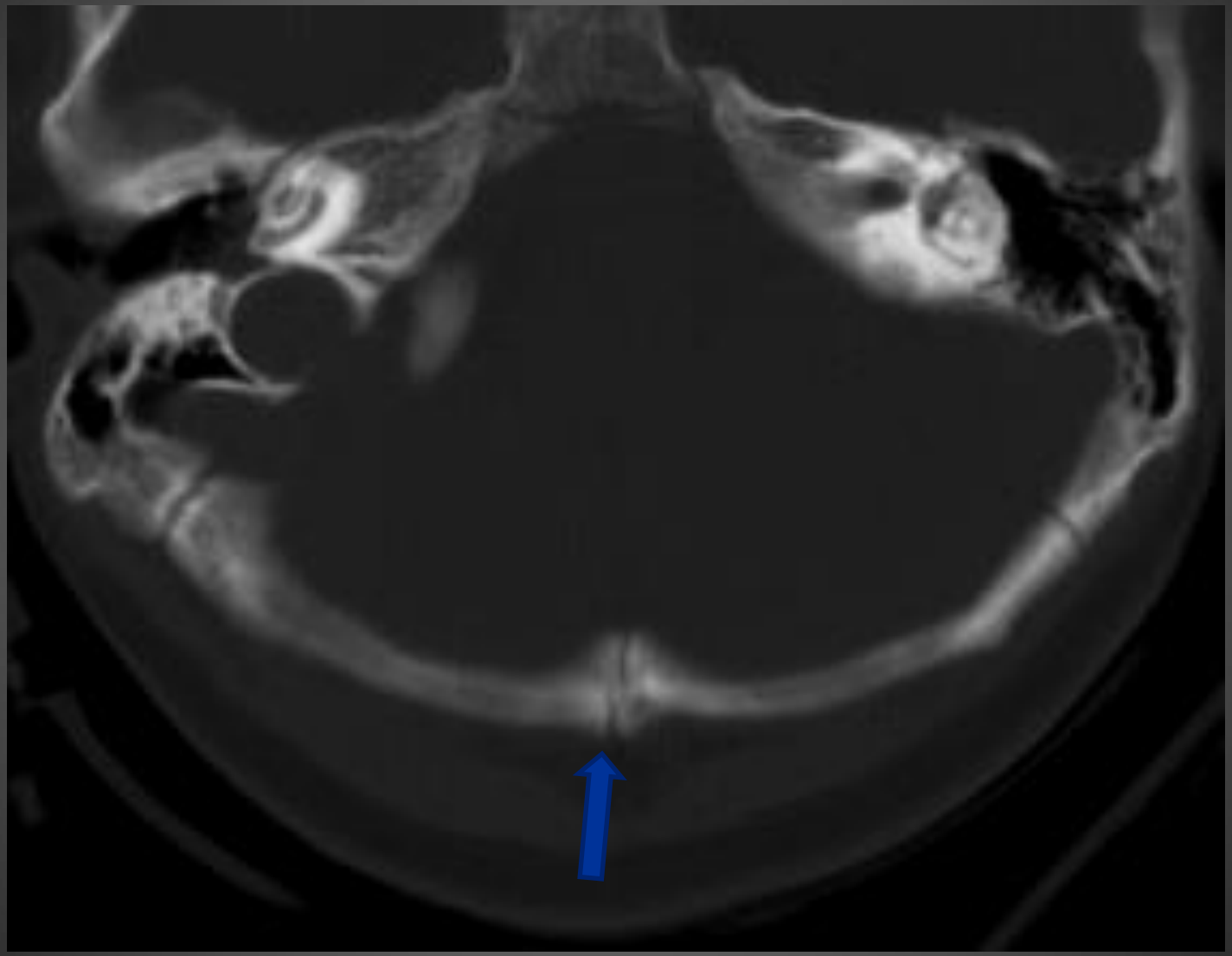


8 year old boy

Pearl

- Fractures can be midline
- It is easier to detect a fracture when you know where midline sutures and accessory sutures most commonly occur (see Module #1)

Midline occipital fracture



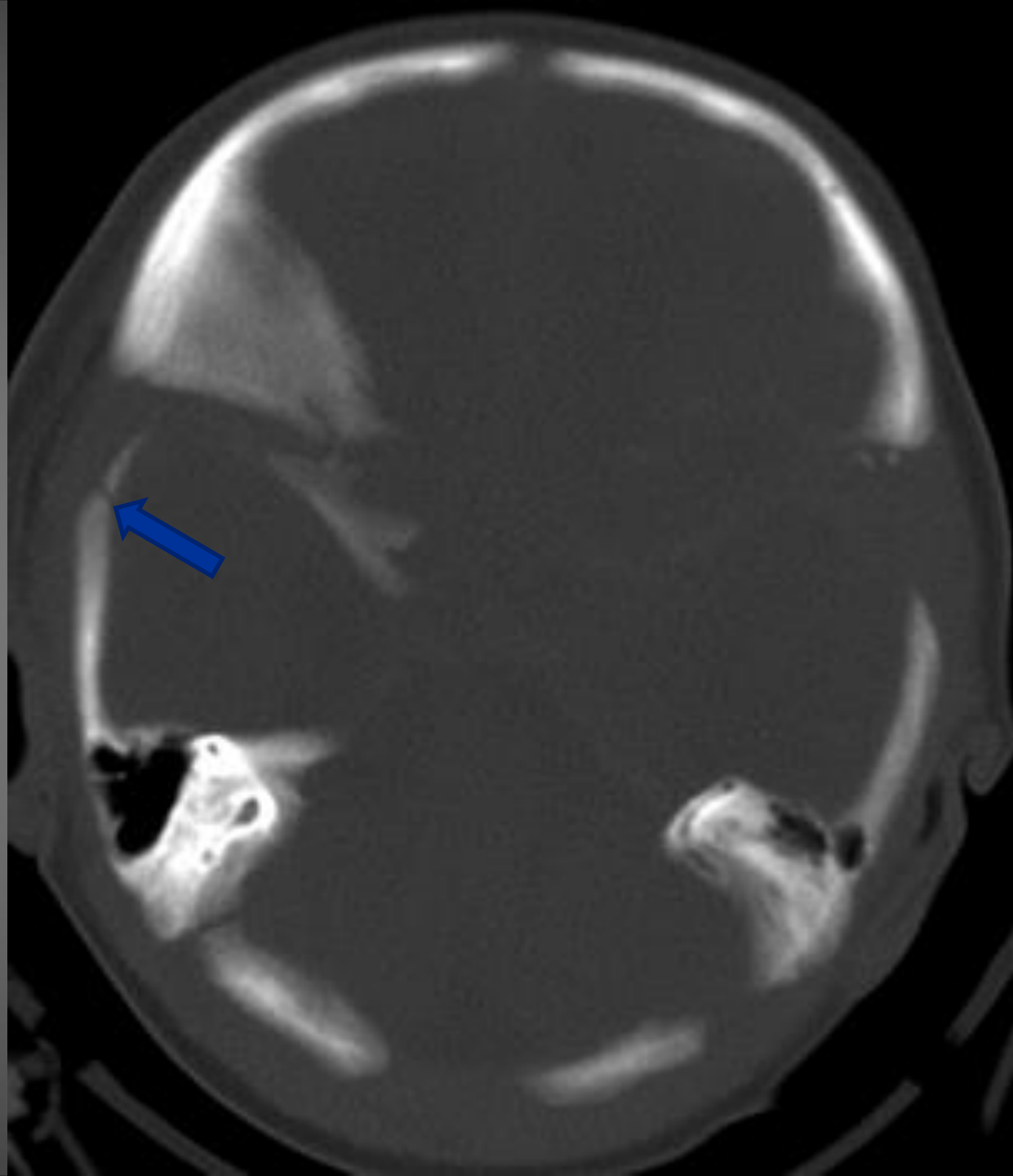
Symmetry

Asymmetry versus tilted head

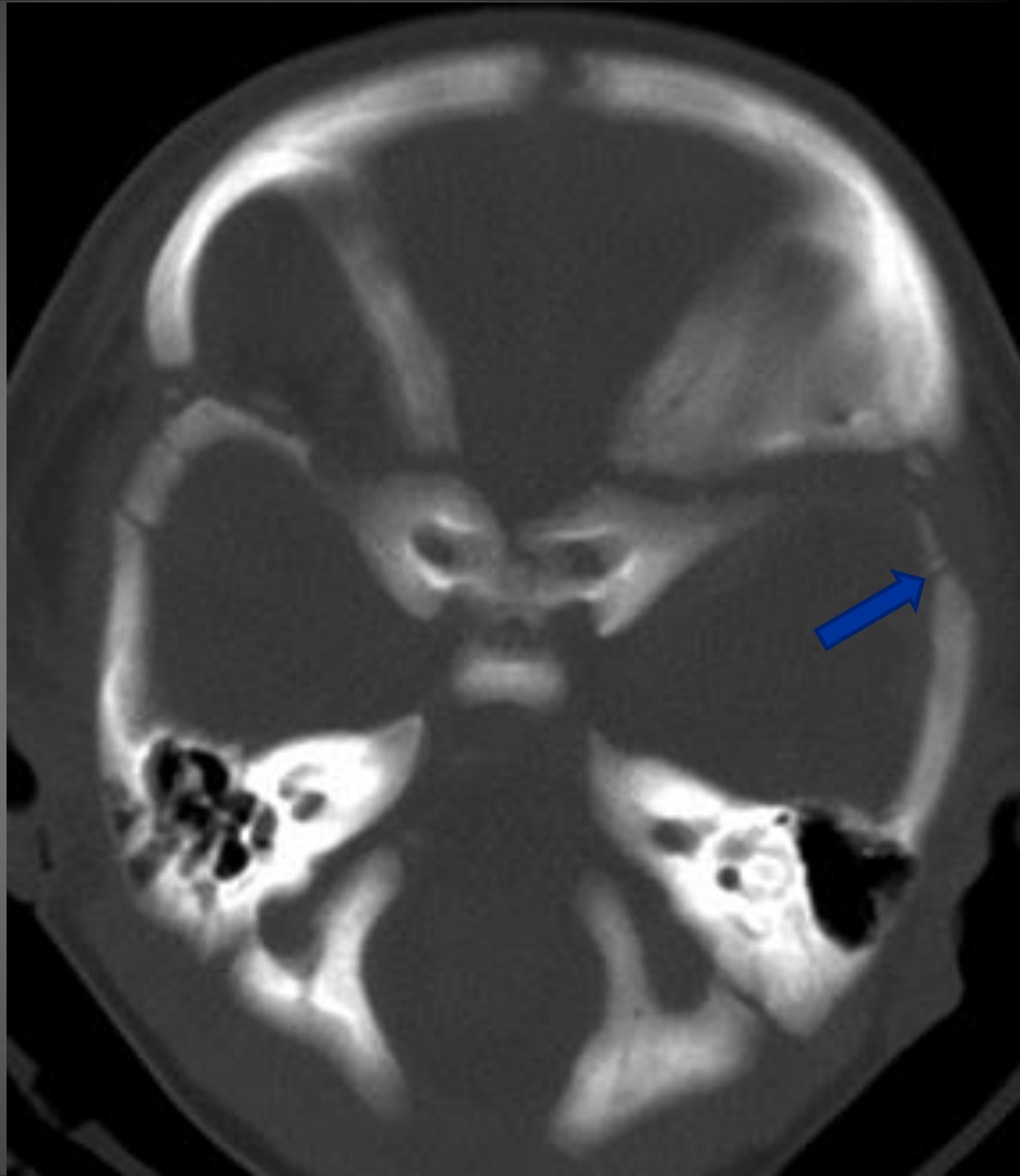
- If the patient's head is tilted, you may not notice the symmetry of a suture
- Scroll to assess findings at comparable imaging levels

Head tilt

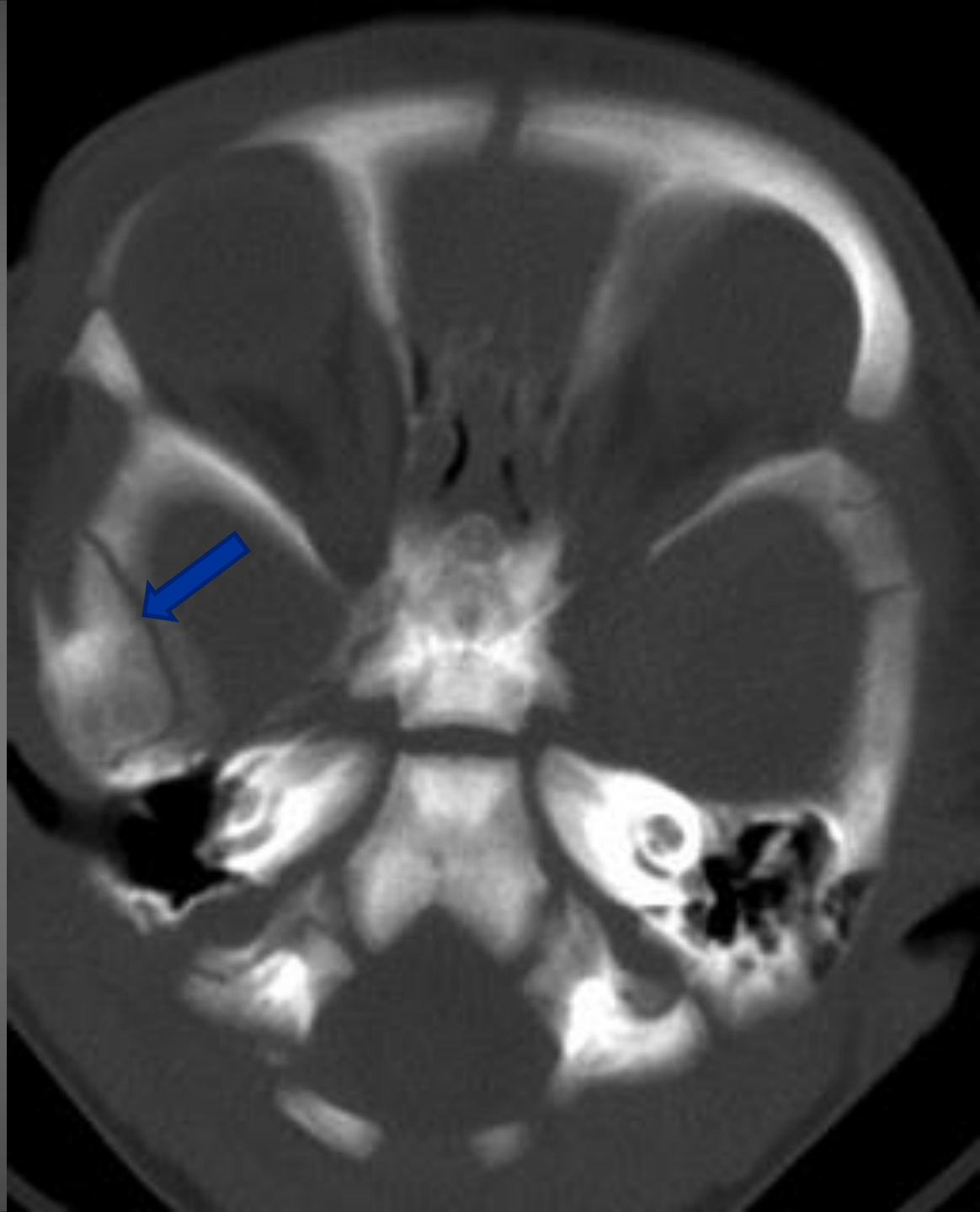
Right temporal fracture?



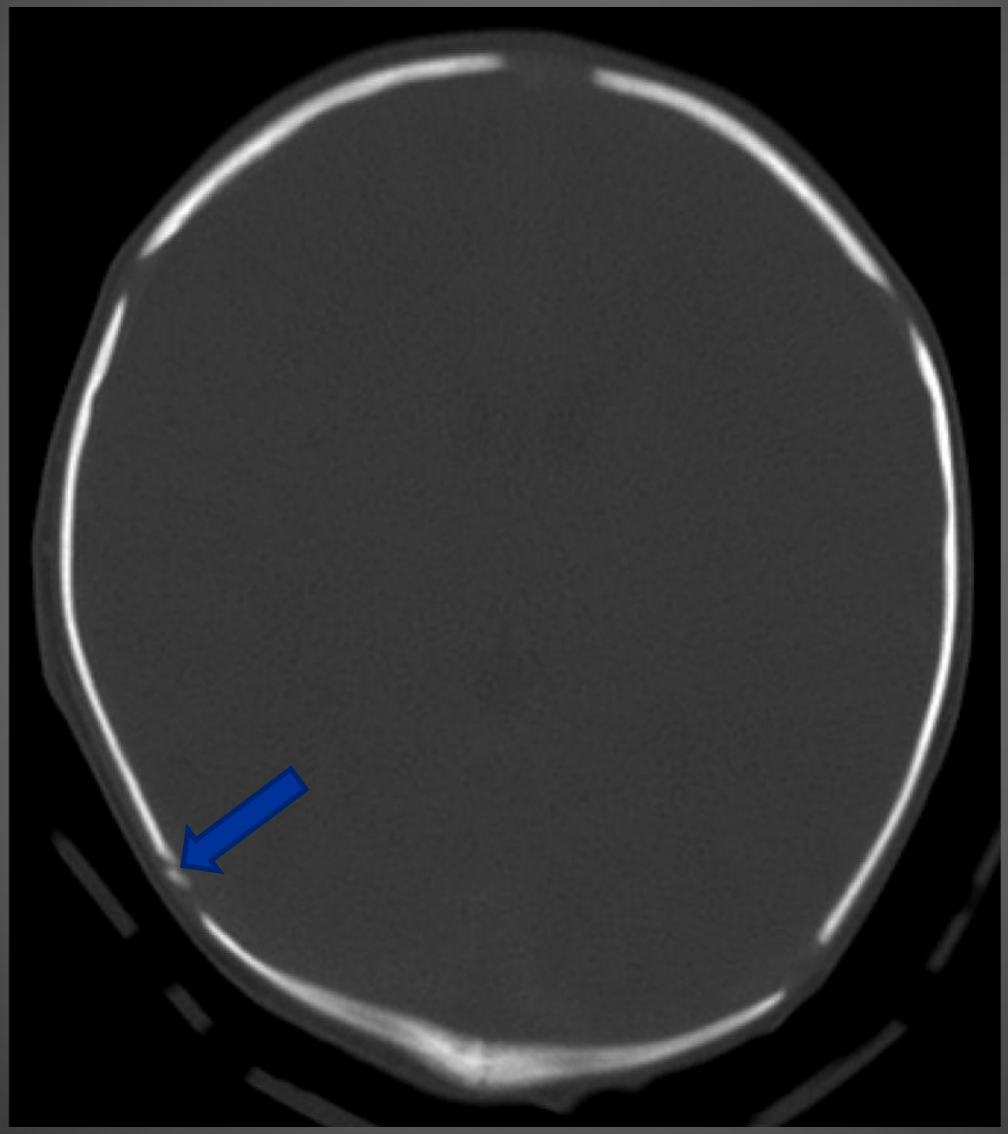
Linear bone lucency is symmetrical considering tilted head.



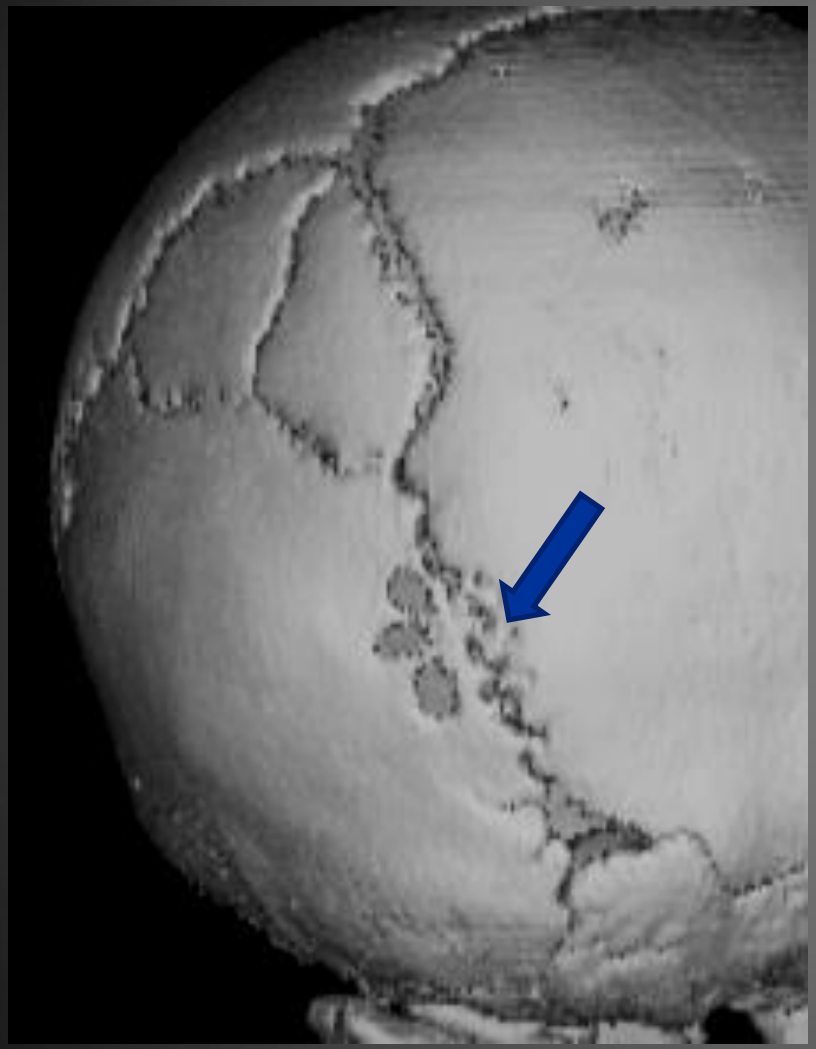
Scrolling farther down, the lucency is part of the sphenotemporal suture.

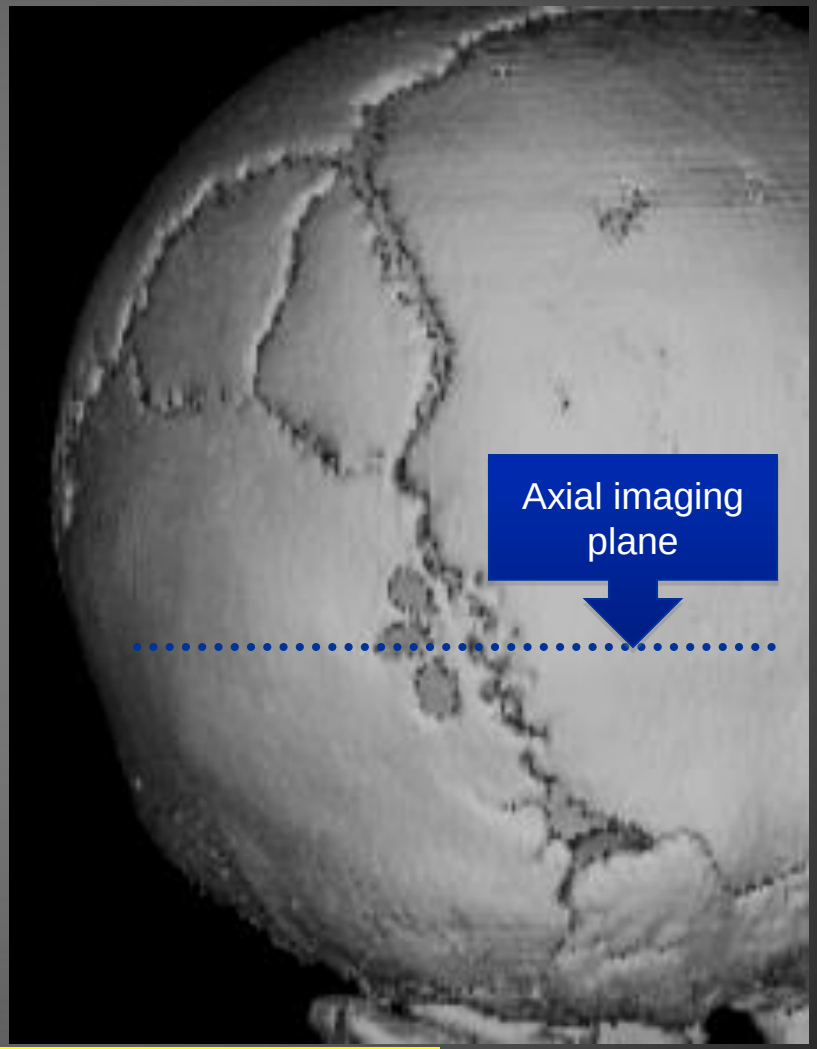


Fracture?



Ongoing squiggly maturation





A small bone “finger” (blue arrow)-
can mimic a fracture is axial plane (dotted line)

END OF MODULE #2

- Continue to the next slide for references.

References

- Barkovich AJ, Charles Raybaud**. Pediatric neuroimaging.** Lippincott Williams & Wilkins; Fifth edition (August 1, 2011).

Pediatric Neuroradiology Precall Primer

Module 3: Bleeds

Relevance

In children just like in adults, it is important to identify in which space a hemorrhage has occurred, as it can be an important **clue to the etiology** of the bleed.

In children, hemorrhages can occur with **abusive** head trauma and should not be missed, even when they are very subtle.

Learning Objectives

After reviewing this module you should be able to:

- Differentiate between epidural, subdural, and subarachnoid bleeds
- Discuss the differential considerations of a hypodense region within an extraaxial hemorrhage
- List mimics of subarachnoid and subdural bleeds

Type of extra-axial bleeds	Worst scenario
Subarachnoid	Aneurysm rupture, abusive head trauma
Subdural	Brain herniation
Epidural	Brain herniation

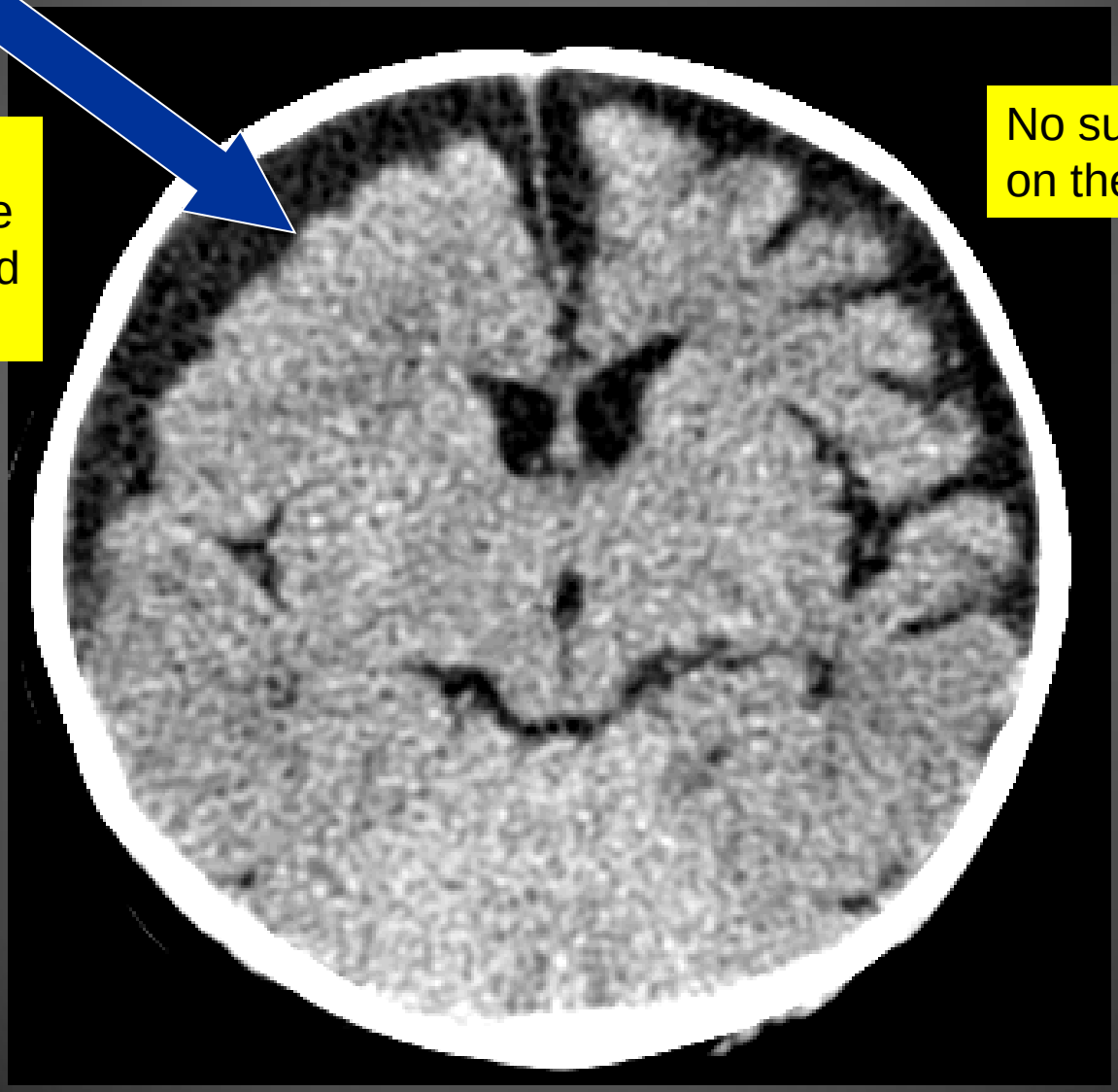
Three Spaces

Epidural	Subdural	Subarachnoid
Potential space	Potential space	Physiologic space
Lentiform bleeds	Crescentic bleeds	Interdigitated with parenchyma from blood in sulci & cisterns
Mass effect on brain	Mass effect on brain	No mass effect on brain
Push cortical veins to brain surface	Push cortical veins to brain surface	Cortical veins travel through
Cross midline	Do not cross midline (with exceptions)	Cross midline
Do not cross coronal, lambdoid sutures	Cross sutures	Cross sutures

Subdural or subarachnoid?

There is prominence of bilateral frontal extraaxial fluid, right worse than left.

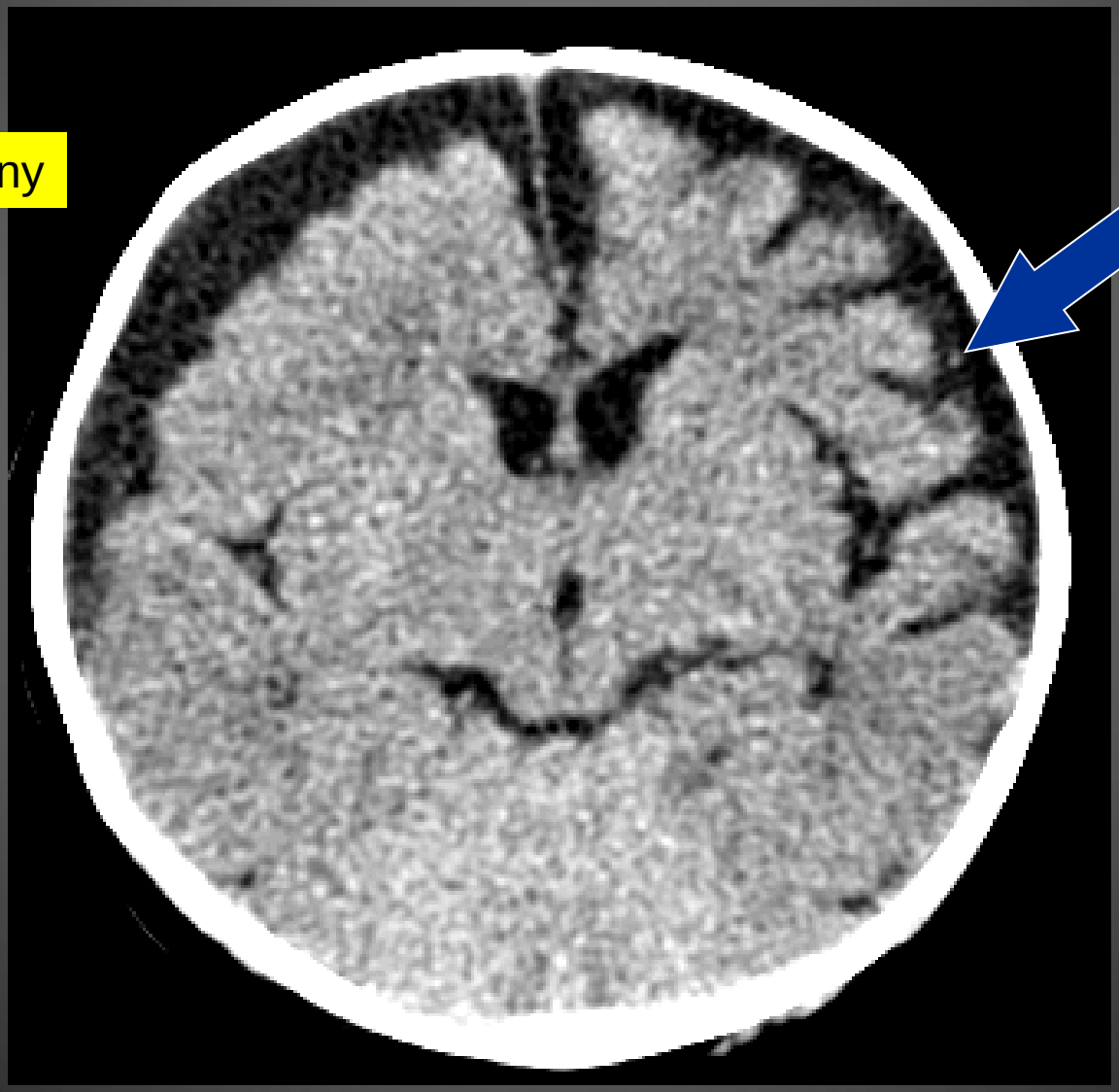
Mass effect?



Yes!
The sulci on the right are effaced (blue arrow).

No sulcal effacement on the left.

Vessels pushed?



Can’t see any

There is one..

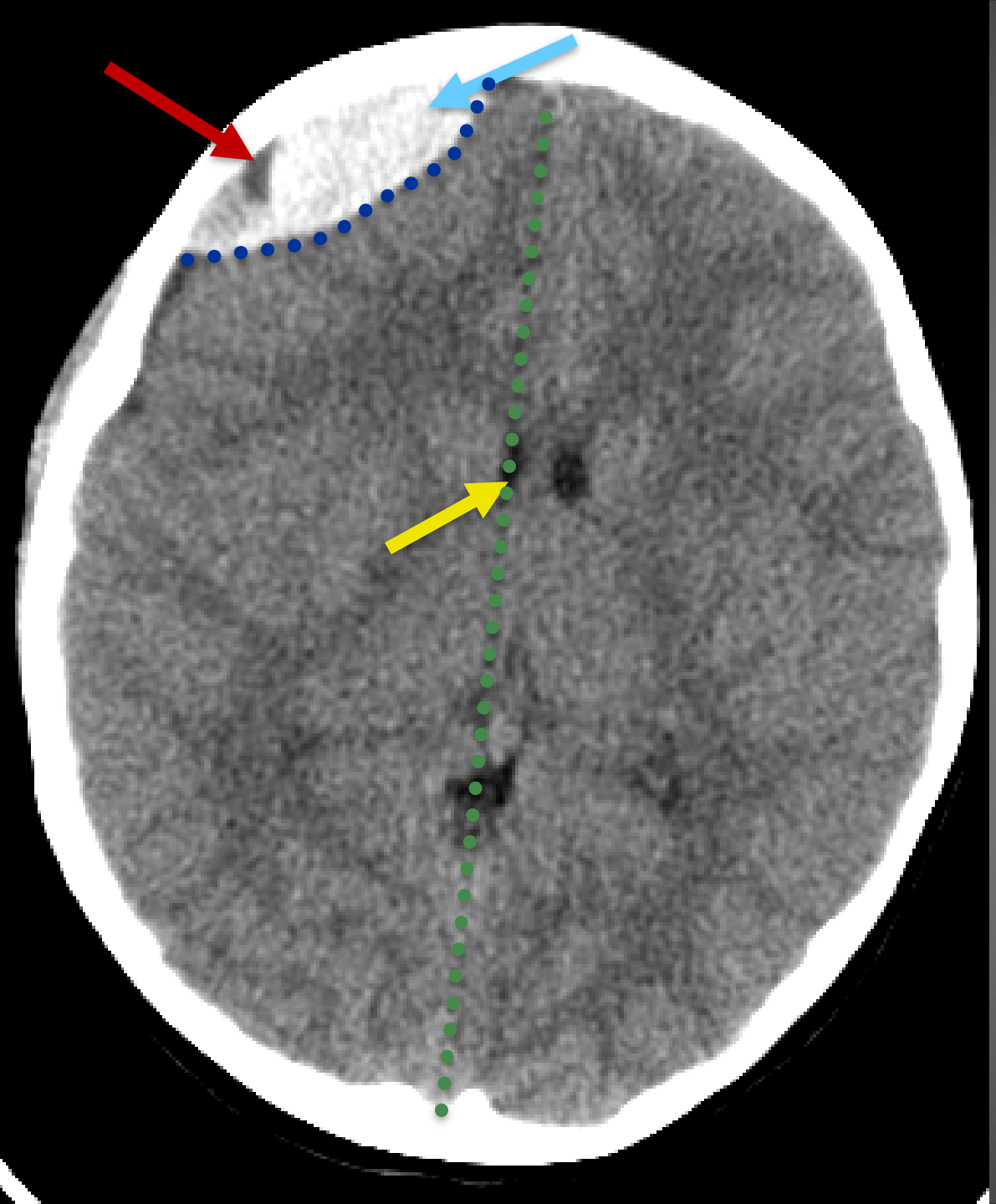
IV contrast helps!

Vessels pushed into sulci (blue arrows), so there is a subdural effusion/bleed.

A follow-up MRI can help assess for associated brain injury and for determining the age of bleeds.

What are the findings?

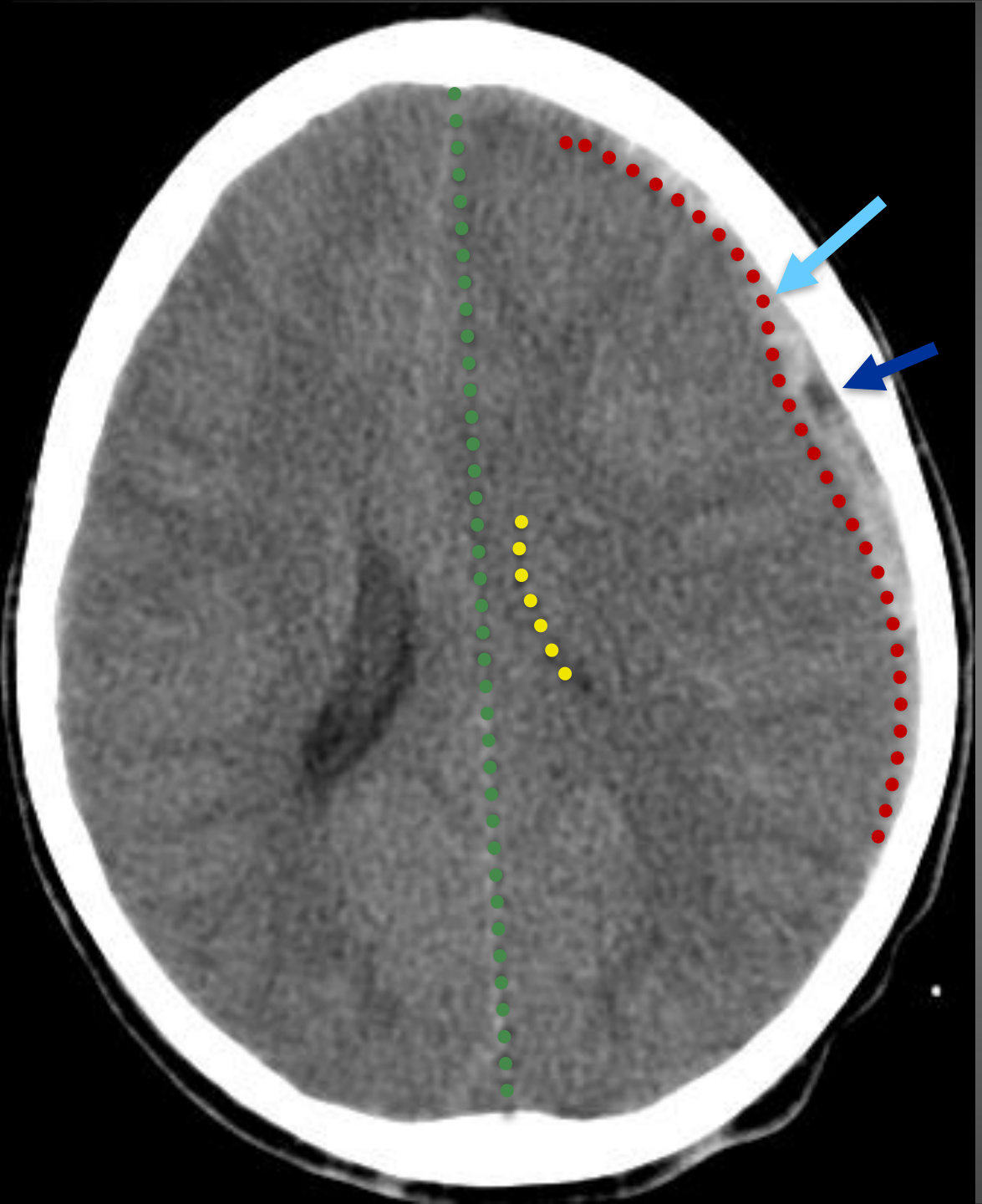
8 year old girl, fall



1. Right frontal epidural hematoma (lentiform)
2. Hypodensity in epidural collection
3. Sulcal effacement (dotted line)
4. Effaced right frontal horn
5. Mild midline shift to left (dotted line)

What are the findings?

4 year old boy, fall



1. Left frontal subdural hematoma (crescentic)
2. Hypodensity within subdural collection
3. Sulcal effacement (dotted line)
4. Effaced left lateral ventricle (dotted line)
5. Midline shift to right (dotted line)

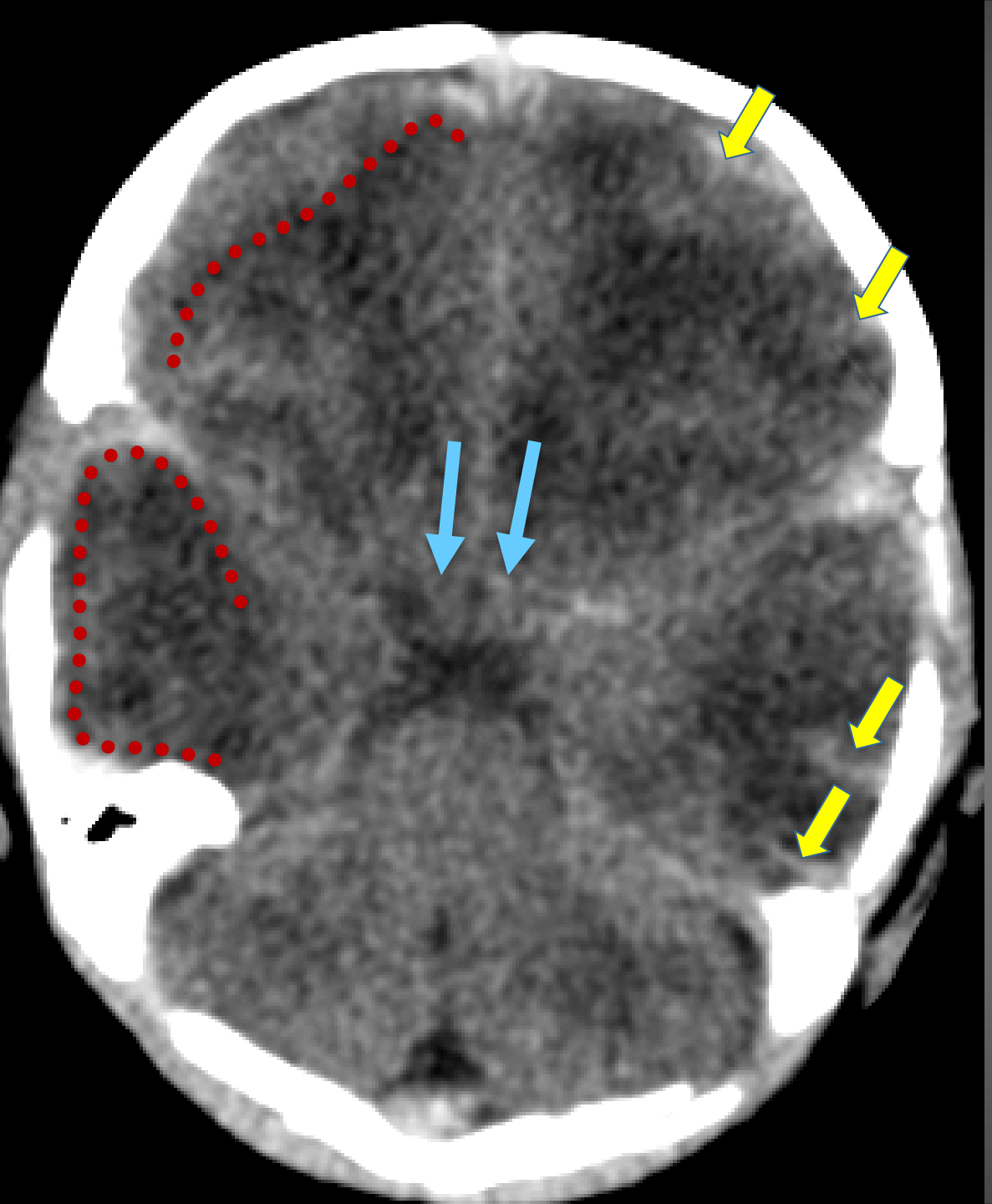
Pearl

A mixture of densities in an extraaxial collection can indicate:

- Hyperacute (ongoing) hemorrhage
- Acute admixtures of CSF and blood
- Clot retraction
- New (acute) on top of old (chronic) blood

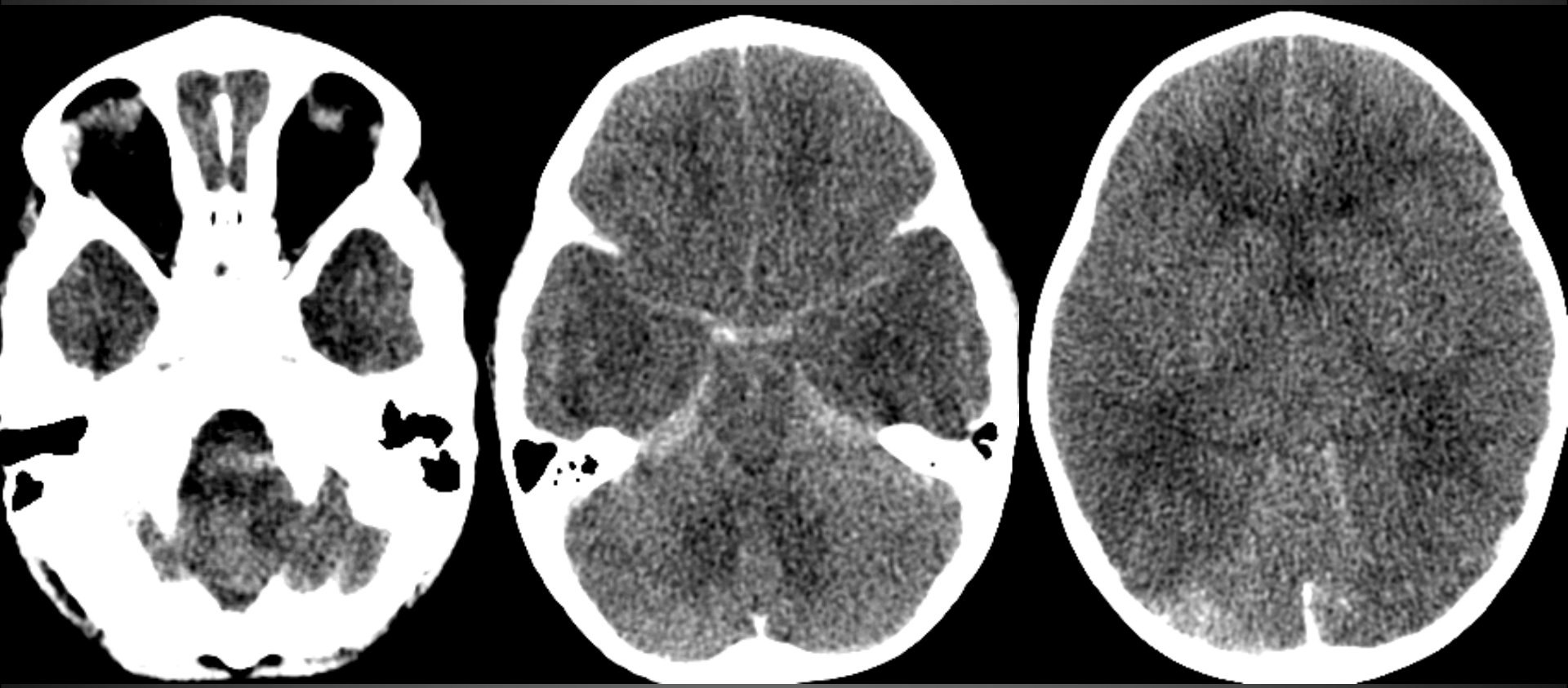
What are the findings?

13 day old boy,
abusive head trauma



1. Subarachnoid hemorrhages (short arrows)
2. Frontal and temporal loss of gray-white differentiation (dotted lines)
3. Mass effect on suprasellar cistern (long arrows)

Does this patient have subarachnoid blood?

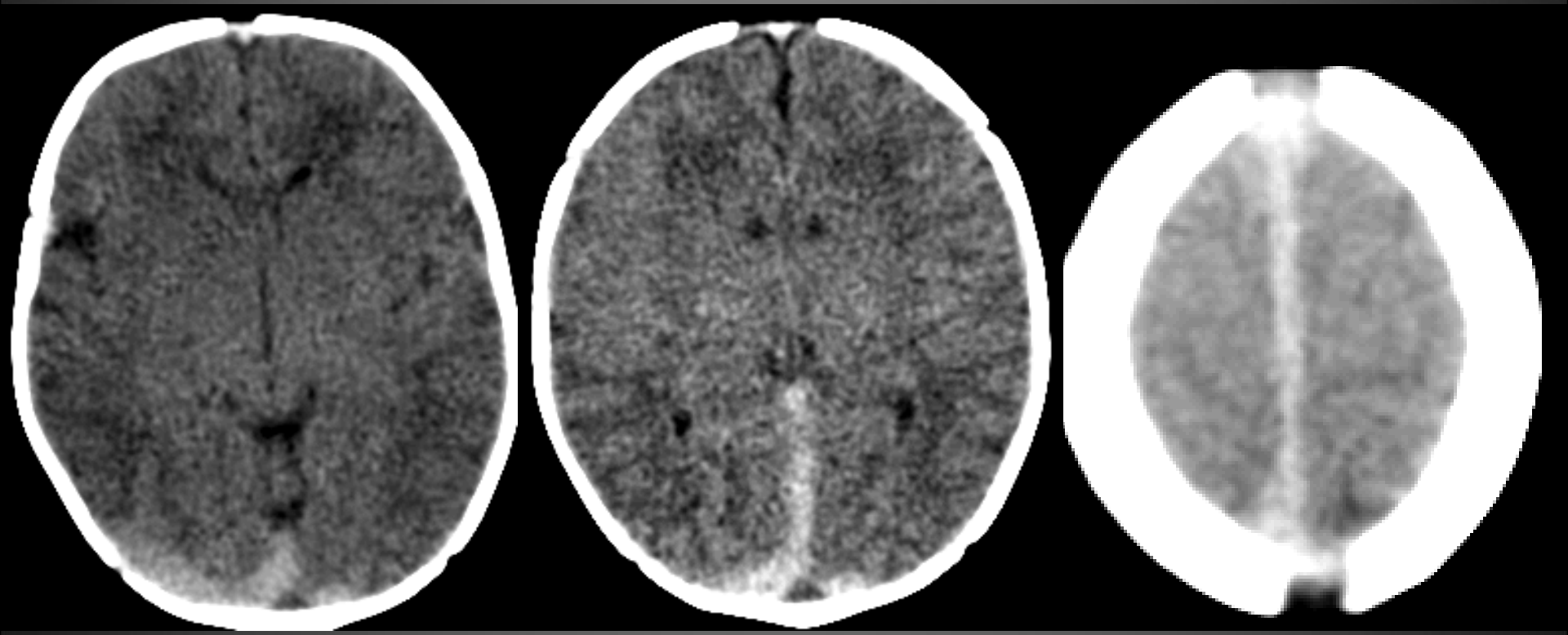


1 year old boy

Answer

- Probably no.
- There is global effacement of sulci, cisterns, ventricles.
- Severe cerebral edema can compress vessels and mimic hemorrhage in cisterns and sulci – so called “pseudo-subarachnoid hemorrhage sign”

Does this newborn have subdural hemorrhages?



Answer

- Likely not.
- Postnatal dehydration (hemo-concentration) likely accounts for this homogeneous and extensive hyperdensity throughout the major venous sinuses.

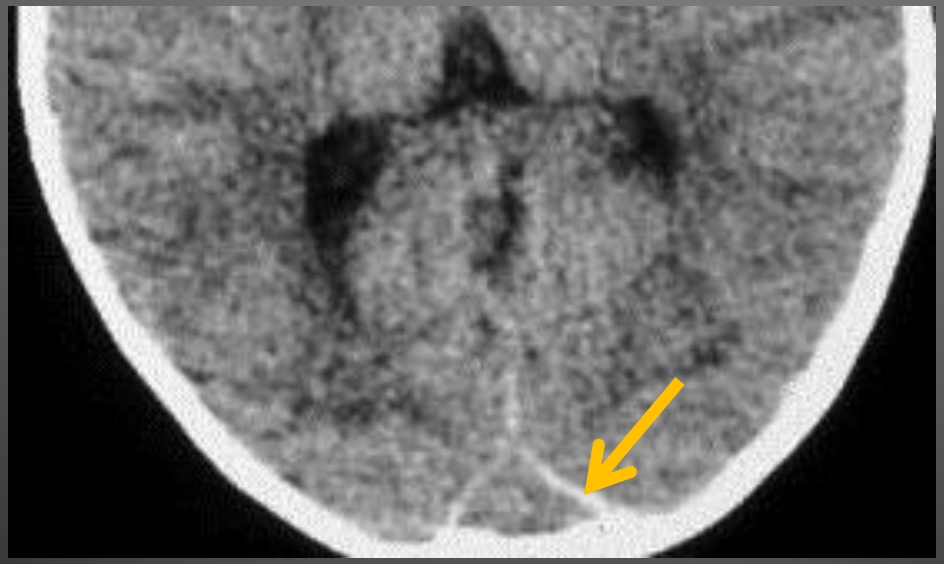
Is there a subdural?

Answer

Yes. This patient has subdural hemorrhage (arrow).

PEARLS:

- Dura should be paper thin, not “cardboard” thick.
- Any asymmetrical thickening or nodular hyperdensity along the dura can be a sign of subdural hemorrhage in the setting of trauma.



END OF MODULE #3

- Continue to the next slide for references.

References

- Harnsberger HR, Osborn AG, Ross JS, Moore KR, Salzman KL, Carrasco CR, Halmiton BE, Davidson HC, Wiggins RH. Diagnostic and Surgical Imaging Anatomy: Brain, Head and Neck, Spine. 3rd ed. Salt Lake City, Utah. Amirsys. 2007.

Pediatric Neuroradiology Precall Primer

Module 4: Sulci & Mass Effect

Relevance

- Evaluation of the CSF spaces can reveal **subtle** evidence of mass effect.
- Mass effect can cause **significant morbidity and mortality** if undetected and untreated.

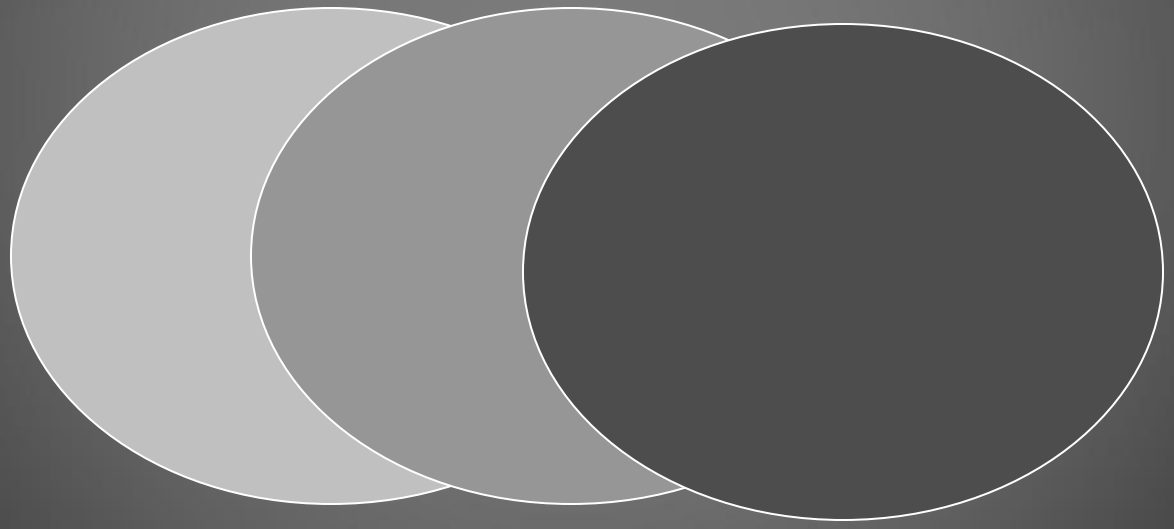
Learning Objectives

After reviewing this module you should be able to:

- Explain the “three shades of gray” approach
- Discuss completely effaced sulci
- Discuss almost completely effaced sulci
- Discuss normal appearing sulci

Three Shades of Gray

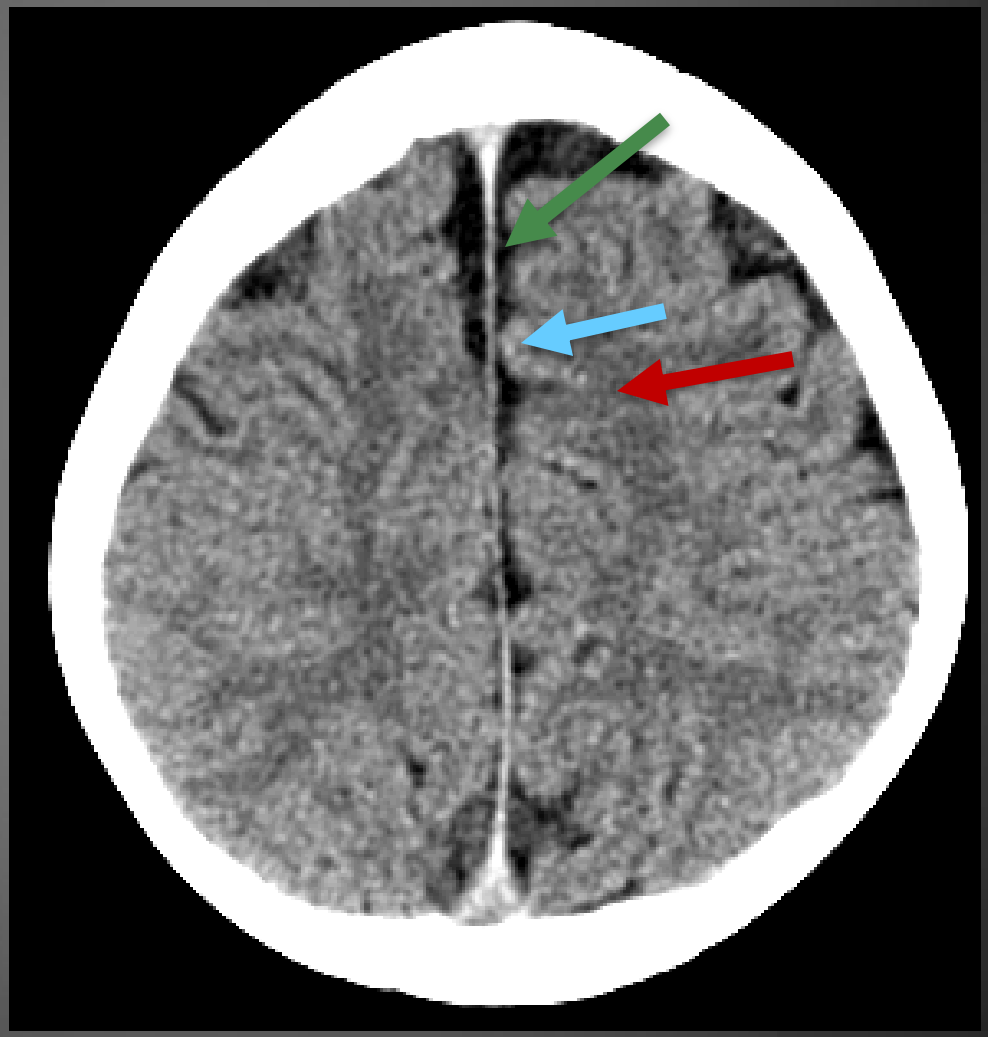
- Identifying “Three Shades of Gray” can help in identifying sulcal effacement.



Three Shades of Gray

Normal 3 shades:

- Light- gray matter
- Medium- white matter
- Dark- CSF



Three Shades of Gray

Shunted patient. Normal baseline shown below.

On follow-up there is an imbalance of three shades of gray, mostly loss of the darkest shade (CSF).

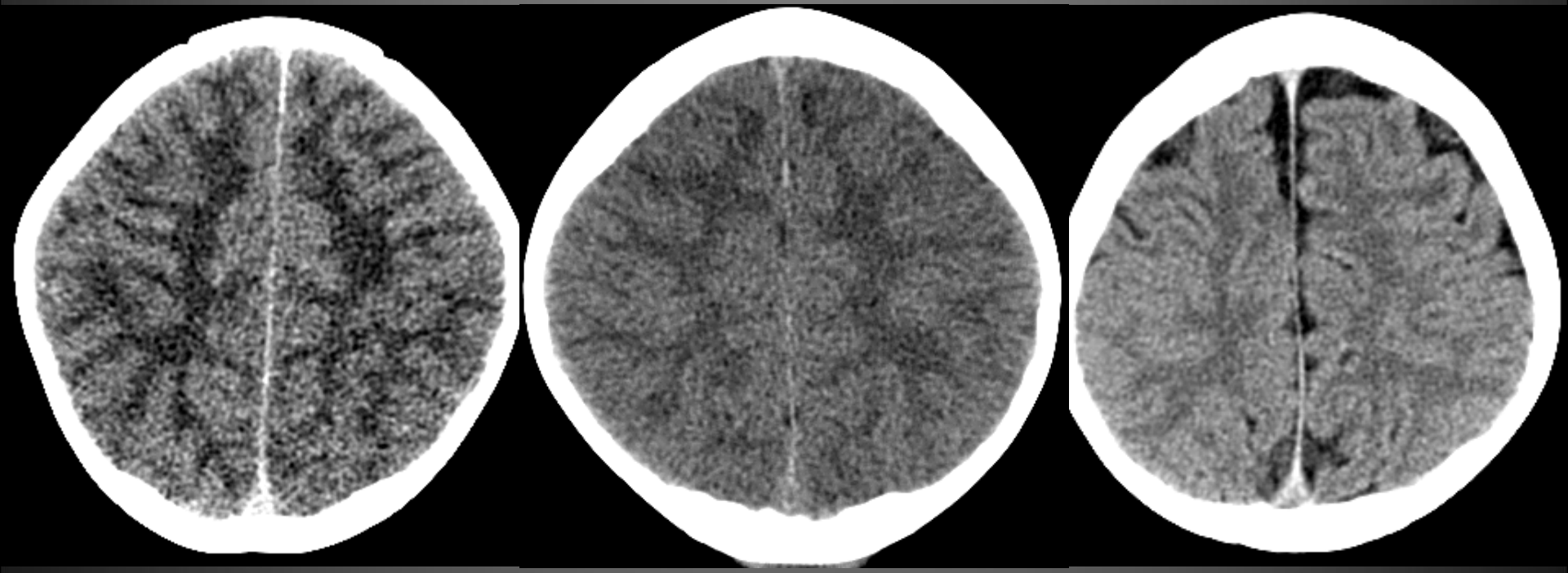
Follow-up: Sulcal effacement.

Normal

Three scenarios of sulci:

Completely effaced
(two shades of gray)

Looks normal
(normal three shades)



Interpretation: “Completely effaced”

- This is abnormal
- It may be hard to determine why sulci are abnormal
- There could be a severe acute event, such as cerebral swelling, diffuse edema (from anoxia, electrolyte derangement, metabolic disorders) meningitis/encephalitis, etc..
- ….or something more “benign”, such as craniosynostosis resulting in restricted skull growth- the growing brain displaces CSF

Interpretation: Some sulci (“hints of sulci”), basilar cisterns, & ventricles are normal

Conclusions:

“Probably normal” or

“No definite findings of brain swelling”

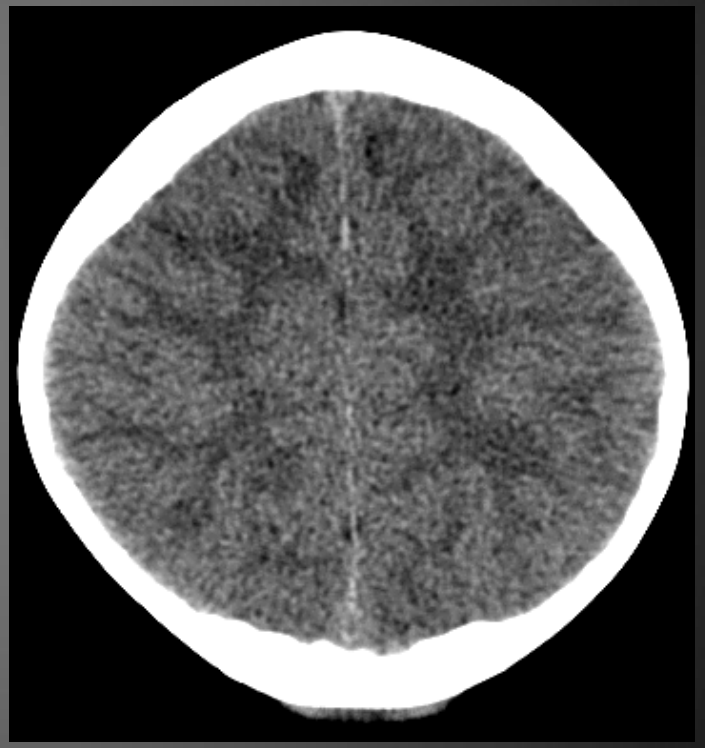
Can add:

“Please correlate with physical exam”

(e.g. level of consciousness)

Rationale:

Patients with brain swelling are likely symptomatic for it.



Interpretation: “Sulci look normal”

Probably there is no cerebral swelling unless on prior study sulci were even more prominent.

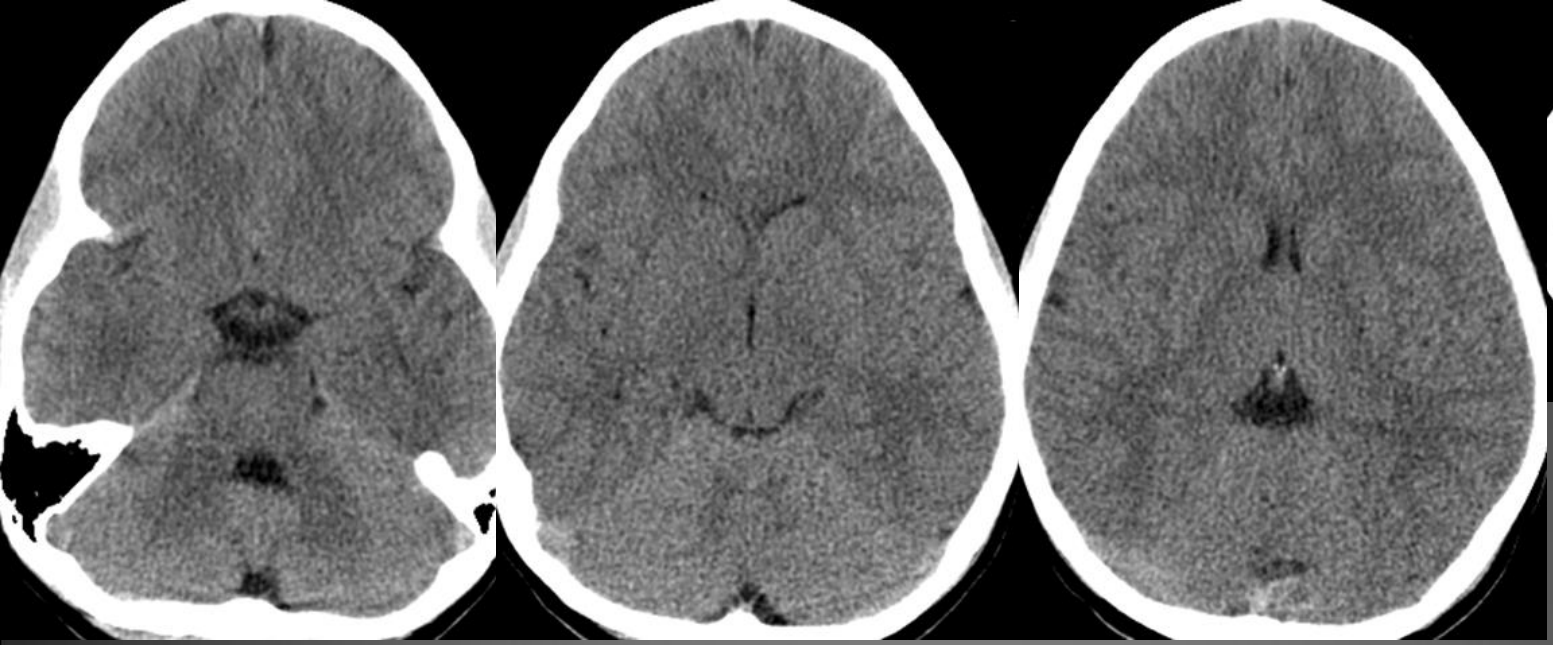
Interpretation summary

Completely effaced	Abnormal. Look for other signs and/or an explanation of edema and/or mass effect.
Some hints of sulci are seen	Could be normal but cannot definitely exclude global mass effect in the absence of a baseline imaging study.
Looks normal	Likely normal. Probably no global mass effect/brain swelling.

Pearl: Cerebral swelling

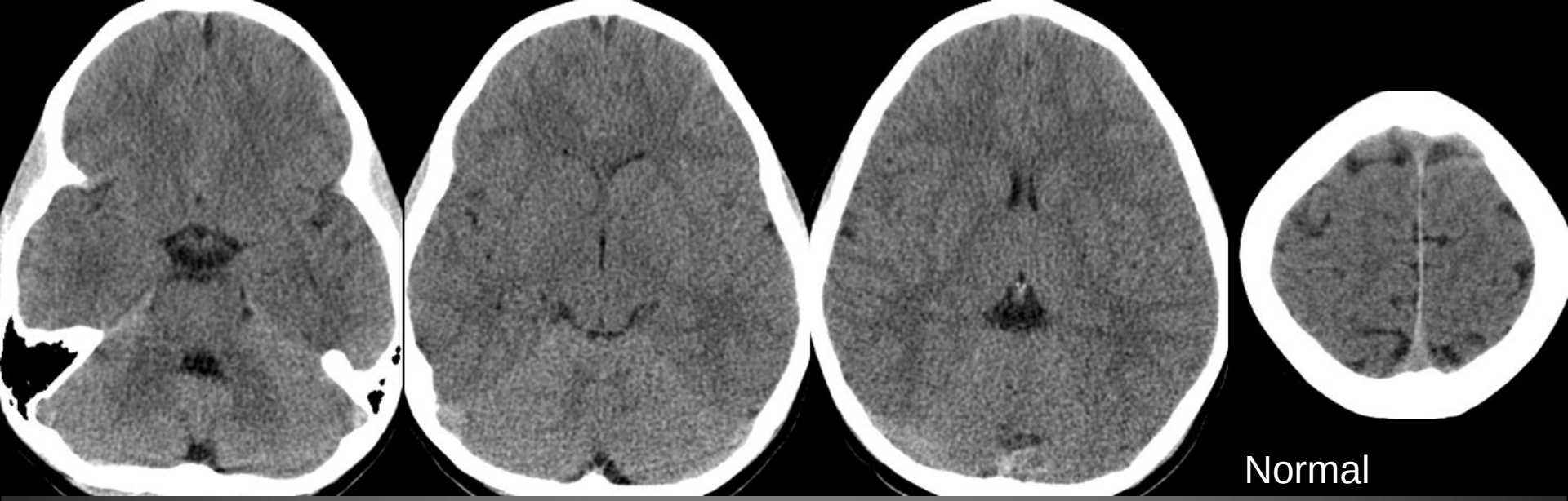
Acute swelling is not easy to determine in children

- The ventricles and sulci are usually small in children (much smaller than in older adults)
- The grey – white contrast (demarcation) in normal children can be accentuated, normal or decreased!

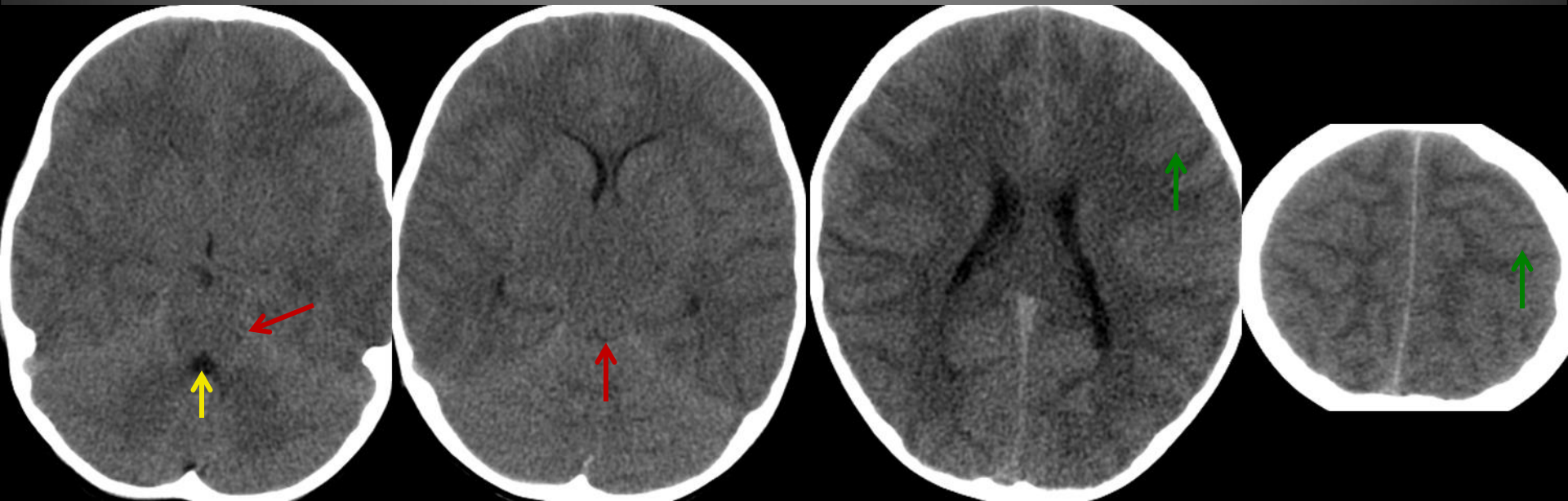


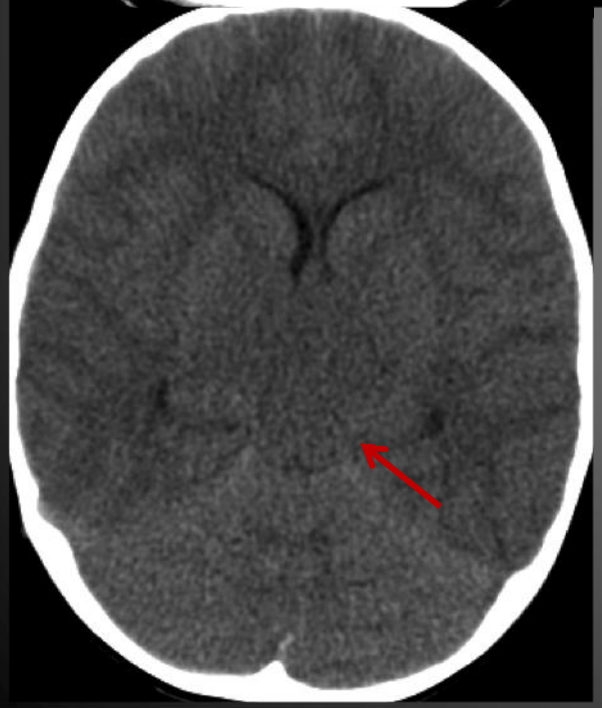
Normal

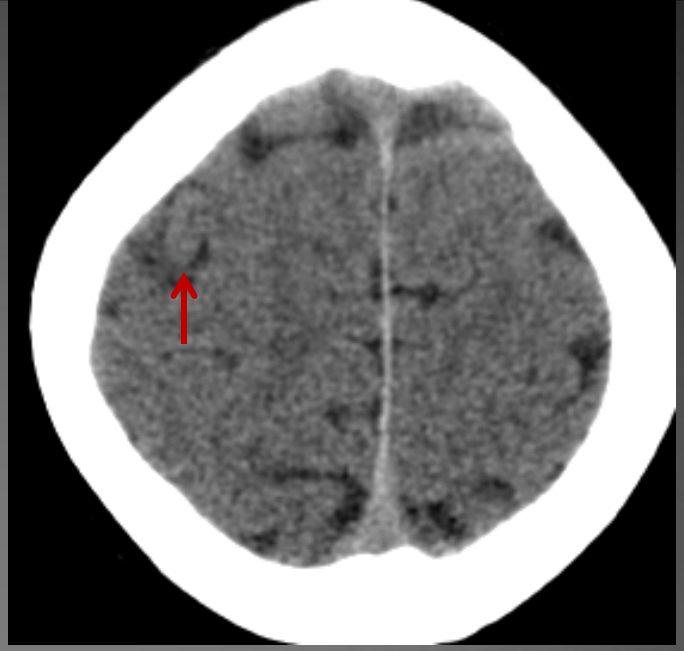
- To properly assess for the presence and the severity of cerebral swelling, you need to particularly evaluate:
  - Sulci
  - Lateral ventricles
  - Basal cisterns
  - 4th ventricle



Below: Diffuse cerebral swelling (same patient as above), impending herniation
(arrows: 4th ventricle blunted, perimesencephalic cistern effaced, sulci effaced)







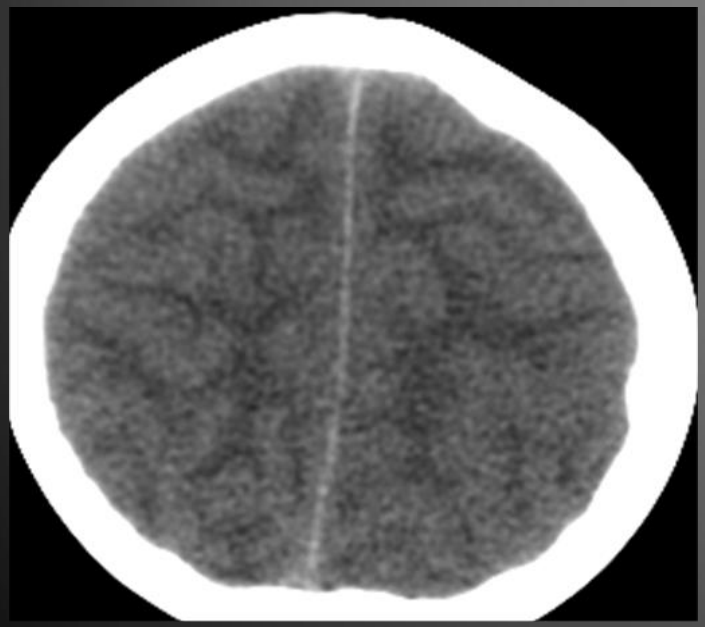
Normal

Diffuse swelling, impending herniation

Craniosynostosis

- Craniosynostosis can have imaging findings that closely resemble cerebral edema, however the differentiation is important due to different treatments.
  - The diagnosis of craniosynostosis relies on noting that there are prematurely fused sutures as seen on the next page.

Premature fusion of the sutures causes effaced sulci in craniosynostosis



Diffuse swelling in cerebral edema

END OF MODULE #4

- Continue to the next slide for references.

References

- Harnsberger HR, Osborn AG, Ross JS, Moore KR, Salzman KL, Carrasco CR, Halmiton BE, Davidson HC, Wiggins RH. Diagnostic and Surgical Imaging Anatomy: Brain, Head and Neck, Spine. 3rd ed. Salt Lake City, Utah. Amirsys. 2007.
- Hedlund GL, Frasier LD. Neuroimaging of abusive head trauma. Forensic Sci Med Pathol. 2009 Dec;5(4):280-90. doi: 10.1007/s12024-009-9132-6. Epub 2009 Dec 12. Review. PubMed PMID: 20012715.

Pediatric Neuroradiology Precall Primer

Module 5: Cisterns

Relevance

- The cisterns of the brain give important information about mass effect.
- They are tricky to evaluate because they are small spaces.

Pearl:

Small changes in small spaces can indicate BIG problems……

Learning Objectives

After reviewing this module you should be able to:

- Name the major cisterns
- List the contents of the cisterns
- Discuss complications of cisternal compression

What are the cisterns you should know?

- Cerebromedullary (Cisterna Magna)
- Prepontine
- Cerebellopontine
- Chiasmatic
- Interpeduncular

Suprasellar cistern

- Crural
- Ambient
- Quadrigeminal

Perimesencephalic cistern

Are there even more cisterns?

- Medullary c.
- Chiasmatic c.
- Crural c.
- Carotid c.
- Sylvian c
- Supracerebellar c.
- Pericallosal c.
- Retrothalamic c.
- Lamina terminalis c.

Combos

Some cistern names refer to a combination of several cisterns

1. Basal cisterns:

premedullary, prepontine, interpeduncular, chiasmatic, CP angle, crural, carotid, sylvian

2. Perimesencephalic cistern:

interpeduncular, crural, ambient, quadrigeminal

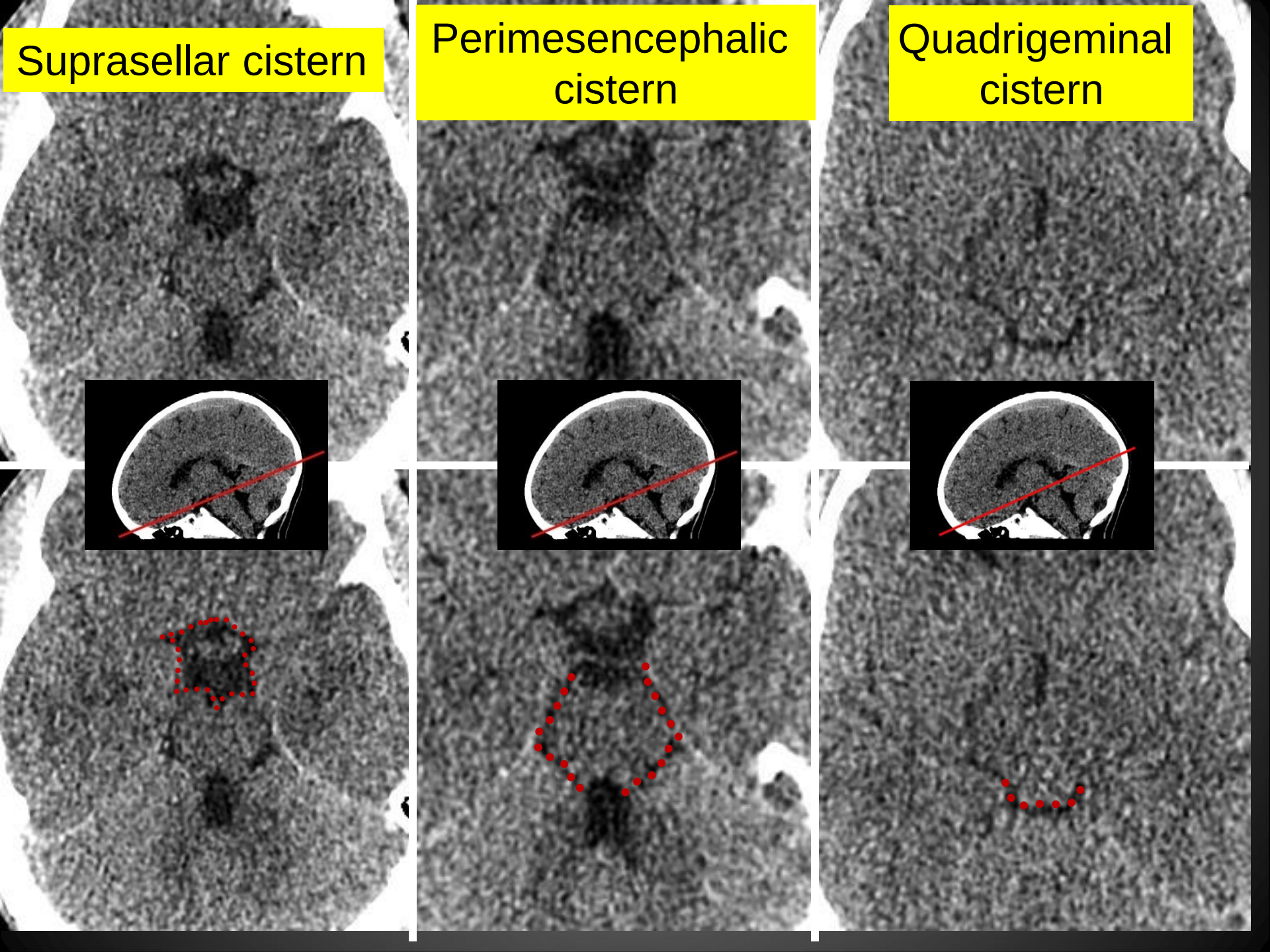
3. Suprasellar cistern

interpeduncular, chiasmatic

Suprasellar cistern

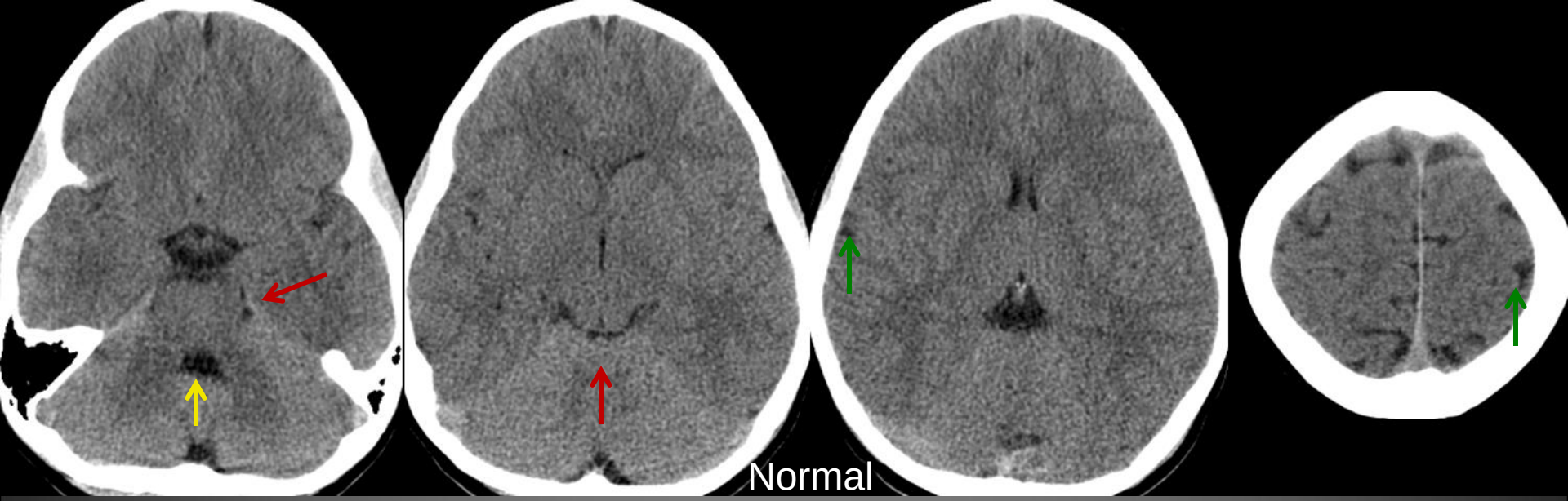
Perimesencephalic cistern

Quadrigeminal cistern



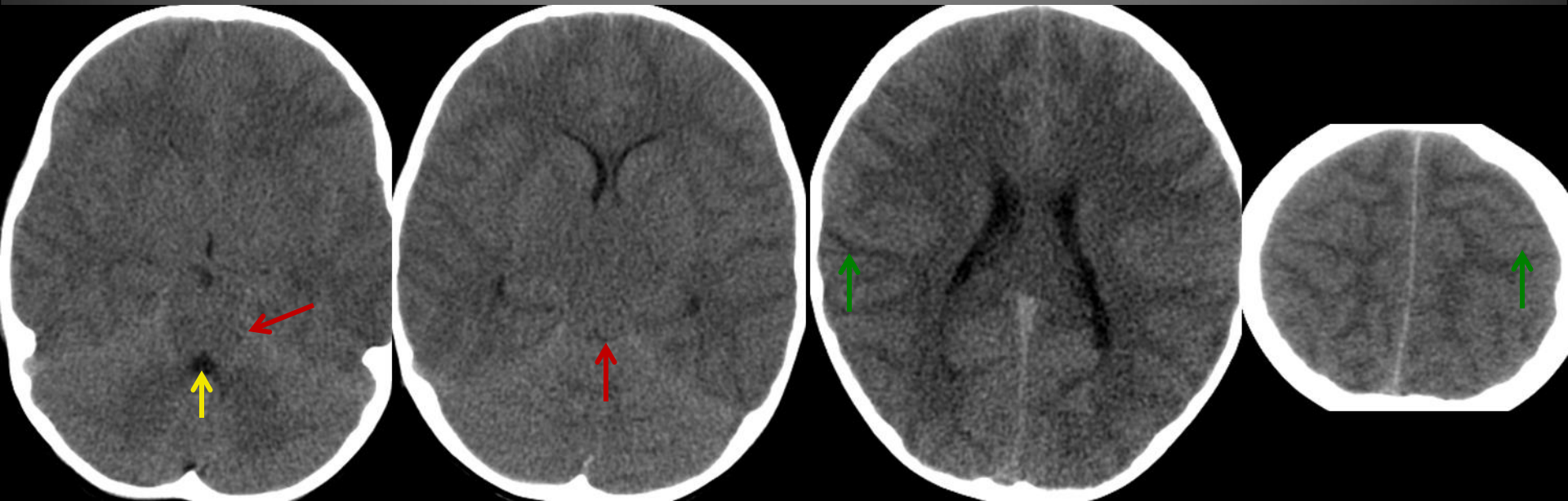
Cisternal compression

- Arteries can become occluded and cause infarction in the territory they supply
- Veins can become compressed and cause congestion/venous infarctions
- Nerves can become compressed and cause palsy



Normal

Below: Diffuse cerebral swelling (same patient as above), impending herniation (arrows: 4th ventricle blunted, perimesencephalic cistern effaced, sulci effaced)



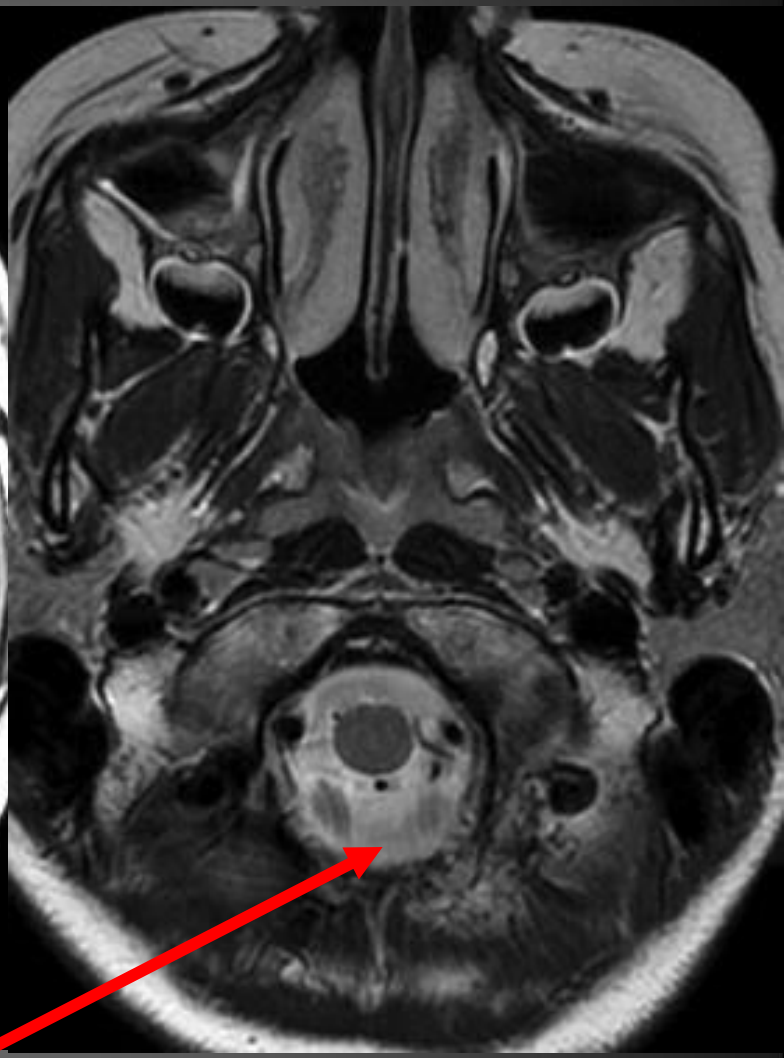
Cerebromedullary (Cisterna magna)

Boundaries

- Largest of the subarachnoid cisterns
- Lies between the cerebellum and the medulla
- Receives CSF from the fourth ventricle via the median foramen of Magendie and the paired lateral foramina of Luschka

Contents

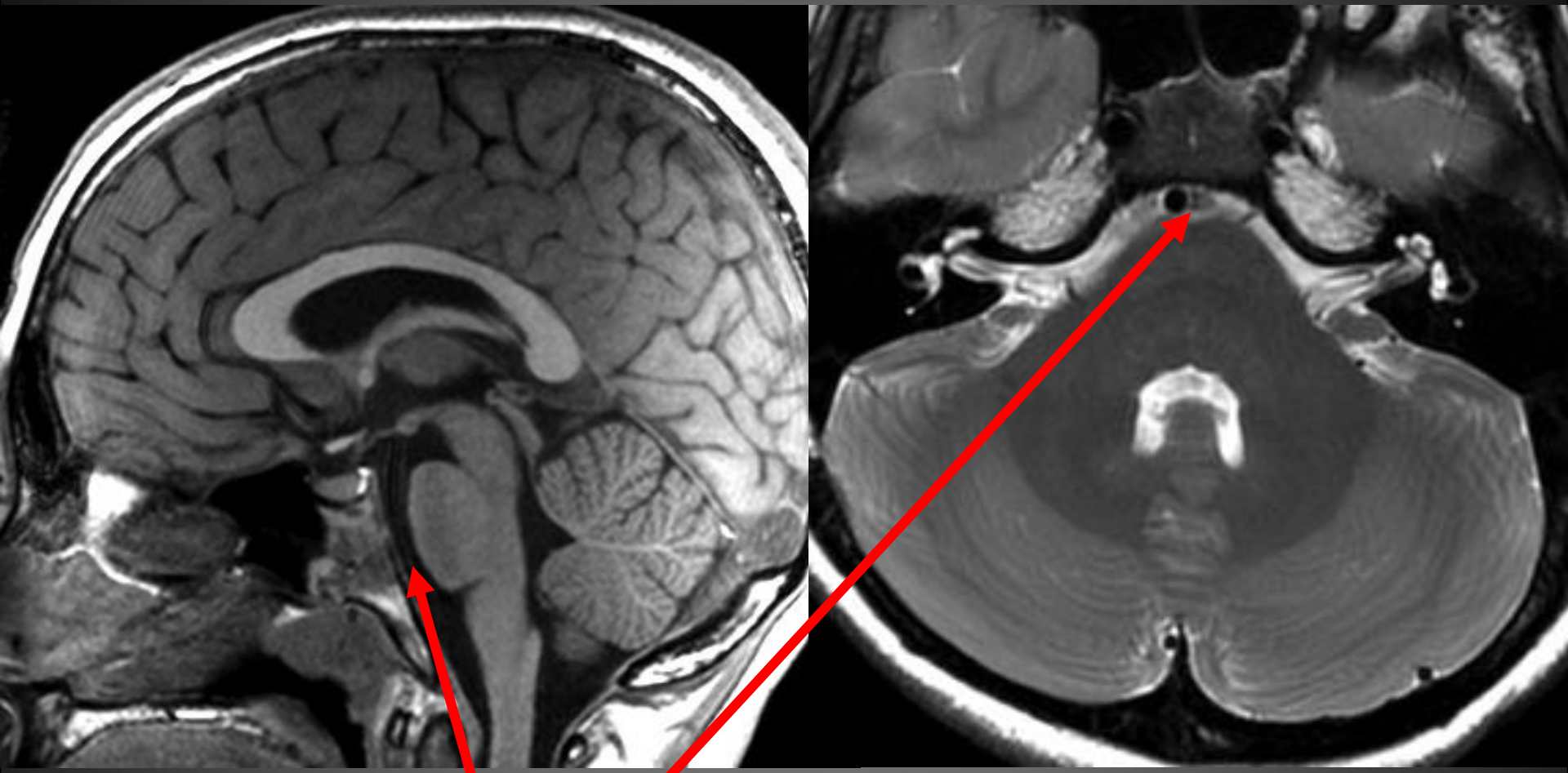
- Vertebral artery
- Postero-inferior cerebellar artery (PICA)
- Cranial nerves nine (IX), ten (X), eleven (XI) and twelve (XII)
- Choroid plexus



Cisterna magna

Prepontine

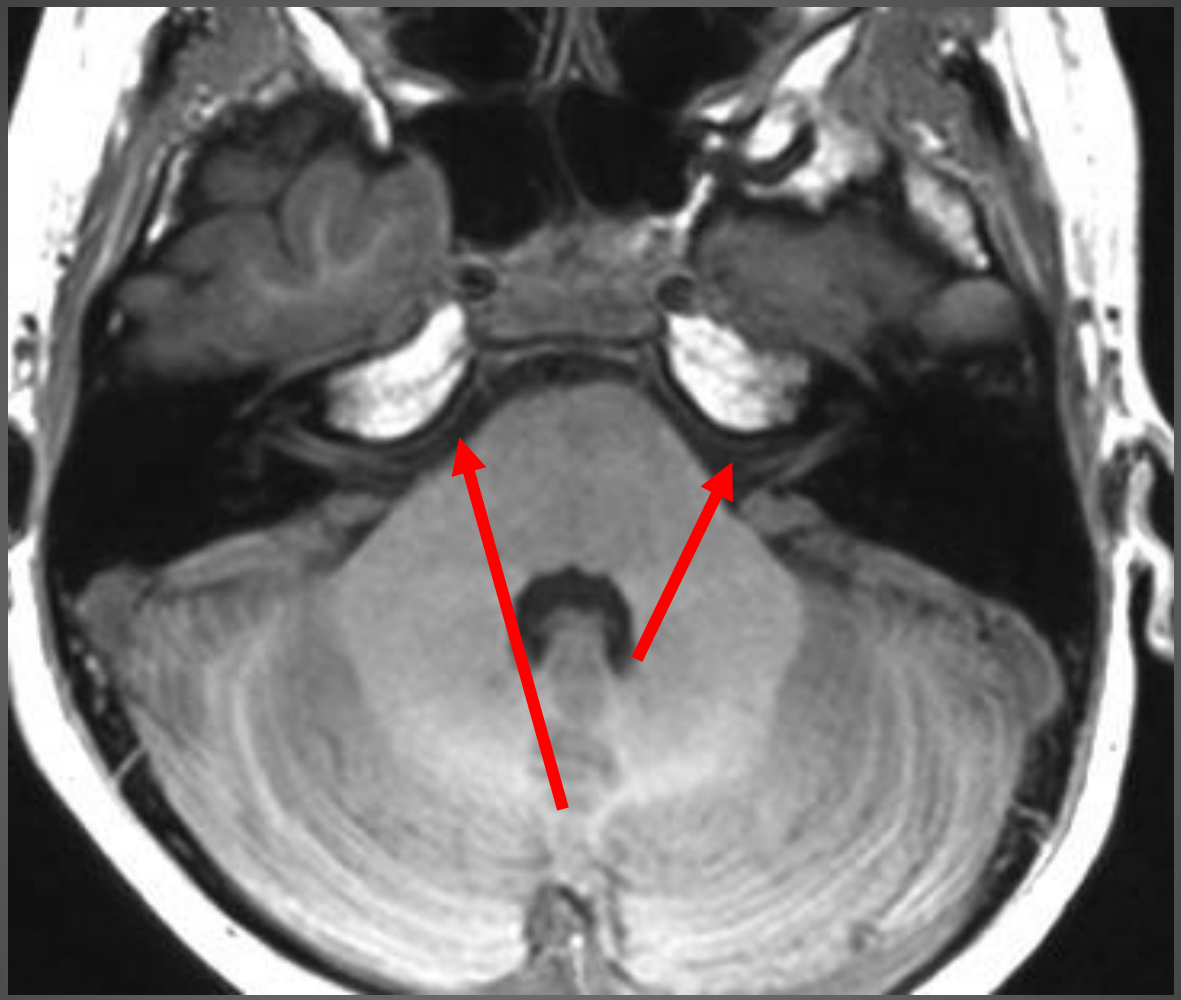
Boundaries	Contents
• Surrounds the ventral aspect of the pons • Anterior boundary are clivus and occipital bones	• Basilar artery • Origin of the anteroinferior cerebellar artery (AICA) • Origin of the superior cerebellar arteries • Cranial nerve six (VI)



Prepontine cistern

Cerebellopontine

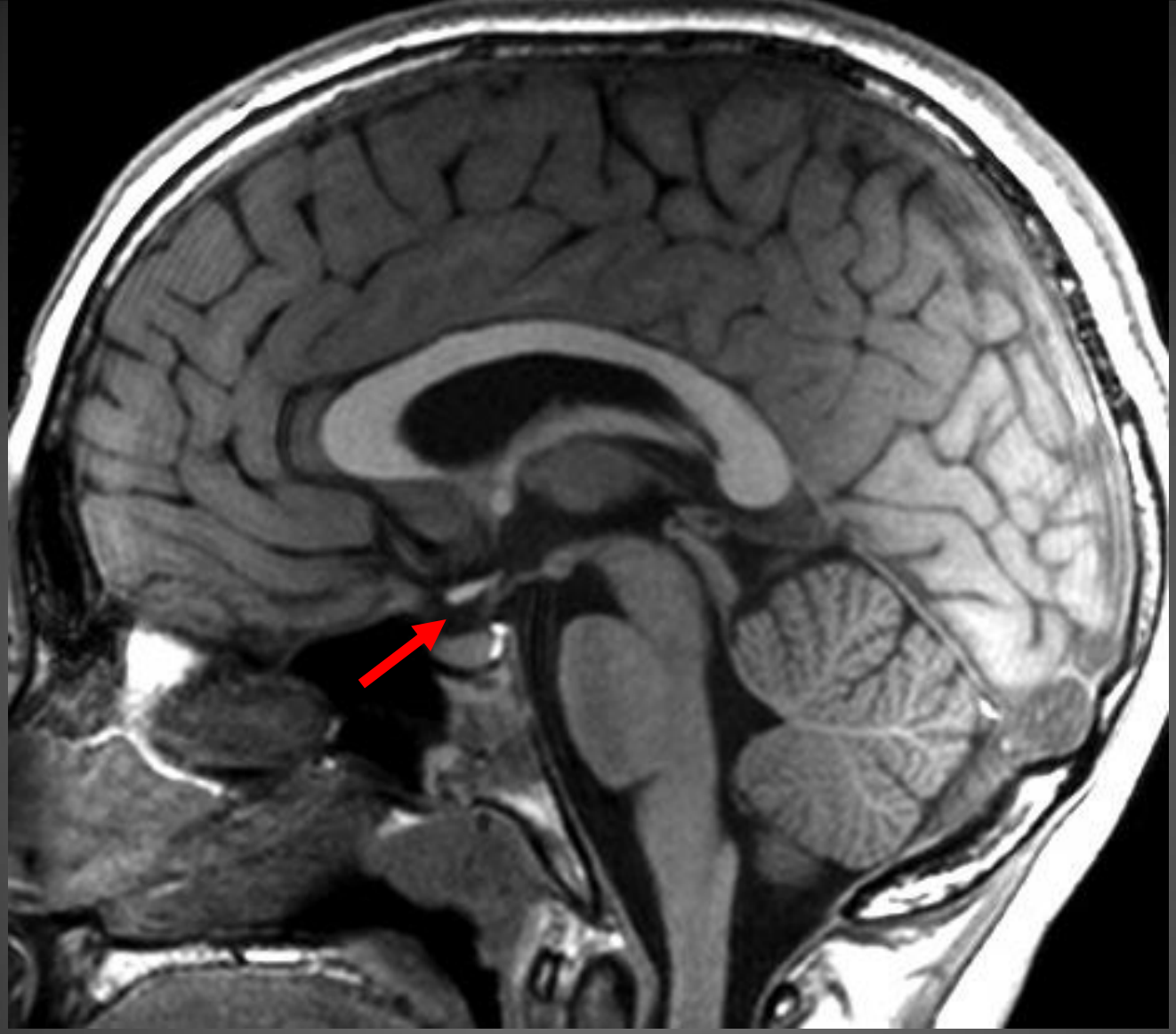
Boundaries	Contents
• In the lateral angle between the cerebellum and the pons	• Cranial nerves five (V), seven (VII) and eight (VIII) • Anteroinferior cerebellar artery (AICA) • Petrosal vein



Cerebellopontine angle cistern

Chiasmatic

Boundaries	Contents
• Ventral to the optic chiasm	• Anterior aspect of the optic chiasm and optic (II) nerves • Hypophyseal stalk • Origin of the anterior cerebral arteries



Chiasmatic cistern

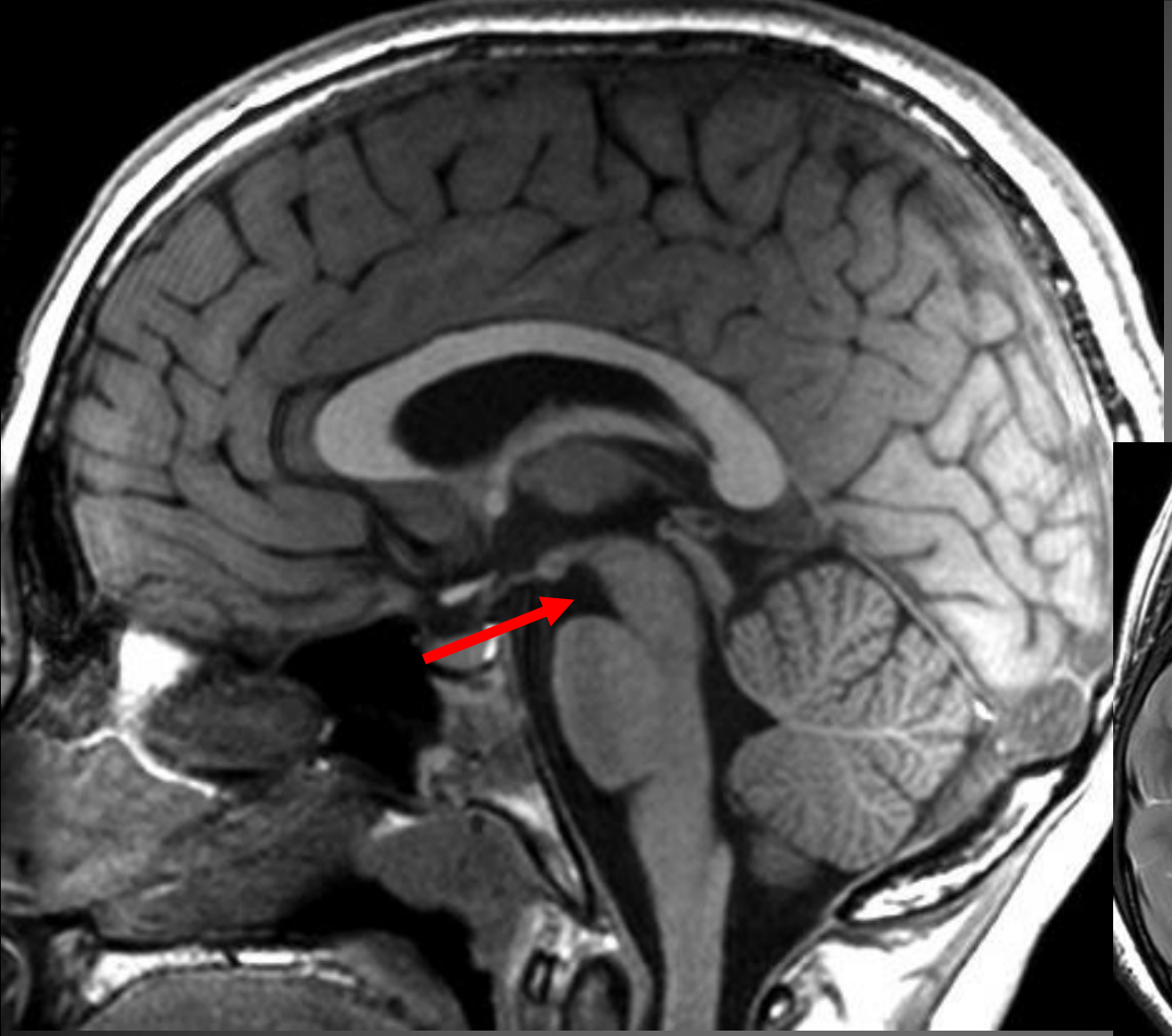
Interpeduncular

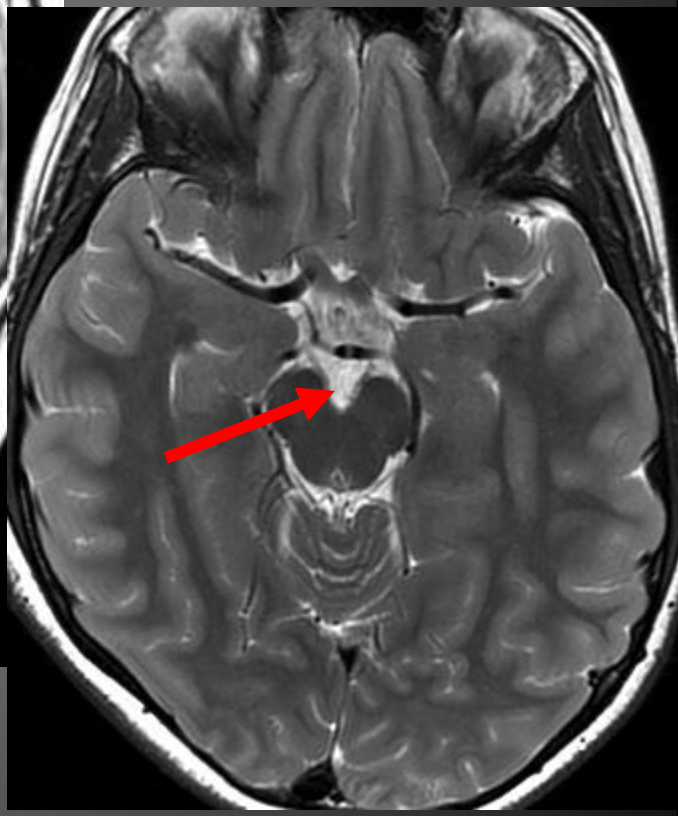
Boundaries

- Situated between the two cerebral peduncles

Contents

- Bifurcation of the basilar artery
- Peduncular segments of the PICA
- Peduncular segments of the superior cerebellar arteries
- Perforating branches of the PICA
- Posterior communicating arteries (PCoA)
- Cranial nerve three (III)

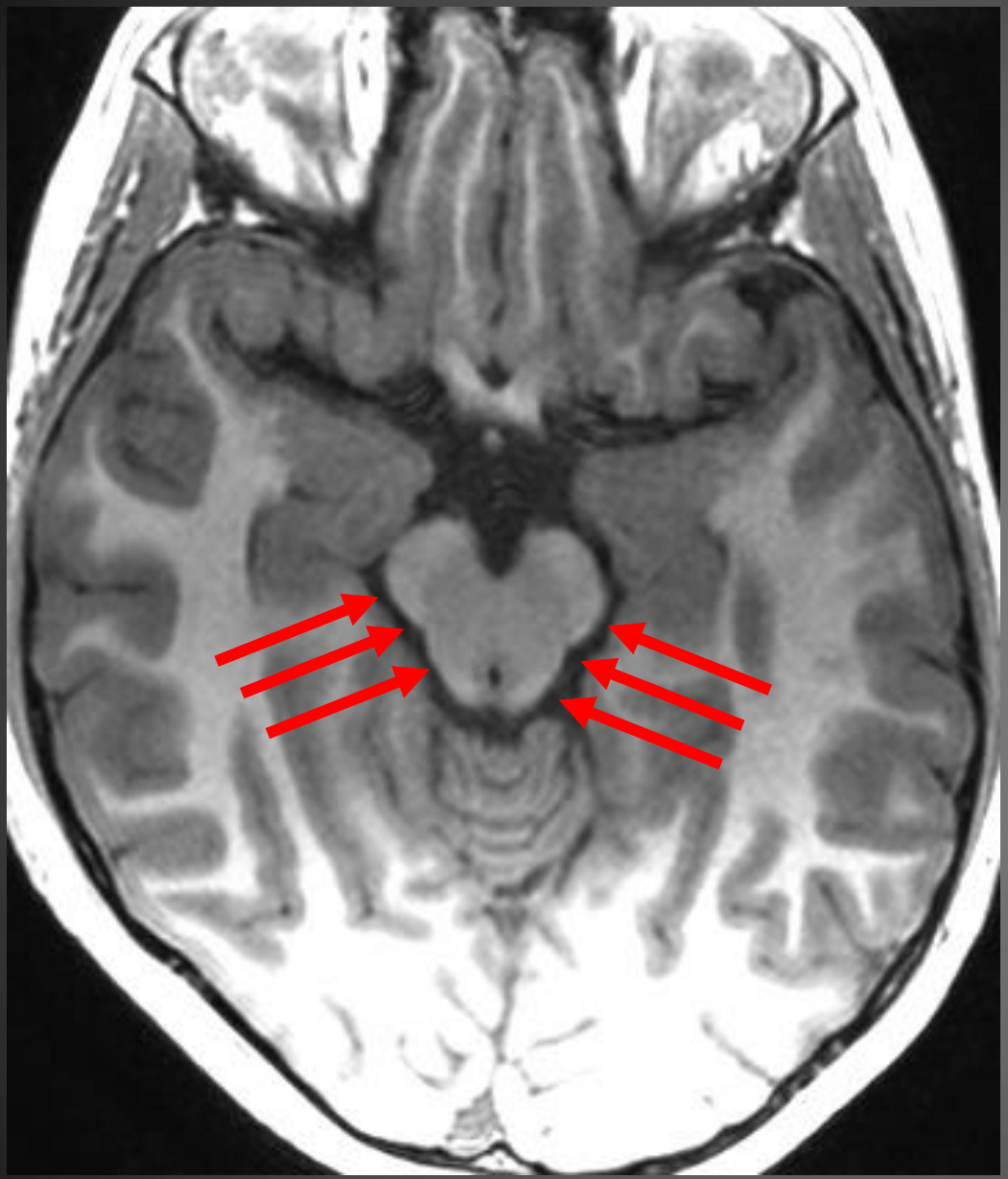


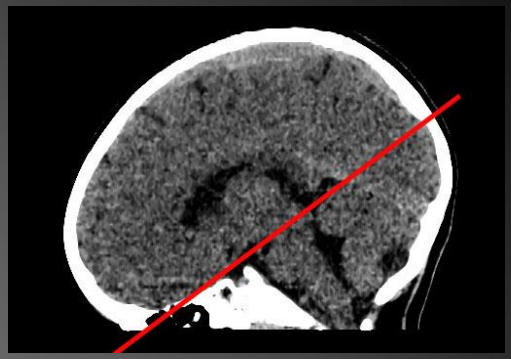


Interpeduncular cistern

Ambient cistern

Boundaries	Contents
• Medial to the temporal lobes • Dorsolateral to midbrain • Connects to crural cisterns • Has supra- and infratentorial compartments	• Cranial nerve four (IV) • Basal vein of Rosenthal



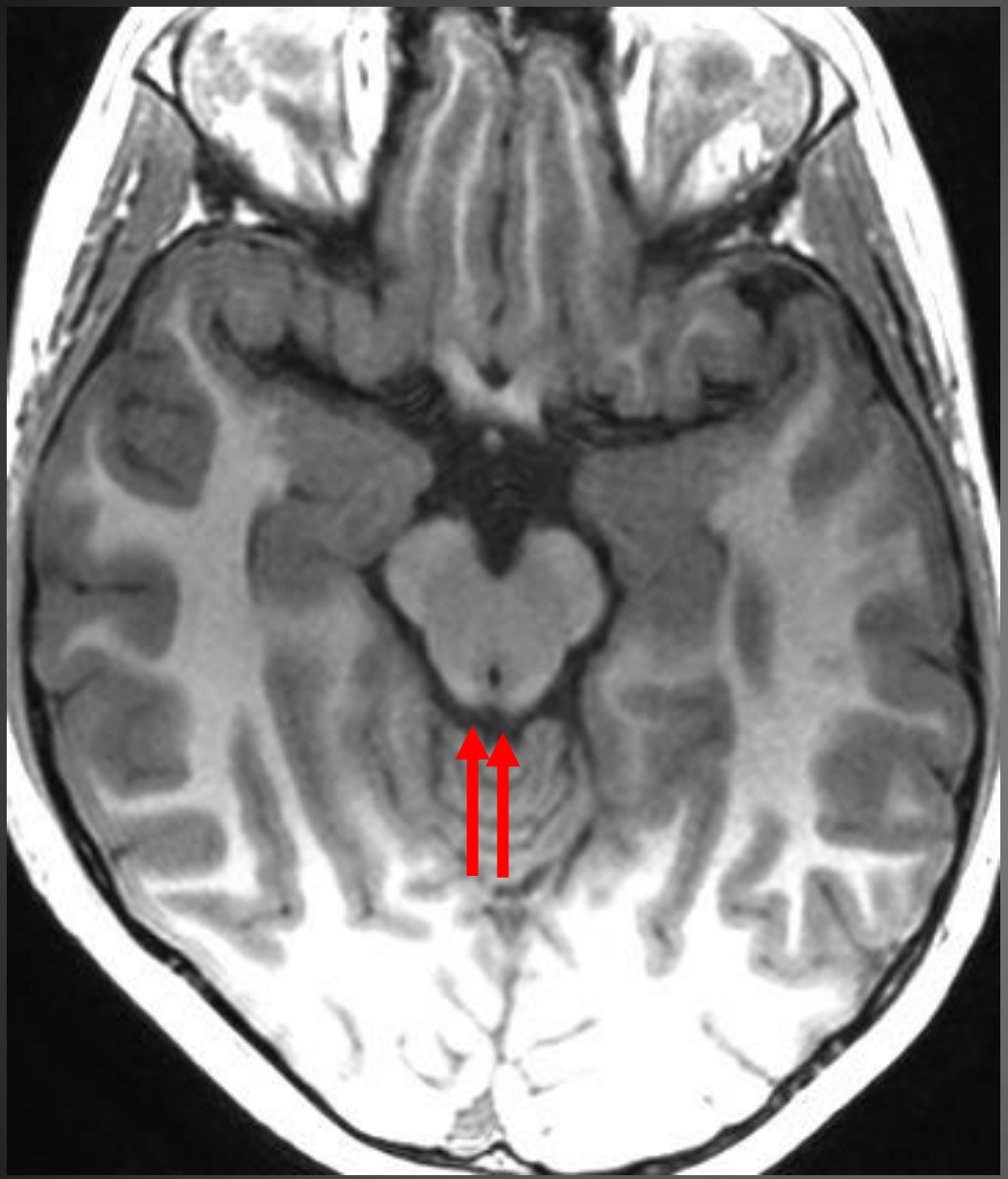


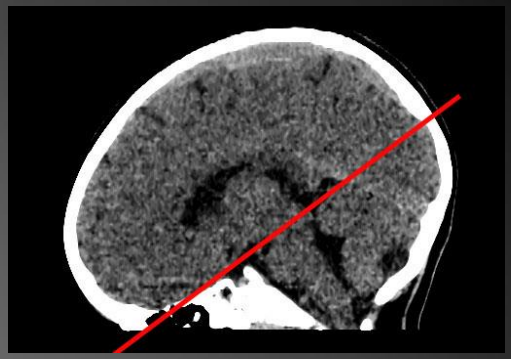
CT image for localization

Cisterna ambiens

Quadrigeminal

Boundaries	Contents
• Dorsal to the midbrain	• Vein of Galen • Posterior pericallosal arteries • Third portion of the superior cerebellar arteries • Perforating branches of the posterior cerebral and superior cerebellar arteries • Third portion of the posterior cerebral arteries





CT image for localization

Quadrigeminal cistern

END OF MODULE #5

- Click next slide for references

References

- Harnsberger HR, Osborn AG, Ross JS, Moore KR, Salzman KL, Carrasco CR, Halmiton BE, Davidson HC, Wiggins RH. Diagnostic and Surgical Imaging Anatomy: Brain, Head and Neck, Spine. 3rd ed. Salt Lake City, Utah. Amirsys. 2007.

Pediatric Neuroradiology Precall Primer

Module 6: Herniation

Relevance

- Herniation can be lethal.
- Understanding and describing herniations requires knowledge of cisterns.
- We can help clinicians understand what is going on by describing the type of herniation as accurately as possible.

Learning Objectives

After reviewing this module you should be able to:

- Describe major types of brain herniations
- Discuss the consequences of brain herniation

Major herniation types

1. Subfalcine
2. Lateral transtentorial (uncal)
3. Central transtentorial, descending
4. Tonsillar
5. Central transtentorial, ascending
6. External

Subfalcine herniation

- Most common type of herniation

Causes:

- Unilateral frontal, parietal, or temporal lobe lesion
- Unilateral brain edema
- Unilateral extraaxial collection

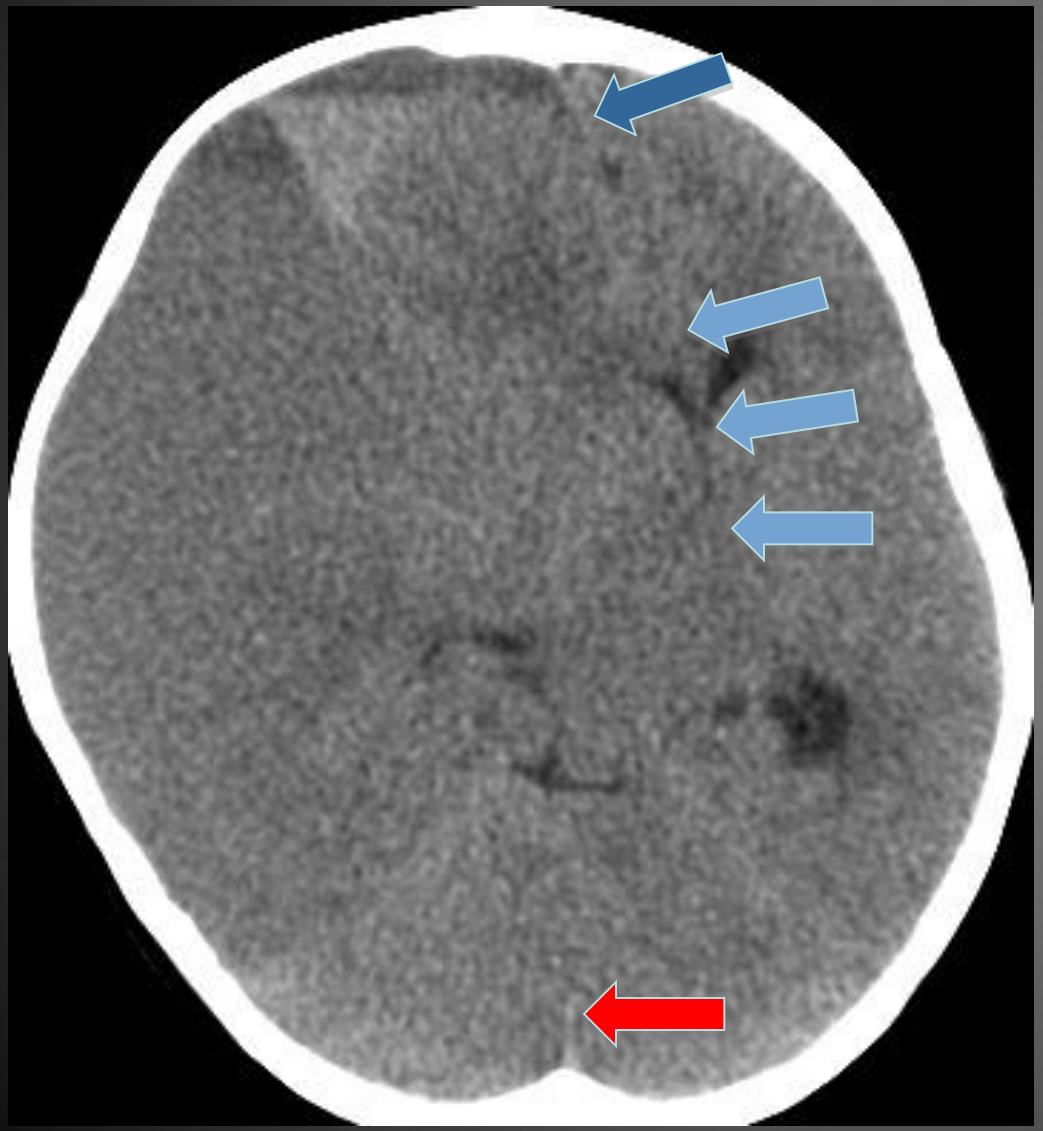
Complications:

- Anterior cerebral artery compression
- Internal cerebral veins compression

Imaging signs:

- Anterior falx tilts away from the mass effect
- Posterior falx is more resistant to displacement
- Ipsilateral ventricle compressed
- Contralateral ventricle obstructed

Subfalcine herniation



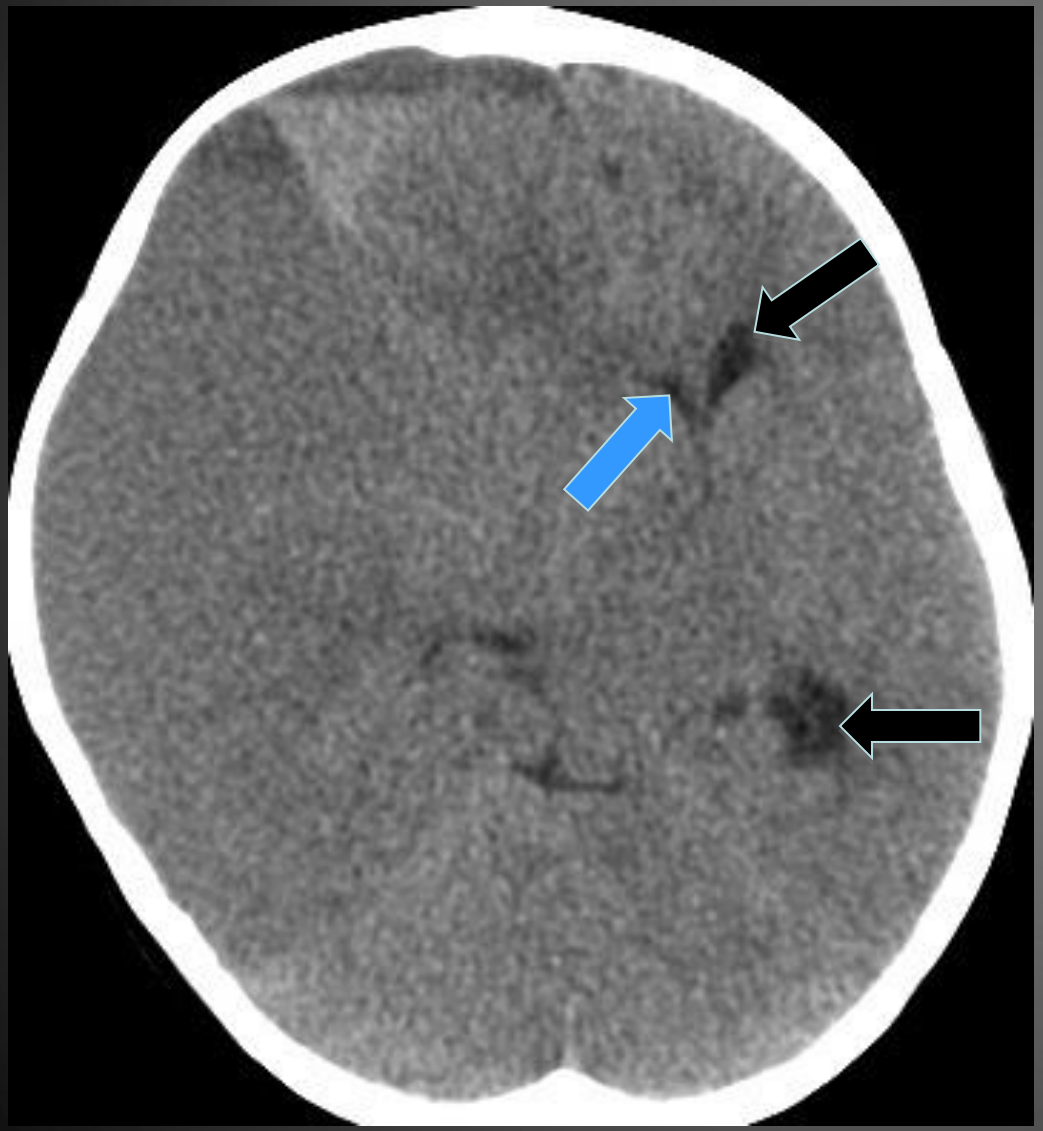
Posttraumatic right epidural hematoma

Anterior falx bowed to the left (black arrow)

Midline shifted to left (blue arrows)

Posterior falx not affected (red arrow)

Subfalcine herniation



Ispilateral ventricle compressed (blue arrow)
Contralateral ventricle obstructed (black arrows)

Uncal herniation

- Is an anterior lateral transtentorial herniation.
- Best-known type of transtentorial herniation

Causes:

- Unilateral unilateral, expanding supratentorial lesion, especially in the *middle cranial fossa*

Complications:

- Ipsilateral 3rd nerve palsy (blown pupil)
- Contralateral cerebral peduncle (contralateral hemiparesis, can cause false lesion localization clinically)

Imaging signs:

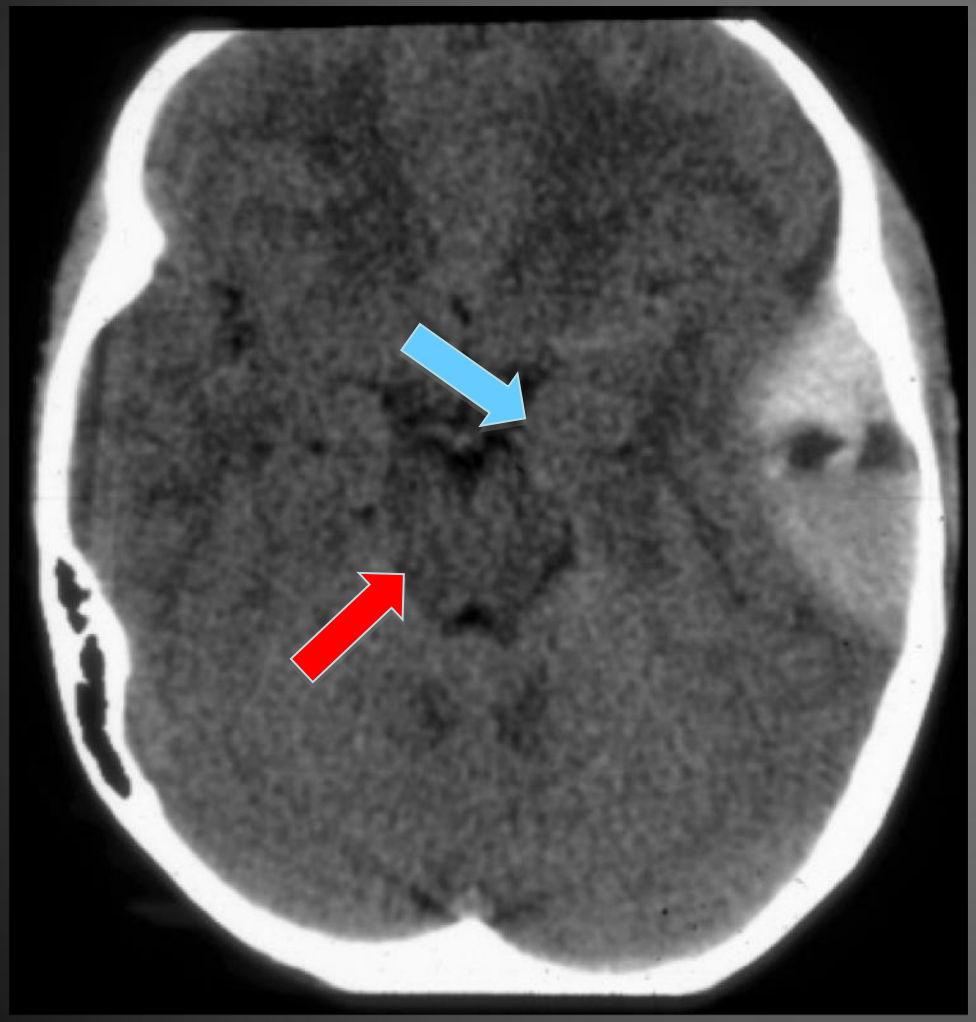
- Uncus is displaced over the free edge of the tentorium
- midbrain is displaced
- opposite cerebral peduncle is squeezed against the contralateral tentorial edge
- Contralateral perimesencephalic cistern is compressed; ipsilateral perimesencephalic cistern is preserved

Uncus

Amygdala- located in the temporal lobe; involved in memory, emotion, and fear.

The amygdala is just beneath the surface of the front, medial part of the temporal lobe where it causes the bulge on the surface called the **uncus**.

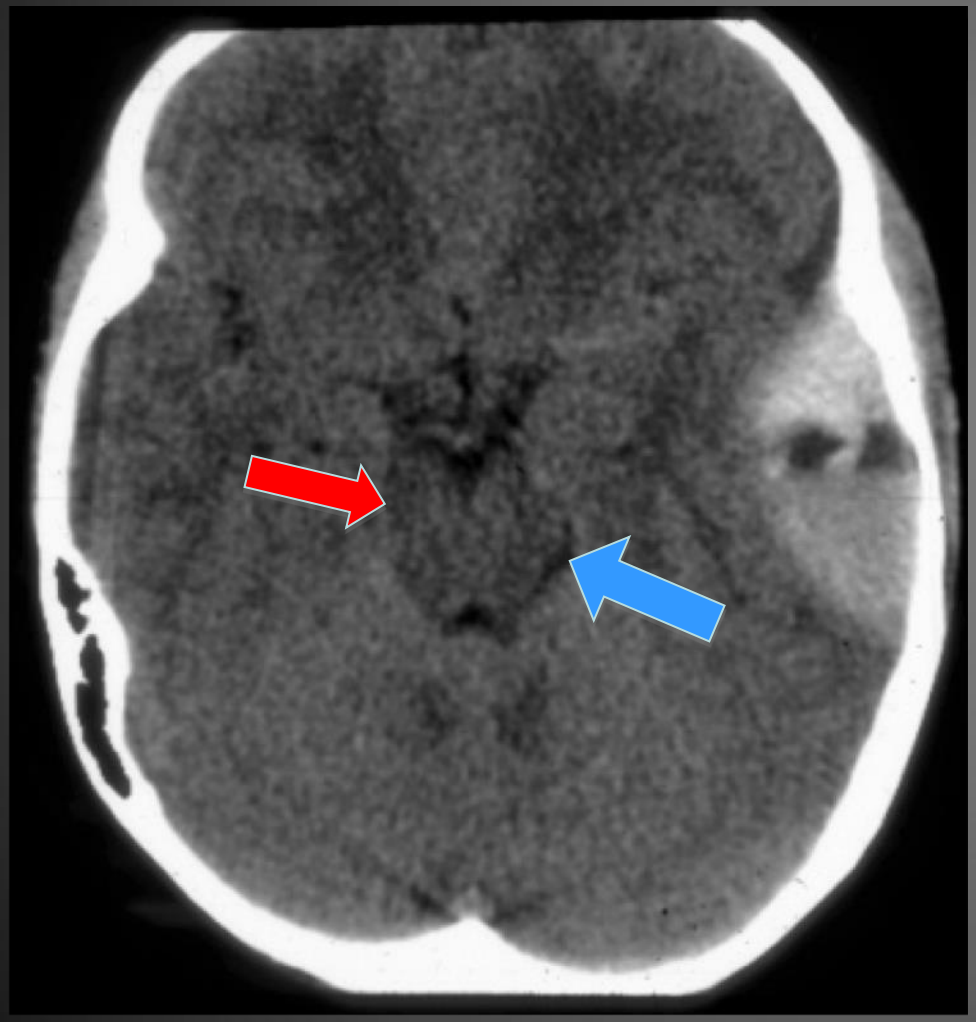
Uncal herniation



Uncus is displaced medially over the free edge of the tentorium (blue arrow)

Midbrain is displaced to the contralateral side, effacing the contralateral ambient cistern (red arrow)

Uncal herniation



Ipsilateral perimesencephalic cistern is visualized (blue arrow)

Contralateral cerebral peduncle is squeezed against the contralateral tentorial edge (red arrows)

Central transtentorial herniation, descending

- Caudal descent of brain tissue through the tentorial incisura

Causes:

•Mass effect in the frontal, parietal, and occipital lobes

Complications:

•Third nerve palsy

•Posterior cerebral artery compression

•Anterior choroidal artery compression

•Duret's brainstem hemorrhage

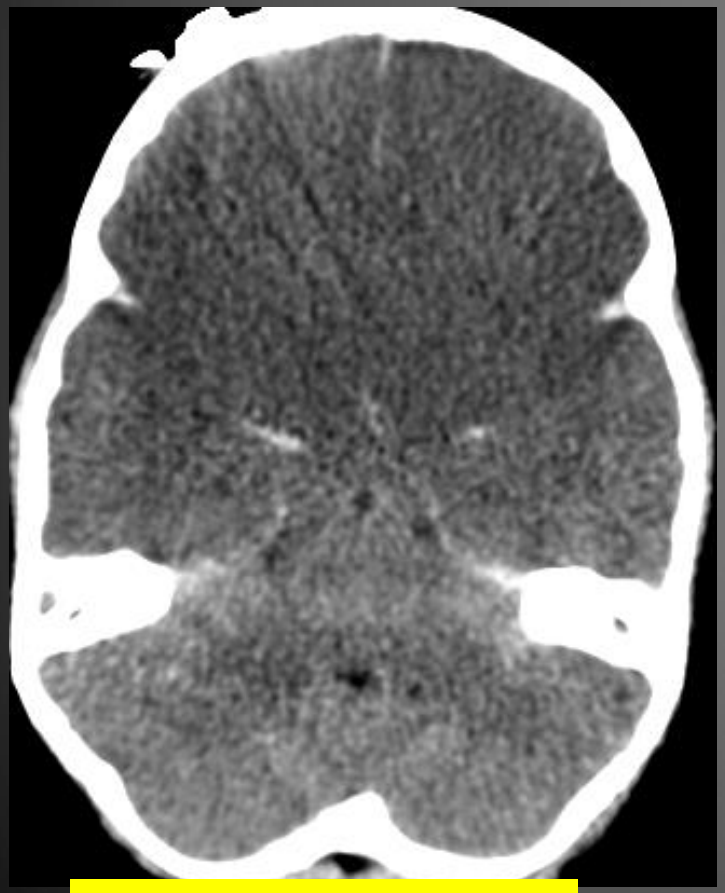
•Aqueductal obstruction

Imaging signs:

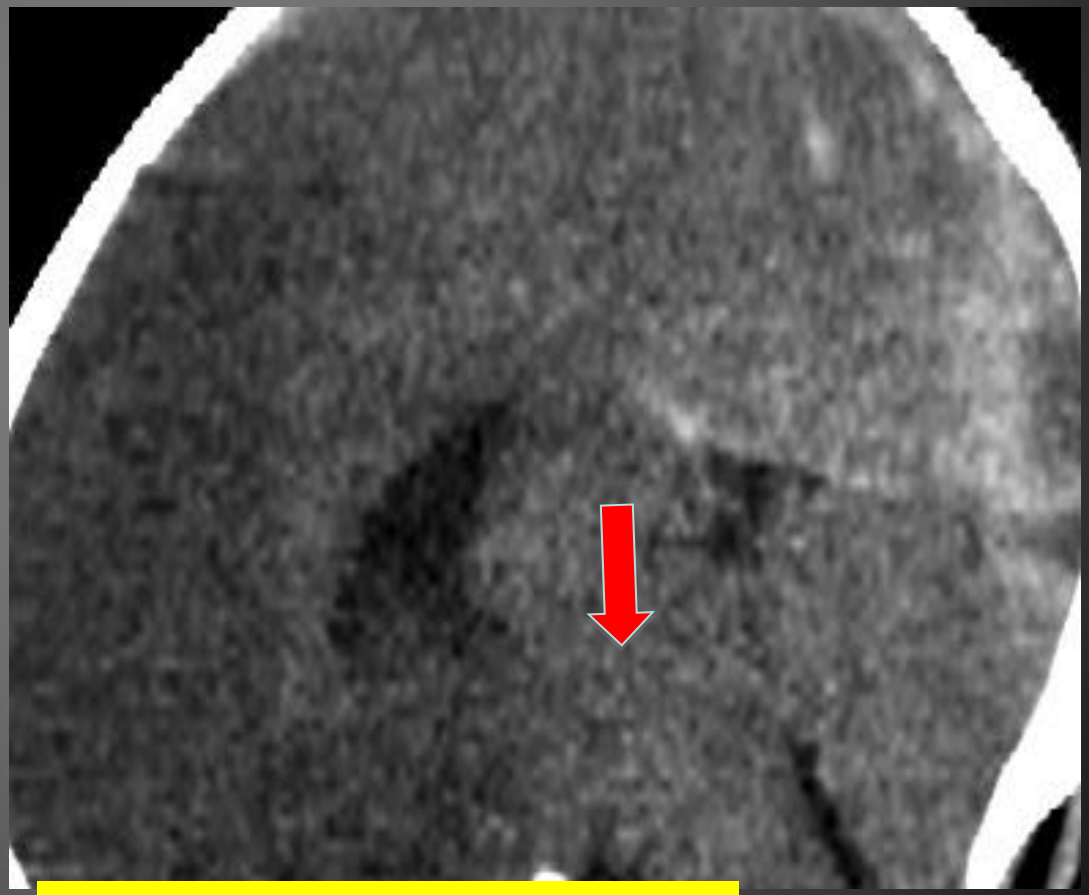
- Obliterated basal cisterns
- Downward displacement of the diencephalon
- Downward displacement of the medial temporal lobes
- Hydrocephalus from aqueduct obstruction
- Compressed 4th ventricle

Central transtentorial herniation, descending

2 y.o. girl, on ECMO< fixed an dilated pupils



Effaced basal cisterns



Downward displacement of the diencephalon (red arrow)

Tonsillar herniation

- Caudal descent of cerebellar tonsils through foramen magnum

Causes:

•Most commonly caused by a posterior fossa mass

•Supratentorial mass that causes downward transtentorial herniation

Complications:

•Damage cardiac and respiratory centers of the brainstem (death)

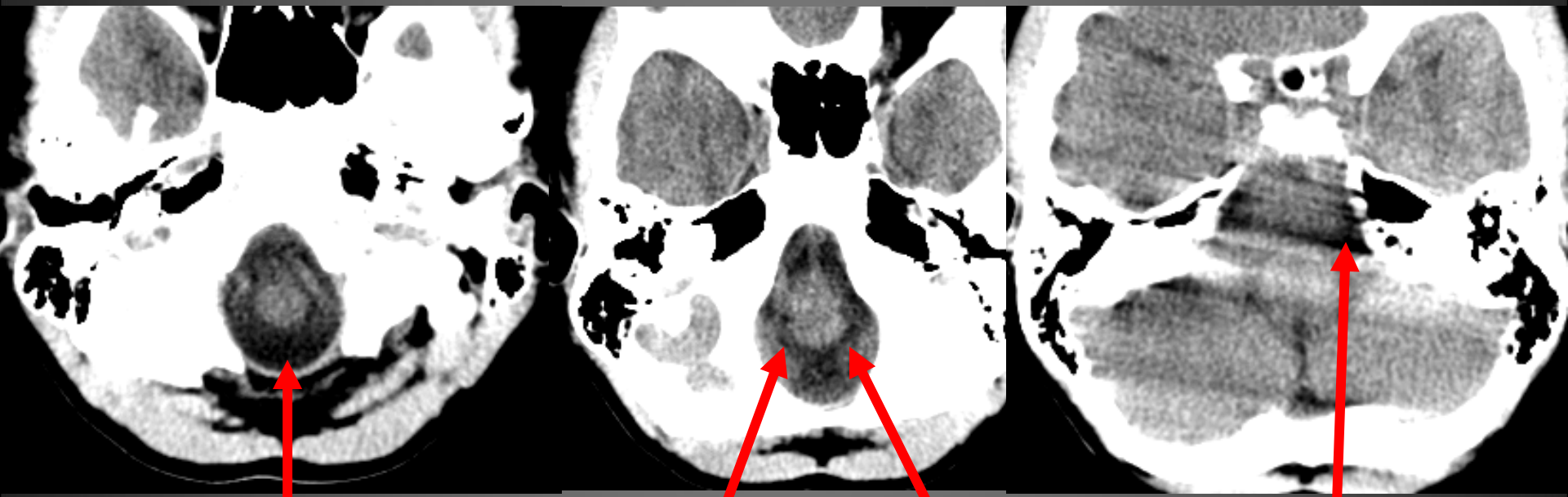
•Occlusion of the posterior inferior cerebellar arteries (infarction)

Imaging signs:

- Tonsils below the foramen magnum
- Anterior brainstem displacement
- Loss of CSF surrounding the brainstem

Tonsillar herniation

4 yo boy, baseline



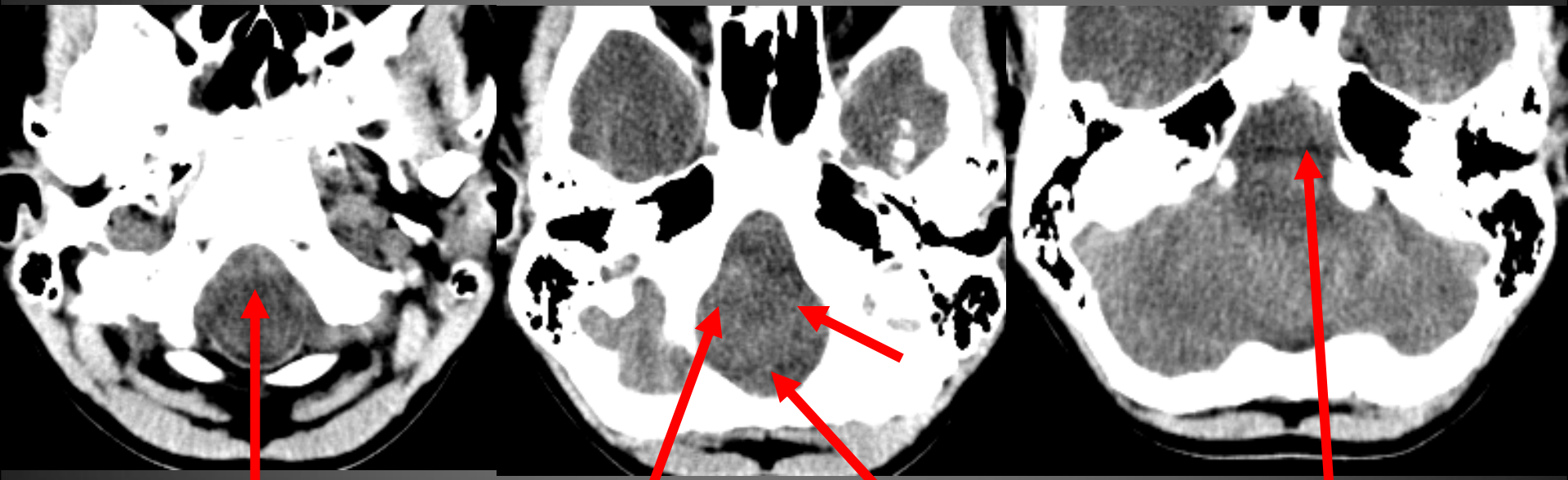
Patent cisterna magna

Patent foramina of Luschka

Beam hardening artifact

Tonsillar herniation

Same 4 yo boy, 2 years later, status epilepticus



Effaced premedullary cistern

Effaced foramina of Luschka

Effaced cisterna magna

Beam hardening artifact

Central transtentorial herniation, ascending

- Cranial ascent of cerebellar tonsils through the incisura

Causes:

•Posterior fossa lesion with mass effect

•Trapped fourth ventricle

Complications:

•Venous compression vein of Galen and basal vein of Rosenthal

•Aqueduct of sylvius compression (hydrocephalus)

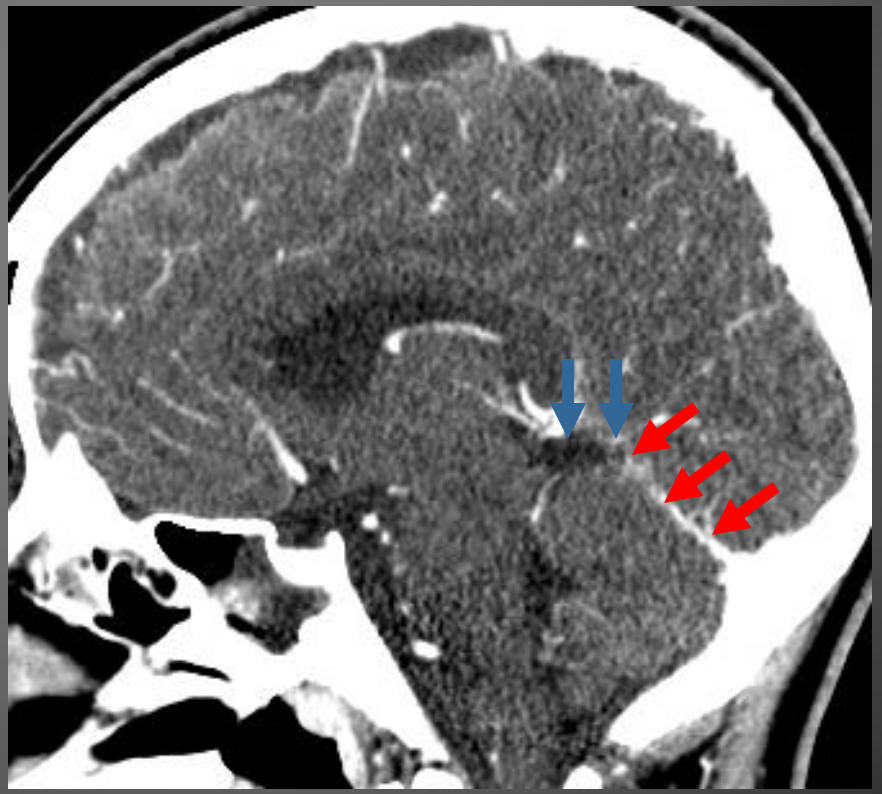
Imaging signs:

- Effacement of the superior cerebellar cistern
- Superior displacement of the superior vermis through the incisura
- Compression of the midbrain
- Forward displacement of the pons against the clivus
- Compression of fourth ventricle (except in trapped fourth ventricle)

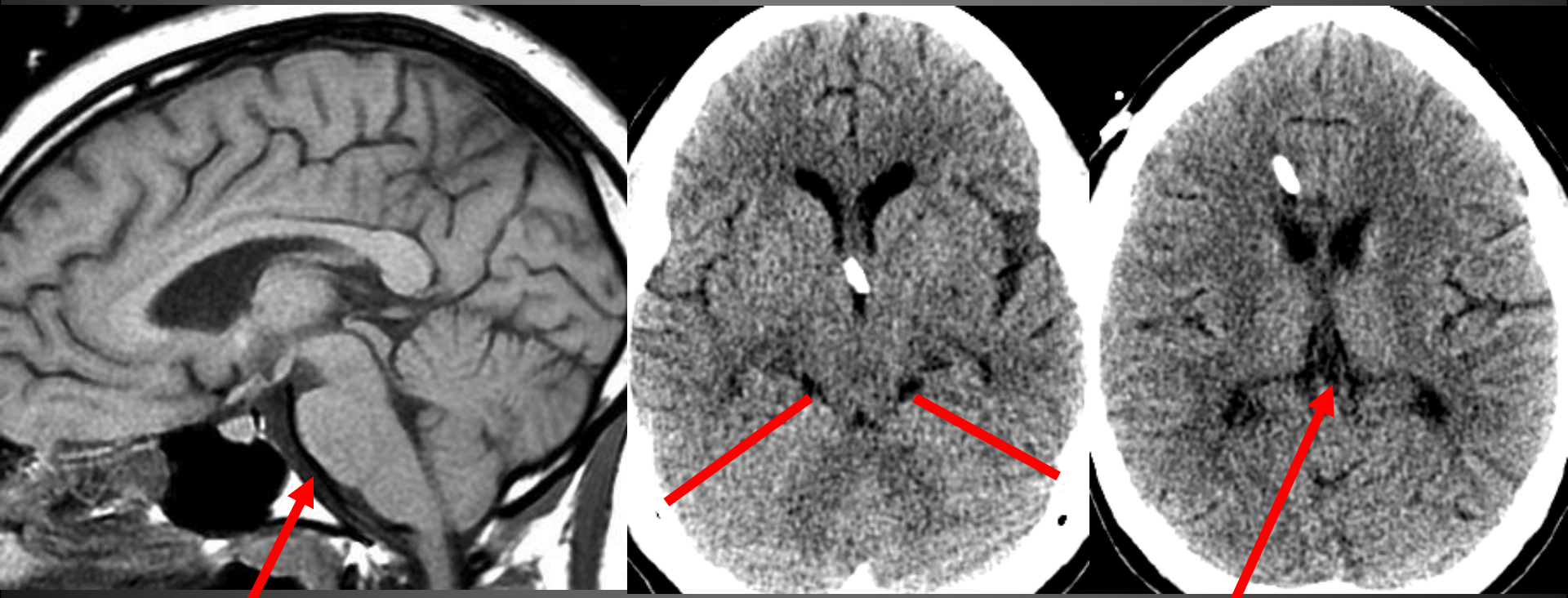
Incisura

- Midline opening of the tentorium

Tentorium (red arrows)
Incisura (blue arrows)



13 y.o. girl, baseline



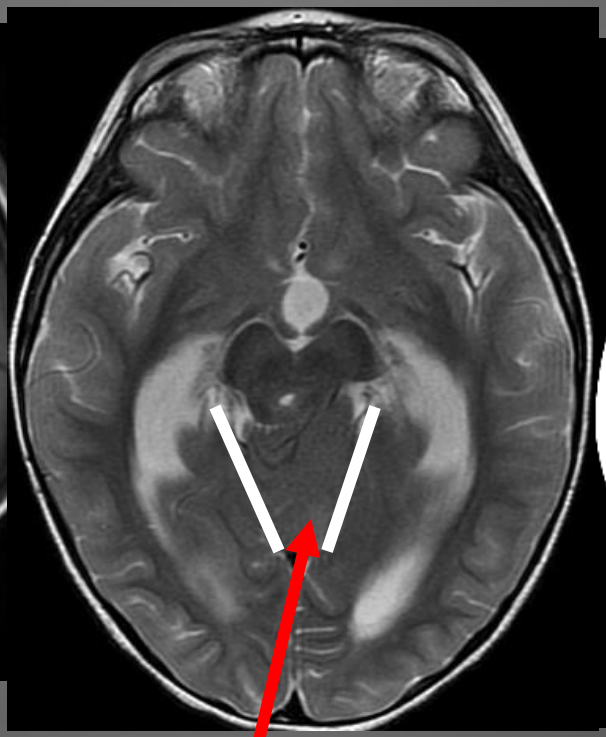
Preserved pre-pontine cistern

Tentorium

Preserved supra-cerebellar cistern

Central transtentorial herniation, ascending

13 y.o. girl with left posterior fossa tumor



Effaced pre-pontine cistern

Compressed 4th ventricle

Superior displacement of the superior vermis through the incisura

Effaced supra-cerebellar cistern

External herniation

- Brain tissue protruding through the skull
- Also known as “fungus cerebri”

Causes:

- Trauma
- Surgery

Imaging signs:

- Brain outside the skull margins

External

3 y.o. boy, non-accidental trauma + edema, right frontal craniectomy

END OF MODULE #6

- Click next slide for references

References

- Johnson PL, Eckard DA, Chason DP, Brecheisen MA, Batnitzky S. Imaging of acquired cerebral herniations. Neuroimaging Clin N Am. 2002 May;12(2):217-28. Review. PubMed PMID: 12391633.