PEDIATRIC RADIOLOGY

Enrico B. Arkink

5th year - 28.09.2022-30.09.2022

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Schedule

- Wednesday 28.09.2022
  - 13.00-13.45: Introduction and MSK
  - 14.00-14:45: Thorax
- Friday 30.09.2022
  - 13.00-13.45: Abdomen
  - 14.00-14.45: Neuro and ENT

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Neuro & ENT

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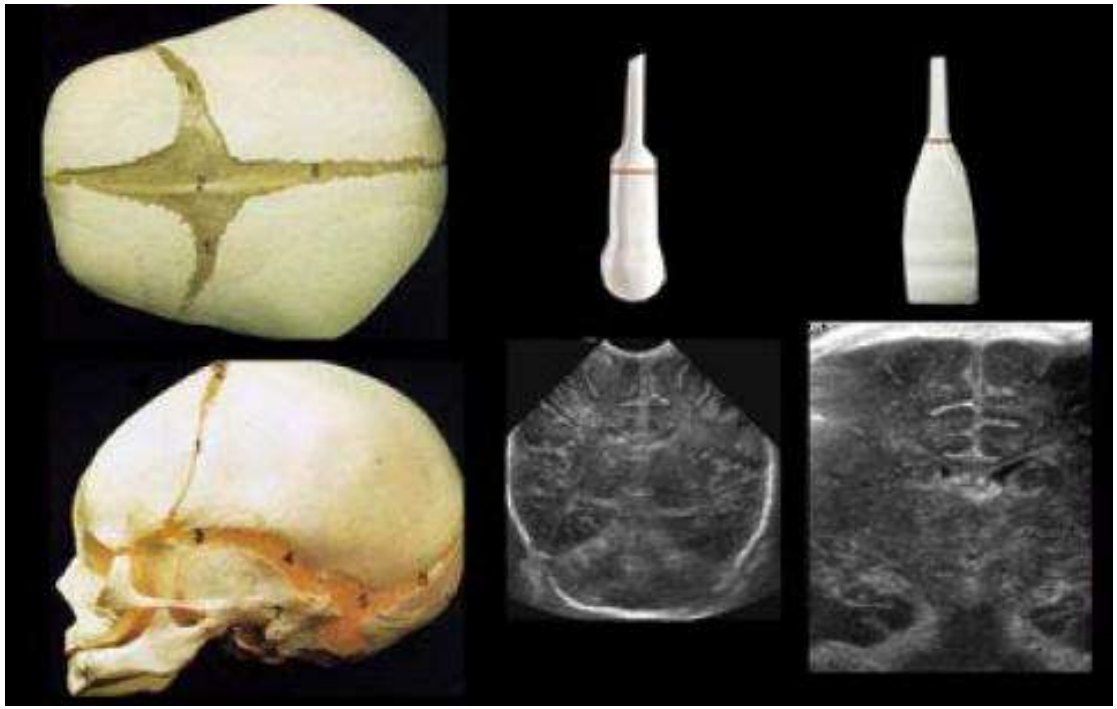
Modalites in pediatric imaging: neuro & ENT

- Ultrasound:
  - Neonatal brain & spine US
  - Neck US
- Magnetic resonance imaging
- Computed tomography
- X-ray → craniosynostosis
- Fluoroscopy → swallowing studies
- Nuclear medicine (isotope scanning, FDG-PET)

Cranial ultrasound

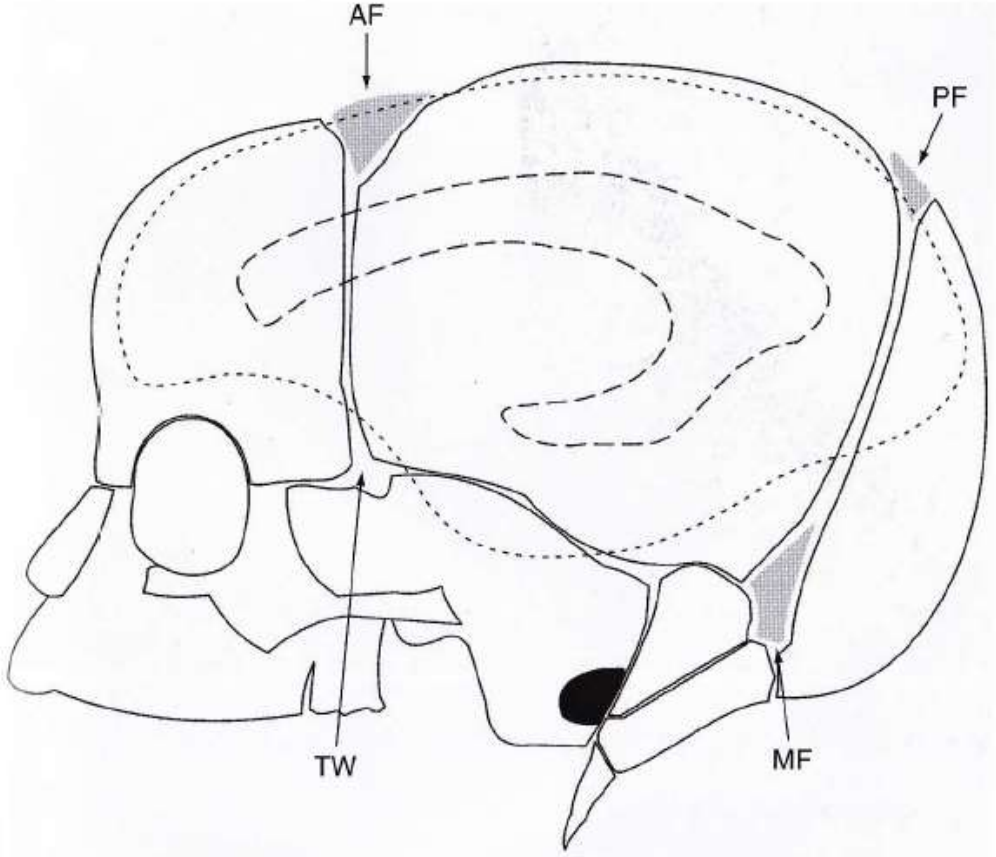
- Cranial US (cUS) is most frequently used for imaging of neonatal brain
- Detection of important and frequently occurring structural brain changes in preterm and term infants
- Convex, phased array and linear transducers
- Transducer frequencies 5-10 mHz
  - 7.5 mHz: standard
  - 5 mHz: basal ganglia, small or hairy fontanel
  - 10 mHz: (sub)cortical structures, very premature

Cranial ultrasound



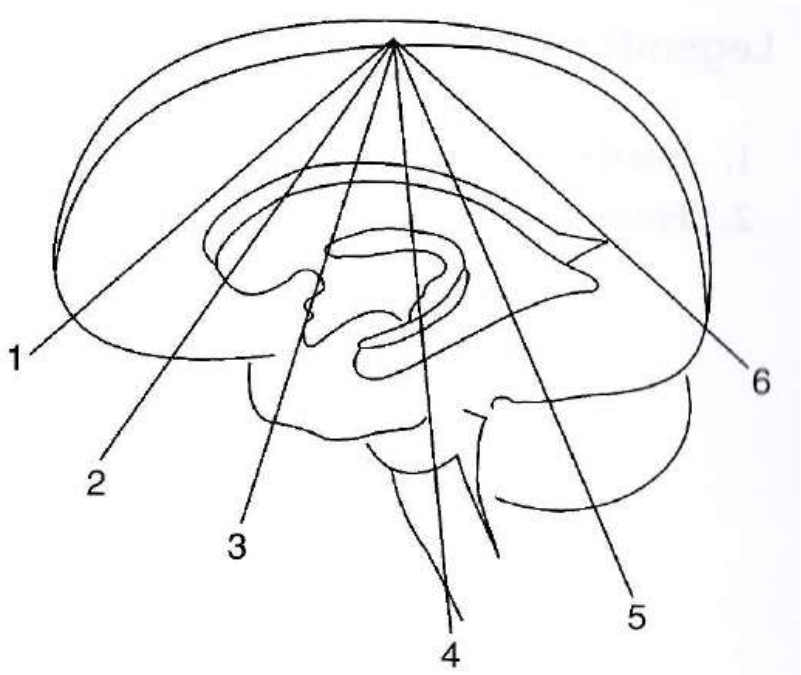
Radiology Assistant, courtesy Erik Beek

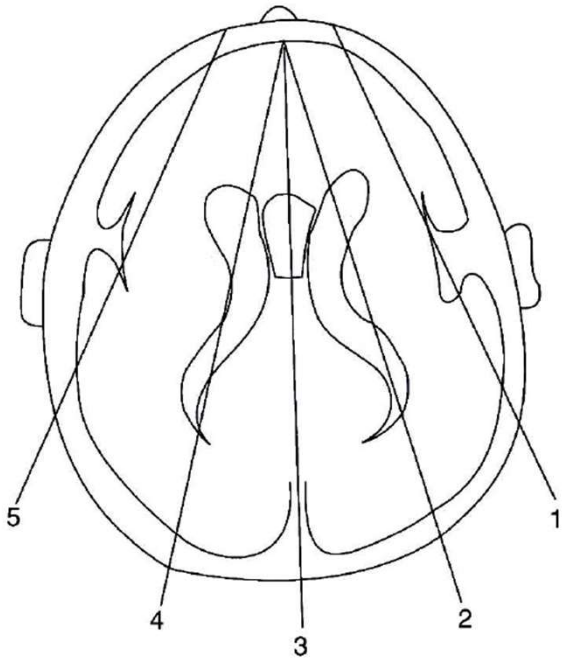
Cranial ultrasound



G. Meijler, Springer-Verlag, 2012

Cranial ultrasound





G. Meijler, Springer-Verlag, 2012

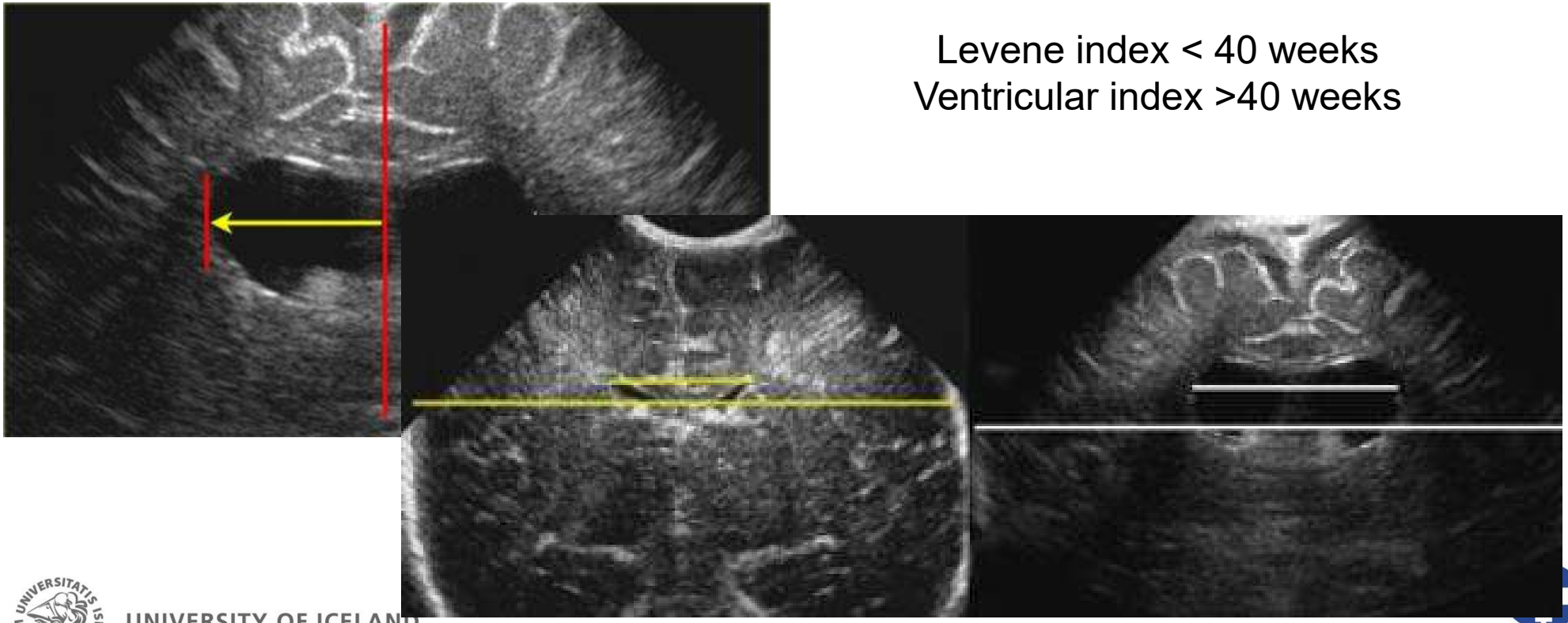
cUS: (dis)advantages compared to MRI

ADVANTAGES	DISADVANTAGES
Bedside-compatible (NICU, neonatal ward)	Operator-dependent (experience & expertise)
No sedation	Small acoustic window
Serial imaging	Assessment of cortical structures, myelination, posterior fossa abnormalities, basal ganglia (hypoxic-ischaemic encephalopathy)
Early imaging	Assessment of diffuse white matter injury
Inexpensive	Assessment of ischemia within 24 hours
Screening	Subtle lesions may be overlooked
Functional imaging (Doppler)	Less reliable in prediction outcome
Detection of lenticulostriate vasculopathy, calcifications, germinolytic cysts	

G. Meijler, Springer-Verlag 2012
De Vries et al., Neuroradiology 2013

Cranial ultrasound: ventricular measurement

Levene index < 40 weeks
Ventricular index >40 weeks



Radiology Assistant, courtesy Erik Beek

Periventricular leukomalacia (PVL)

- Hypoxic-ischemic encephalopathy (HIE) of the preterm, particularly <33 weeks (38% PVL) and <1500 g birth weight (45% PVL)
- White matter disease affecting periventricular zones
- Periventricular zones are watershed zone between deep and superficial vessels
- PVL → increased echogenicity of WM (normally less than choroid plexus)
- Significant part → cerebral palsy, visual or intellectual impairment

Source: Radiology Assistant

Periventricular leukomalacia (PVL)

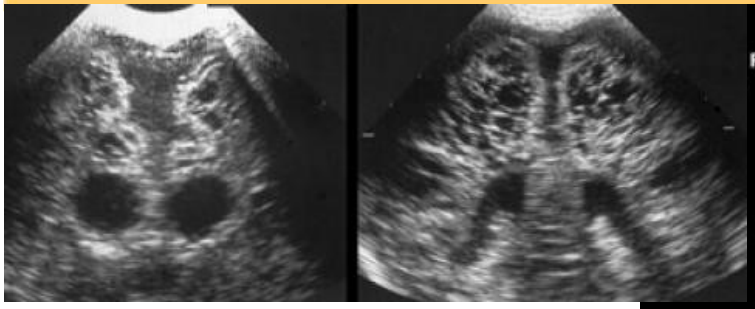
PVL = Increased periventricular echogenicity

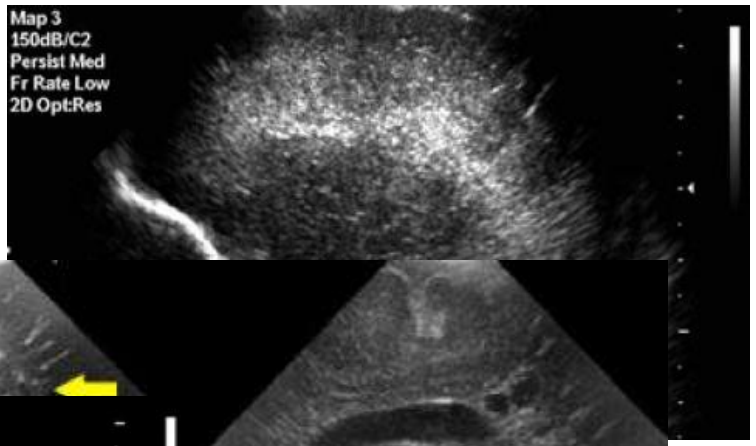
Grade 1. Persisting more than 7 days

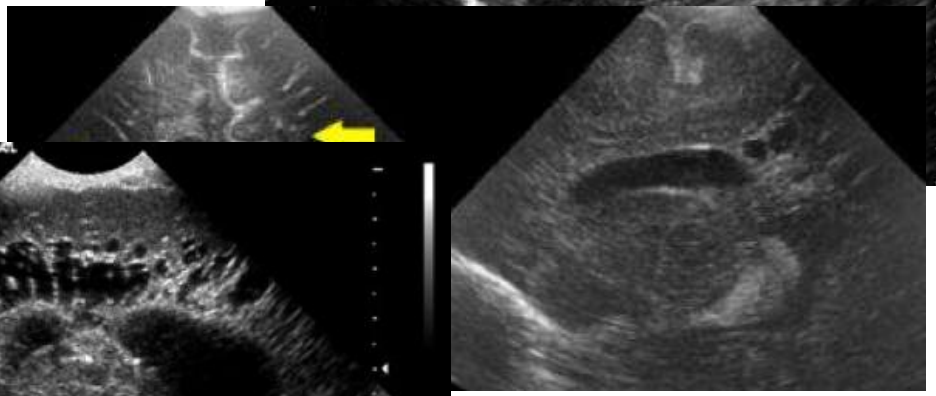
Grade 2. Developing into small periventricular cysts

Grade 3. Developing into extensive periventricular cysts, occipital and fronto-parietal

Grade 4. In deep white matter developing into extensive subcortical cysts







Radiology Assistant, courtesy Erik Beek

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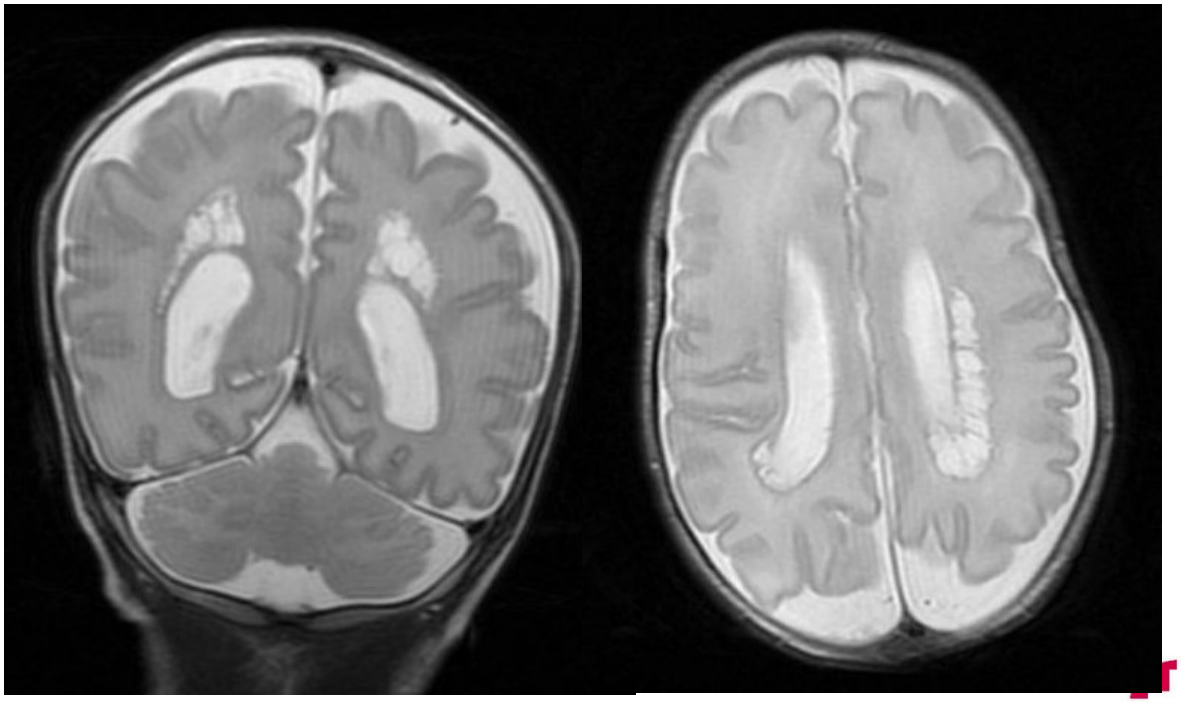
Periventricular leukomalacia (PVL)



Radiopaedia, courtesy Mohammad A. ElBeialy and Hani Makky Al Salam

Germinal matrix hemorrhage (GMH)

- Also periventricular hemorrhage, preterm caudothalamic hemorrhage
- In highly vascular though stress sensitive germinal matrix (area in developing fetal brain: produce neuronal cells that become grey matter)
- Transiently present as region with thin-walled vessels, migrating neuronal components and vessel precursors
- Matured by 34 weeks gestation → bleeding after that age unlikely
- Most GMHs in 1st week of life
- In caudothalmic groove and may extend into lateral ventricles and PV brain parenchyma

Source: Radiology Assistant

Germinal matrix hemorrhage (GMH)

Intracranial hemorrhage

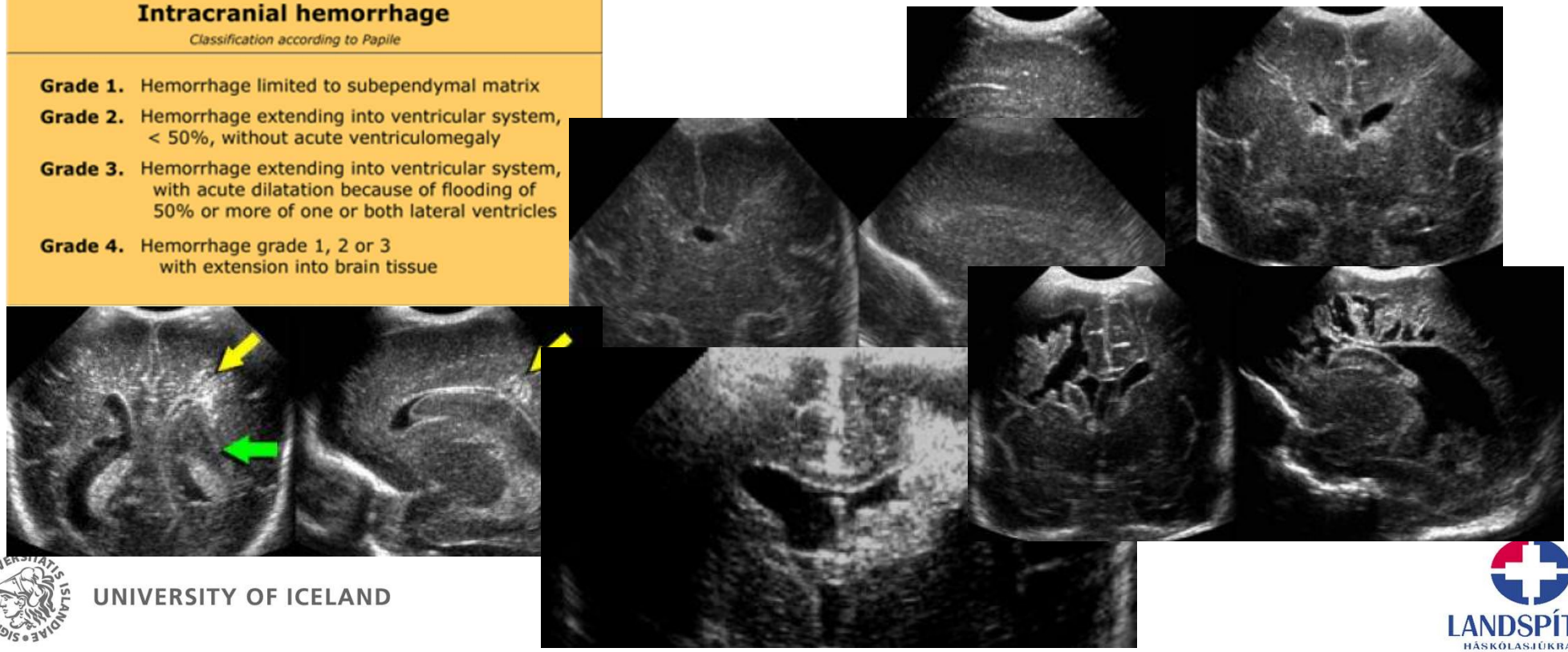
Classification according to Papile

Grade 1. Hemorrhage limited to subependymal matrix

Grade 2. Hemorrhage extending into ventricular system, < 50%, without acute ventriculomegaly

Grade 3. Hemorrhage extending into ventricular system, with acute dilatation because of flooding of 50% or more of one or both lateral ventricles

Grade 4. Hemorrhage grade 1, 2 or 3 with extension into brain tissue



Radiology Assistant, courtesy Erik Beek

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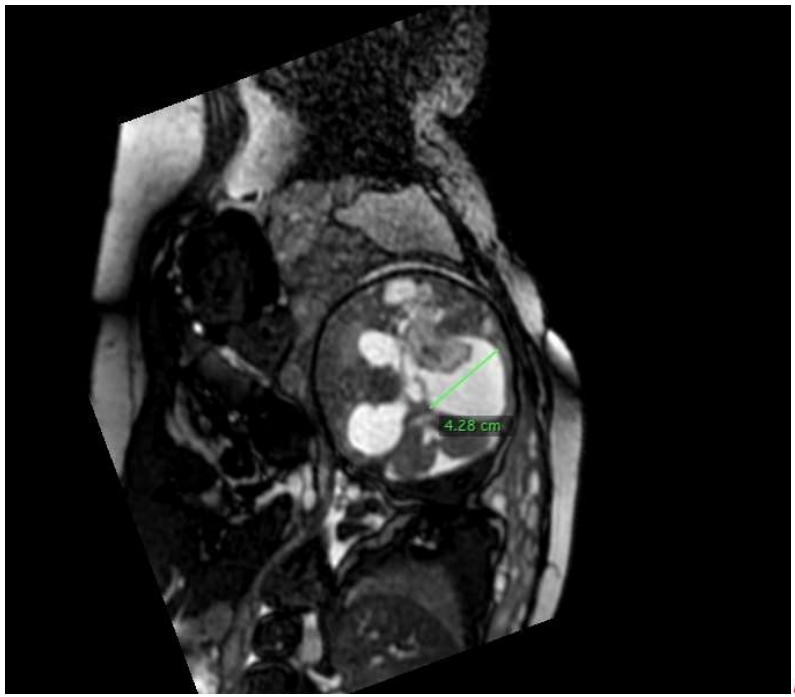
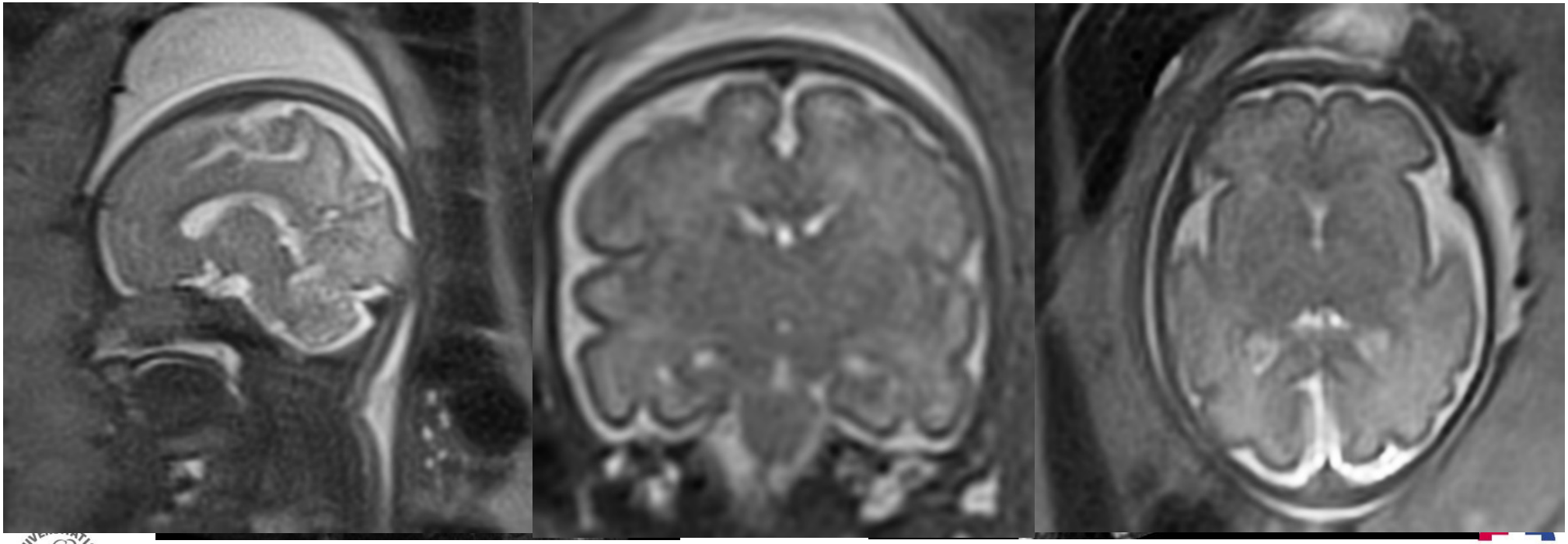
Germinal matrix hemorrhage (GMH)



Radiopaedia, courtesy Ghada Sheta

Fetal MRI

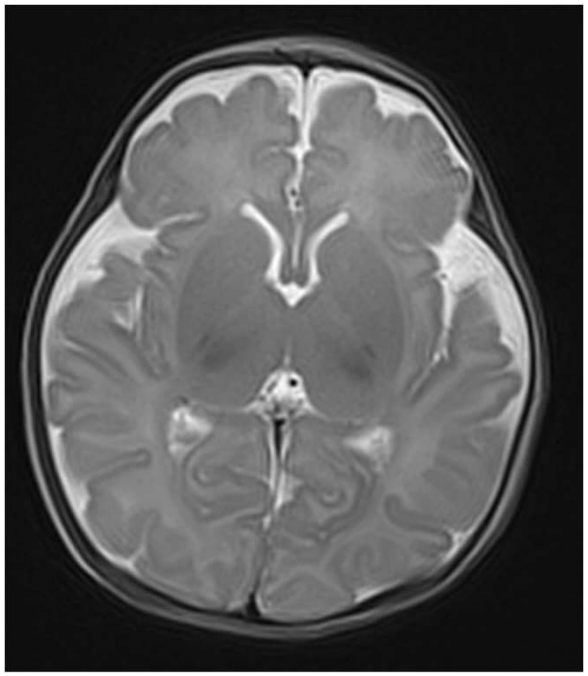


Radiopaedia, courtesy Ghada Sheta, Stacy Goergen and Alexandra Stanislavsky

Fetal MRI

- Imaging the developing fetus in utero
- Commonly used when ultrasound equivocal
- To detect abnormalities for ongoing management or prognostication (including consultation on, f.i., terminating pregnancy)
- Mainly used for CNS:
  - brain abnormalities such as hydrocephalus, holoprosencephaly (monoventricle), callosal agenesis, sulcation and gyration abnormalities, etc.
  - spina bifida
- Other organs can also be assessed

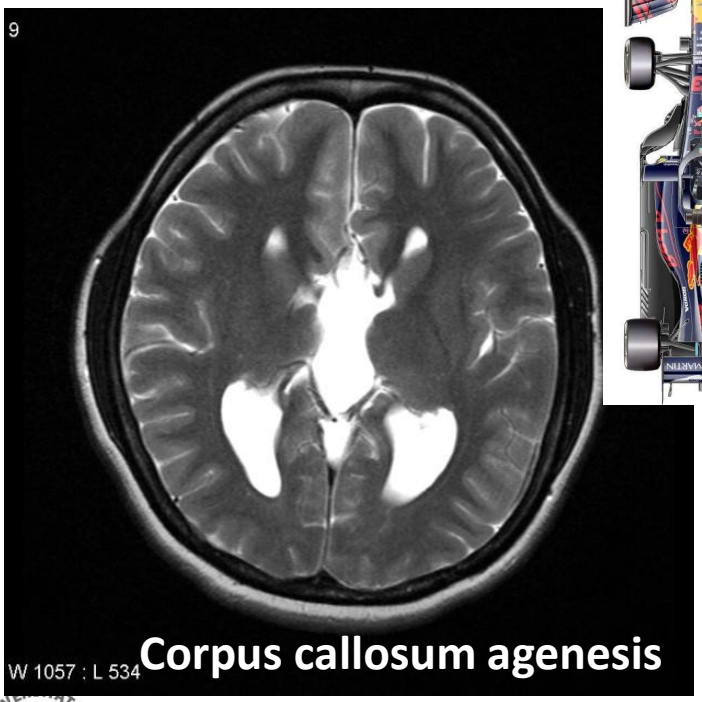
Neonatal and infant MRI



Radiopaedia, courtesy Ian Bickle

- Imaging after birth
- In the early neonatal phase, often in relationship to perinatal events
  - Extensive germinal matrix bleeding (premature)
  - Hypoxic-ischemic encephalopathy
- Slightly later in time
  - Late effects of previous perinatal events (cyst formation)
  - Developmental abnormalties (corpus callosum agenesis, cortical folding or migration abnormalities, etc. etc.)

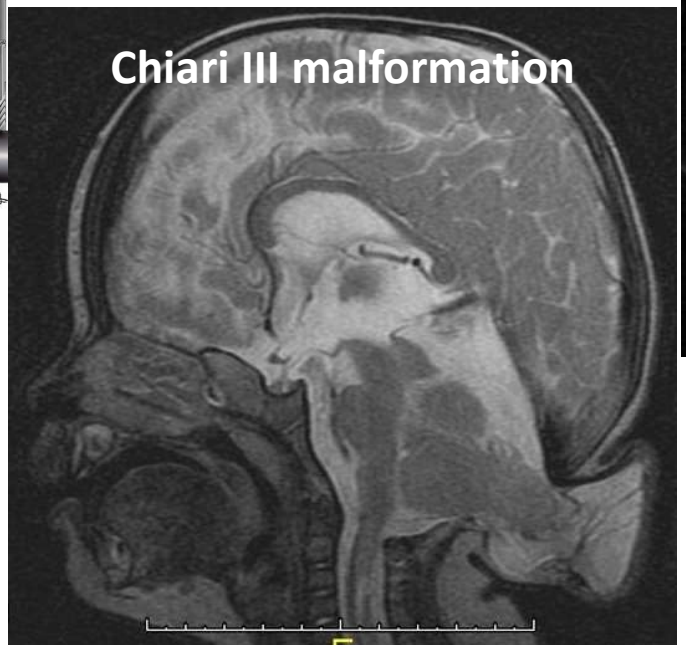
Neonatal and infant MRI



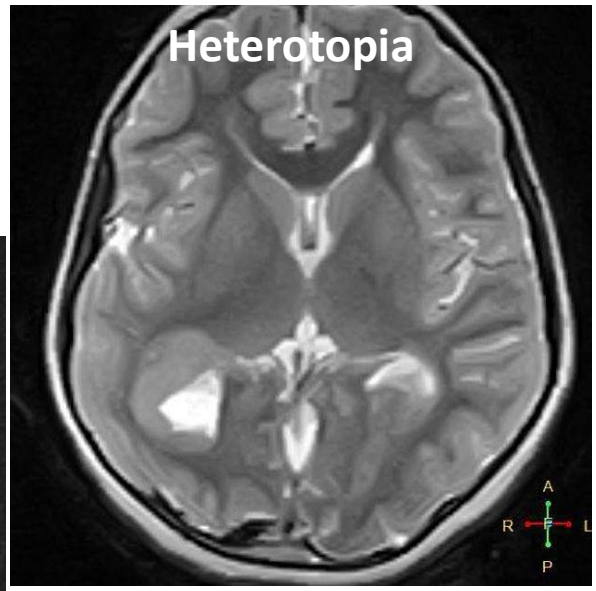
Radiopaedia, courtesy Frank Gaillard

Corpus callosum agenesis

Radiopaedia, courtesy Prashant Gupta



Chiari III malformation



Heterotopia

Radiopaedia, courtesy Heba Abdelmonem

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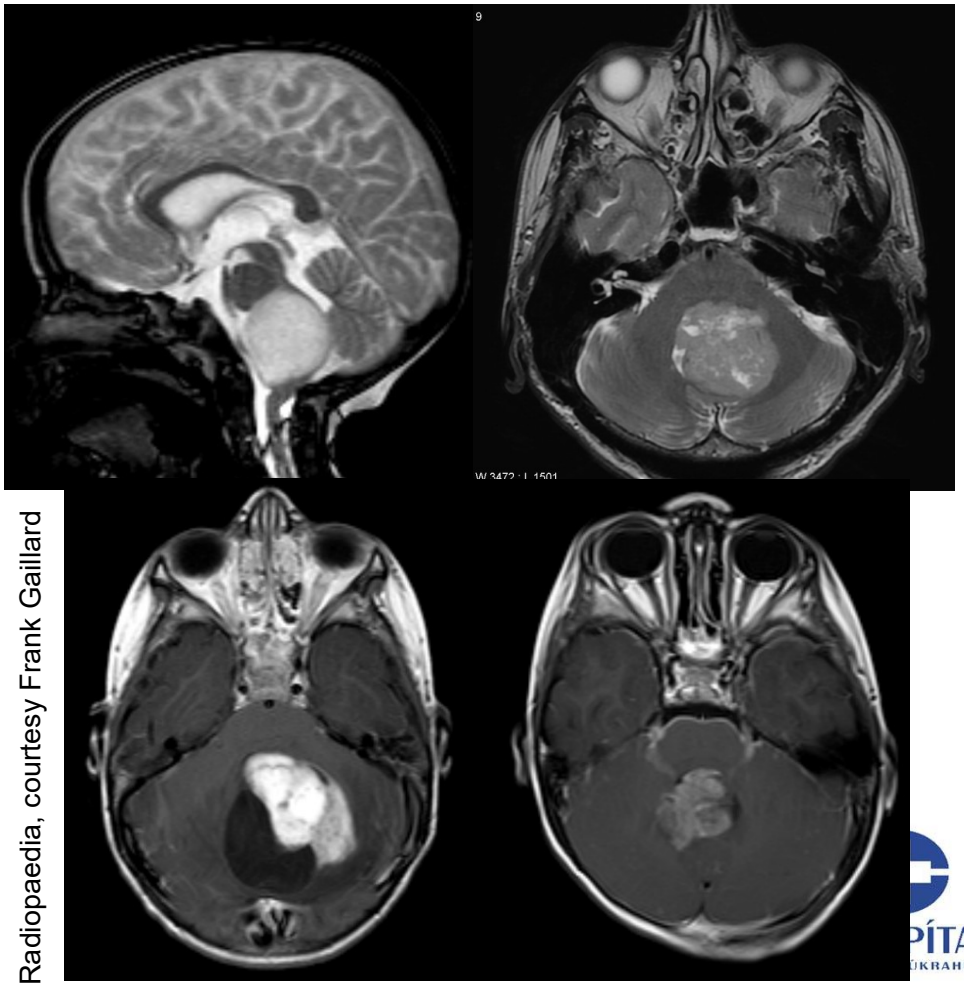
Pediatric MRI

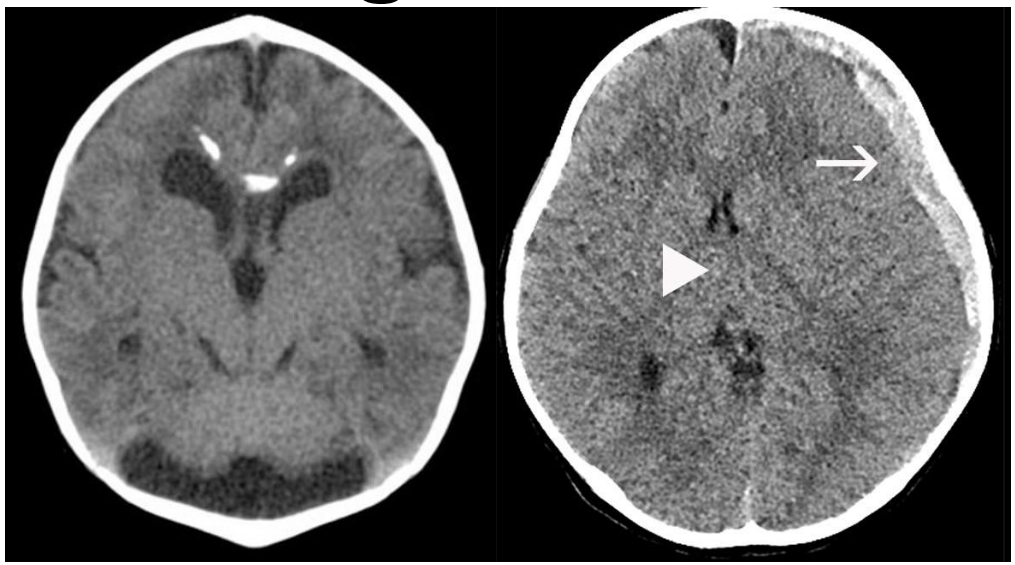
- More often serious pathology
- Brain tumours
  - Supratentorial
  - Infratentorial:
    - **B**rain stem glioma
    - **E**pendymoma
    - **A**strocytoma, pilocytic
    - **M**edulloblastoma

Source: Radiopaedia



Radiopaedia, courtesy Frank Gaillard

Usage of CT in infants and pediatrics?

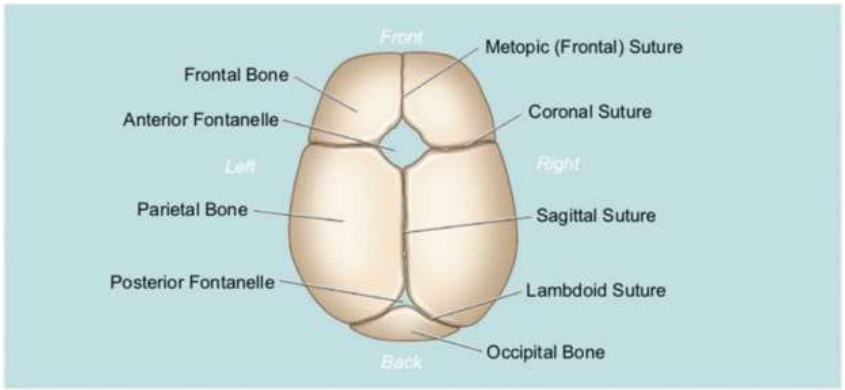


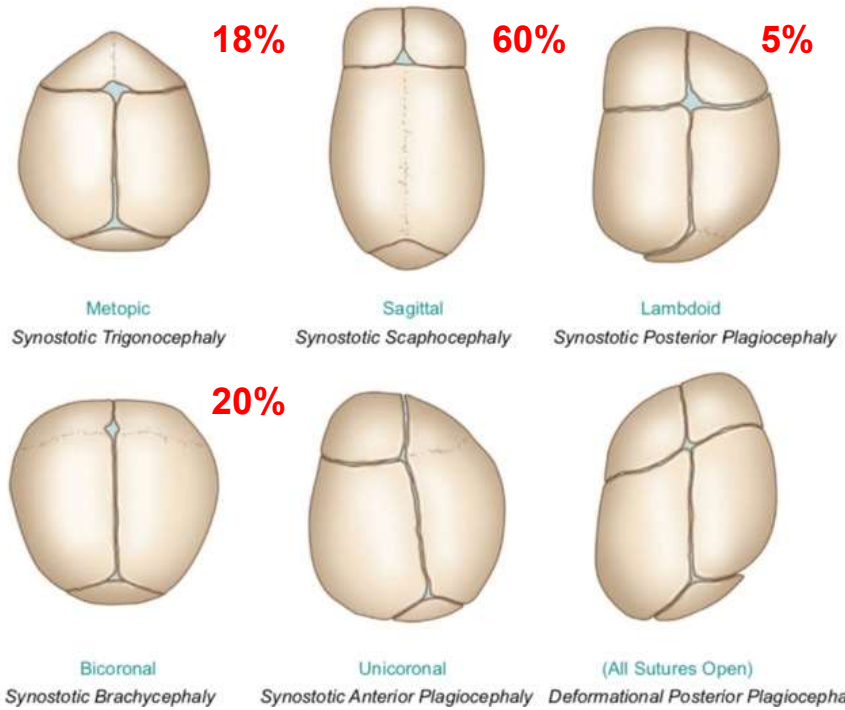
Congenital CMV **Trauma**

- Very limited
- Seldomly for depicting Ca2+ (often assessed by cUS or MRI)
- In urgent setting
  - Trauma → low dose CT to screen for potentially life-threatening injury
  - Skull fractures (think also NAI → child battering!)

Usage of CT in infants and pediatrics?

- Screening for intracranial tumor when clinically suspected and MRI is not readily available
  - Hydrocephalus





Courtesy: Demspey et al., Nonsyndromic Craniosynostosis, Clin Plast Surg 2019

Craniosynostosis

- Premature closure of cranial sutures
- Skull shape undergoes characteristic changes depending on which suture close early
- M:F=3:1
- 1:2000-2500
- Normal closure of largest sutures:
  - Metopic (3-9 months)
  - Anterior fontanelle (18-24 months)
  - Sagittal (22 years)
  - Coronal (24 years)
  - Lambdoid (26 years)

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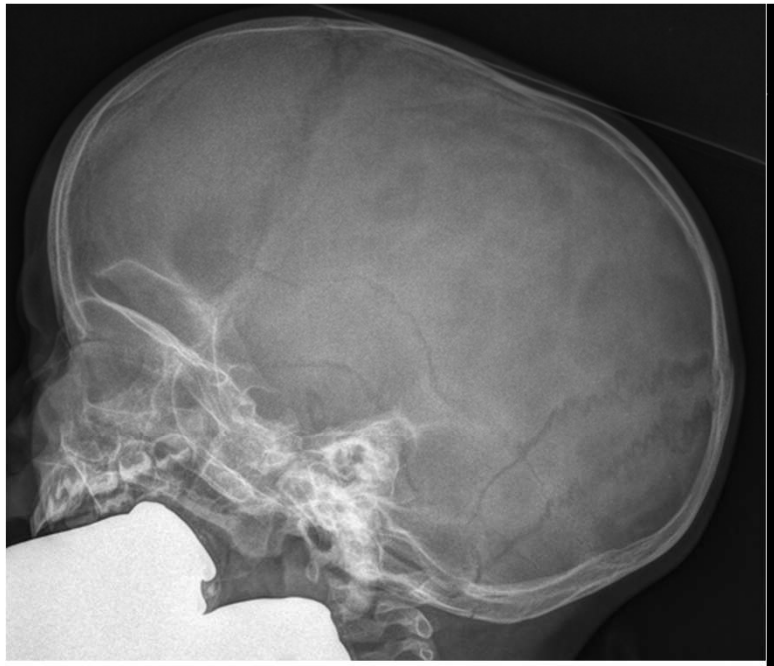
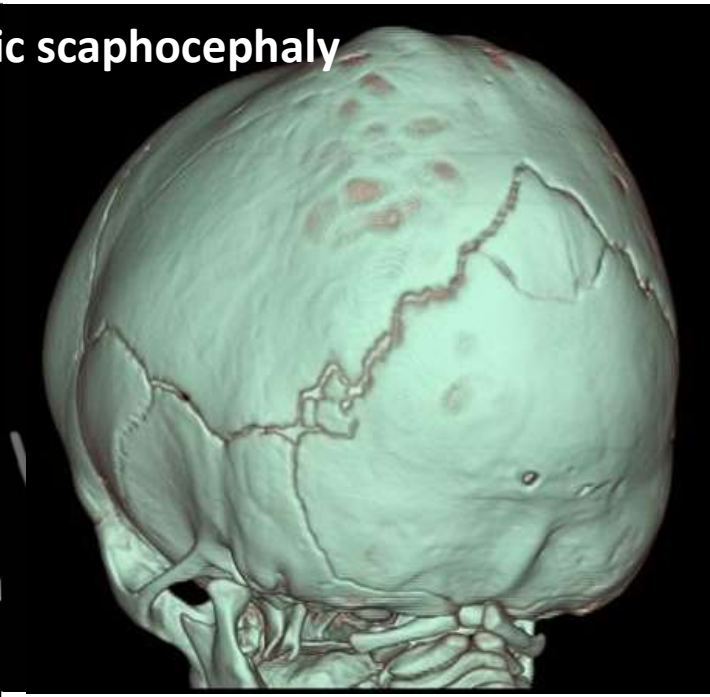
Craniosynostosis



Dolichocephaly

Synostotic scaphocephaly



Radiopaedia, courtesy Fakhry Mahmoud Ebouda

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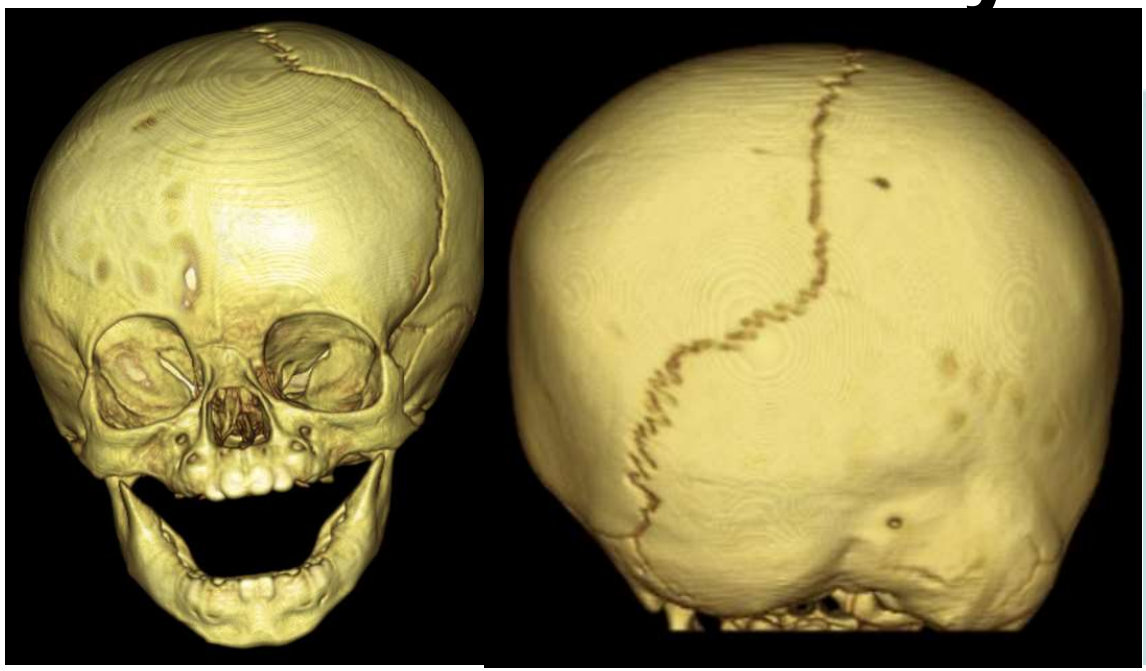
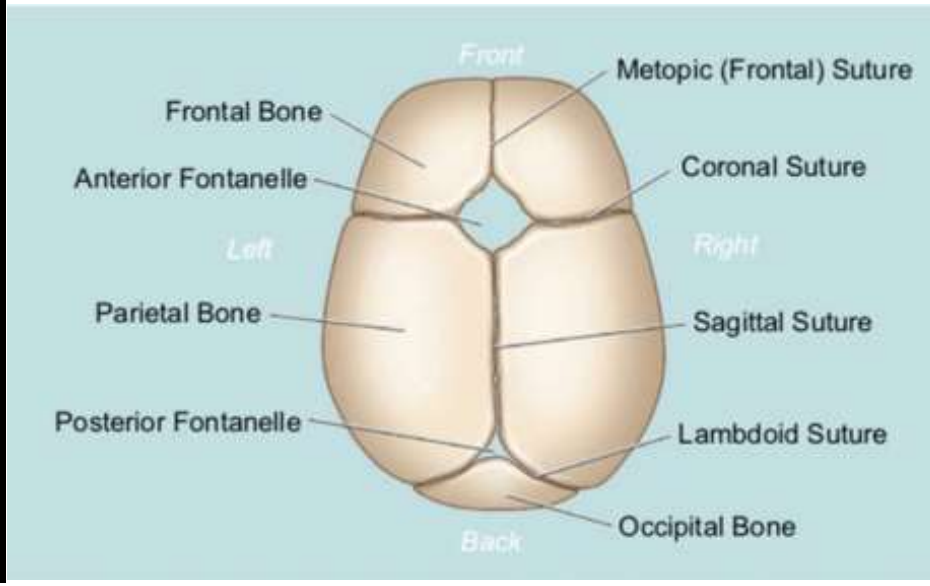
Craniosynostosis



Radiopaedia, courtesy Michael Sargent & Frank Gaillard

Unilateral coronal **Unilateral lambdoid**



Courtesy: Demspey et al.,Clin Plast Surg 2019

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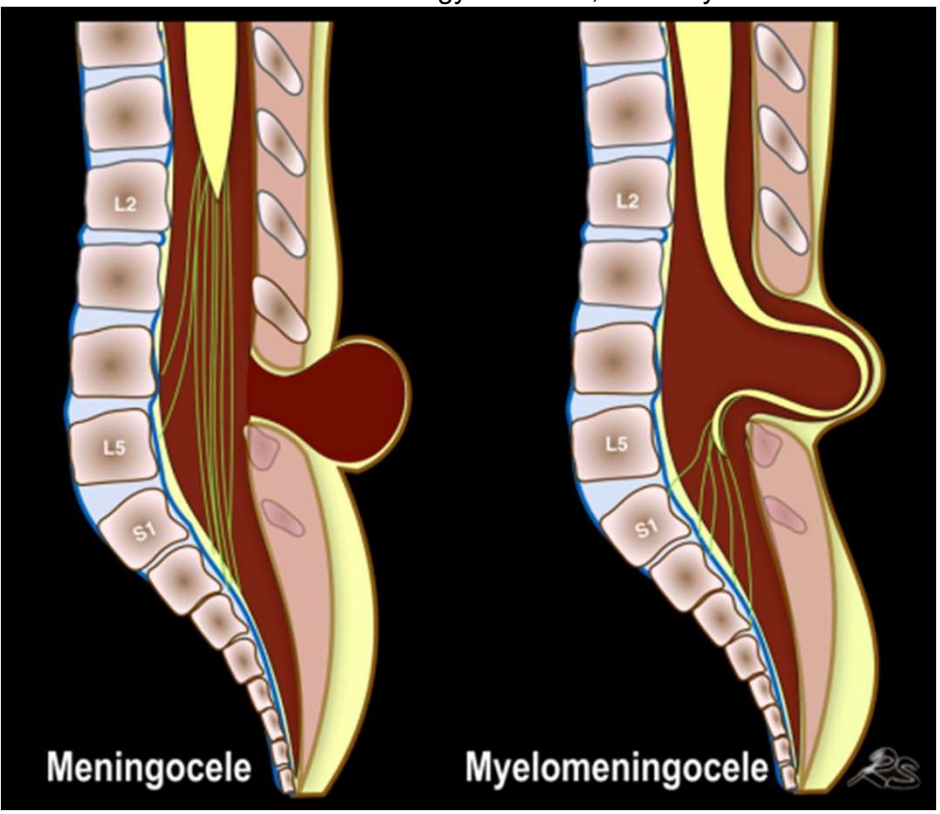
Radiology Assistant, courtesy Robin Smithuis



Spinal dyspraphism

- A.k.a. spina bifida
- Congenital anomaly resulting in defective closure of the neural arch
- Open (spina bifida aperta)
  - Swelling over back
  - May contain meninges and CSF (*meningocele*) or include also parts of spinal cord or nerves (*myelomeningocele*)
  - Further assessment → MRI
- Closed (spina bifida occulta)

Radiology Assistant, courtesy Robin Smithuis

Spina bifida occulta

- Intact covering of the skin
- Anomaly suspected due to skin changes (hair tufts, hemangiomas, pigmented spots, cutaneous dimples, sugcutaeneous mass)
- Commonest form of spina bifida; up to 10-20% of the population
- MRI modality of choice at later pediatric and adult age
- At neonatal age: ultrasound!

Spinal ultrasound

Radiology Assistant, courtesy Robin Smithuis

Tethered cord

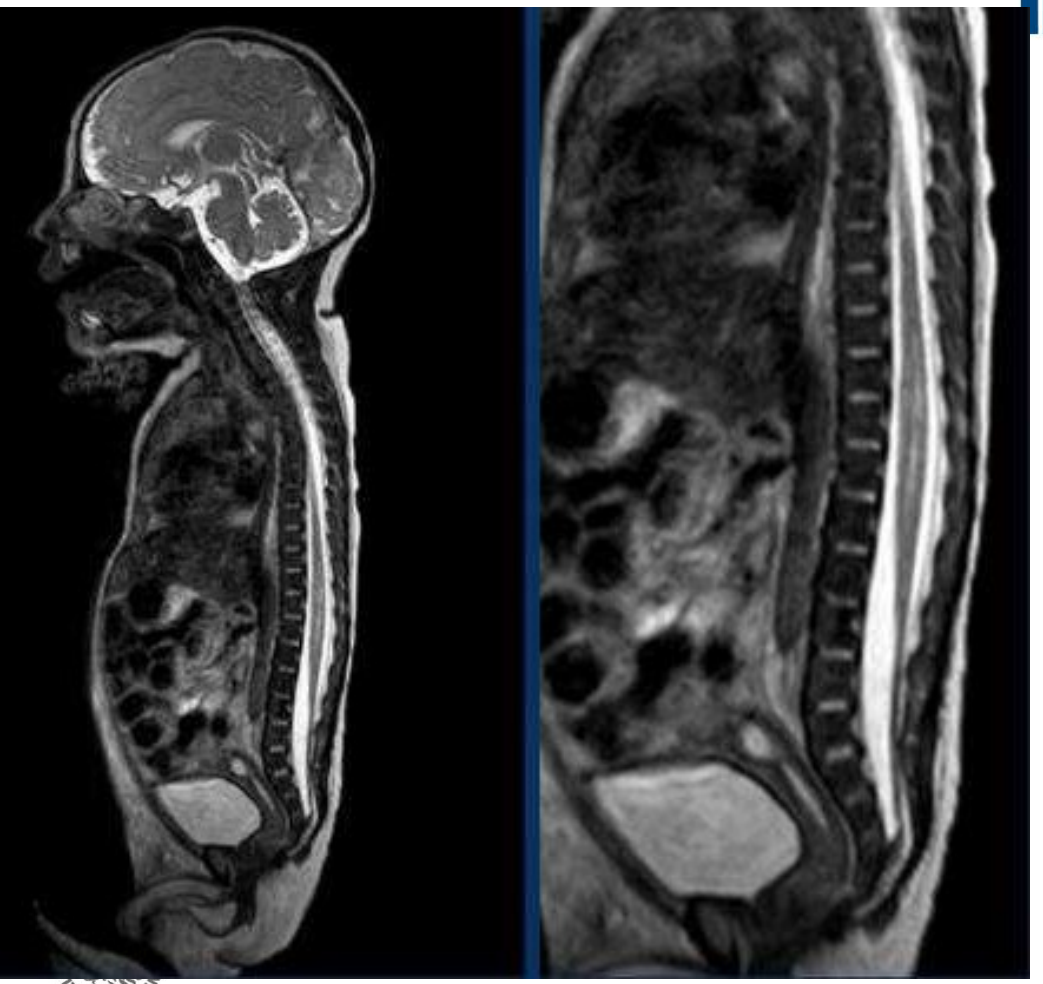
Signs associated with a tethered cord

- Low conus - below the level of L2
- Tickened or tight filum terminale
- Lipoma in the spinal column
- Dermal sinus tract
- Diastematomyelia - split spinal cord
- Restricted movement of the nerve strands

- Occult spinal dysraphism often no symptoms
- If symptoms → often due to tethering cord
- Pathological fixation of the spinal cord in an abnormal caudal location
- Leading to stretching, distortion, ischemia with growth and development

Tethered cord

Radiology Assistant, courtesy Robin Smithuis



Radiology Assistant, courtesy Robin Smithuis

Tethered cord

- MRI shows:
  - Hydromyelia
  - Low ending conus medullaris
  - Thickened filum terminale
- Conus medullaris in healthy newborns normally at L1-L2, should not be below L2-L3

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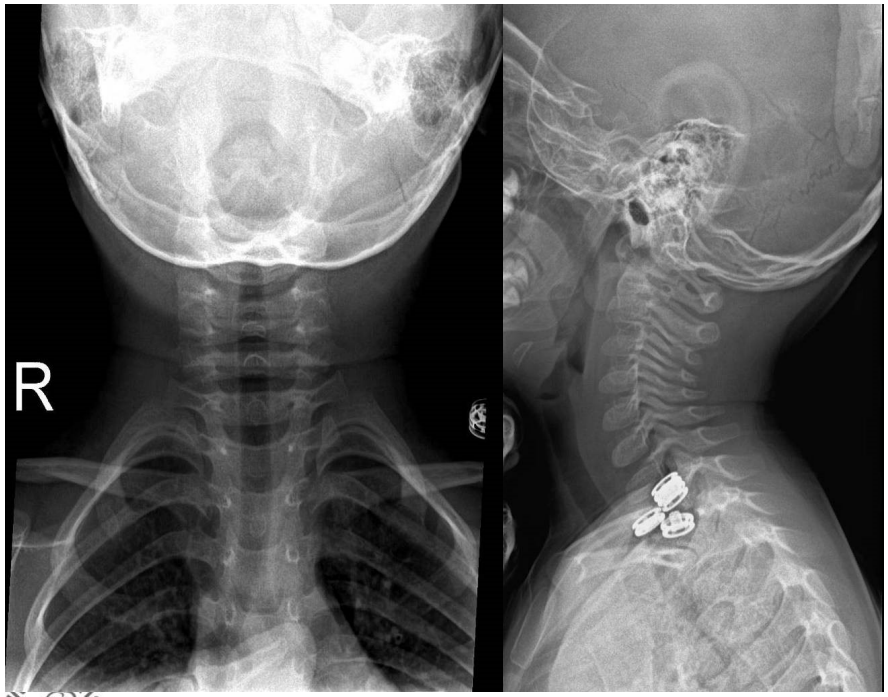
Cervical spine imaging: trauma

- What to do when imaging is required after cervical spinal trauma?
  - In adults? → **CT is primary modality**
  - In children?
    - X-ray
    - CT
    - MRI

Cervical spine imaging: trauma

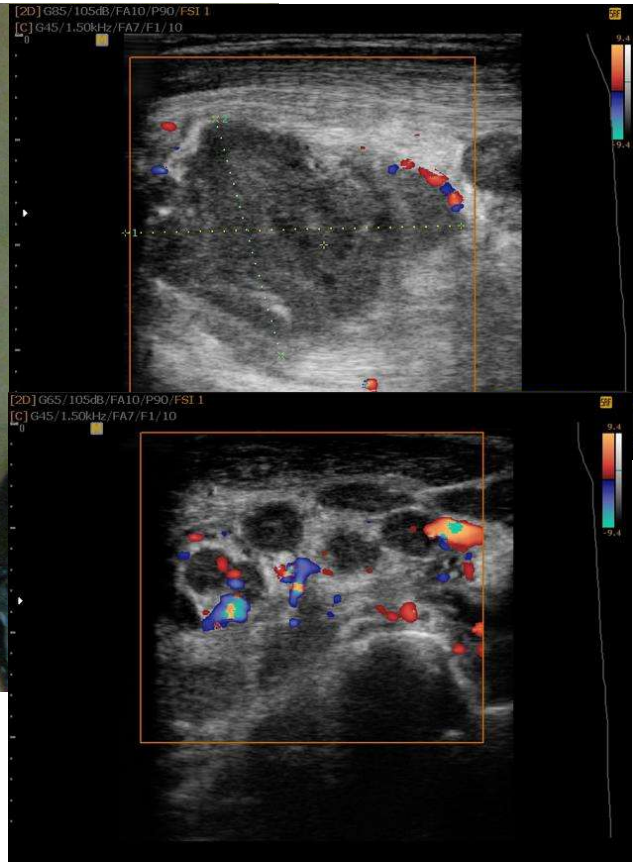


Radiopaedia, courtesy Yair Glick

- Radiation dose for a CT cervical spine in children up to 90-200 times higher than cervical spine X-ray
- Risk of thyroid cancer
- Sensitivity for excluding or detecting of cervical spine injury on X-ray is already very high
- Up to age of 16, start with X-ray, continue with CT if unclear or obvious fracture
- CT in hemodynamically instable patients
- MRI if neurological symptoms

Neck imaging: swelling

Radiopaedia, courtesy Saeed Soltany Hosn



- Unilateral or bilateral
- Painful
- On ultrasound one or more hypoechogenic masses…
- Lymph nodes!!!
- → **Lymphadenitis**
- By far the most common cause for neck swelling in children

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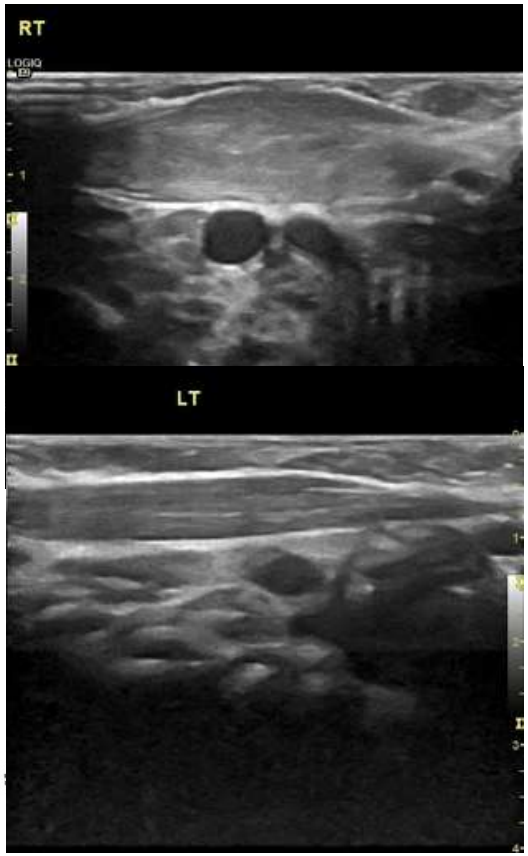
Neck imaging: swelling



Radiopaedia, courtesy Abdulmajid Bawazeer

- Unilateral neck swelling 1-2 months after birth
- Often after complicated vaginal delivery.
- Head tilted towards affected side (torticollis)
- Palpable neck mass

- On US: unilateral thickening of the sternocleidomastoid muscle (right-sided in 73% of the cases for unknown reasons)
- → **Fibromatosis colli**

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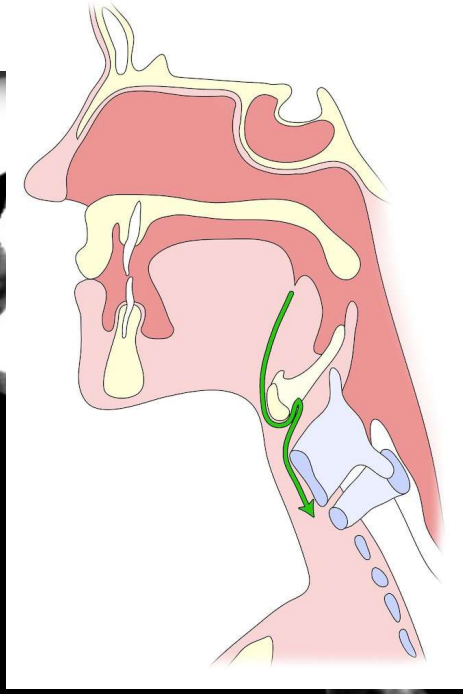
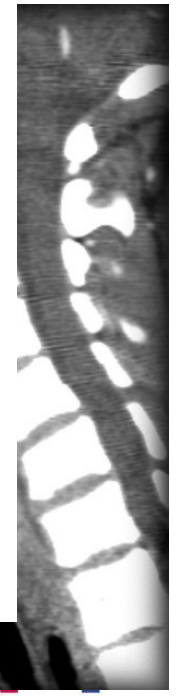
Neck imaging: swelling

Lingual thyroid

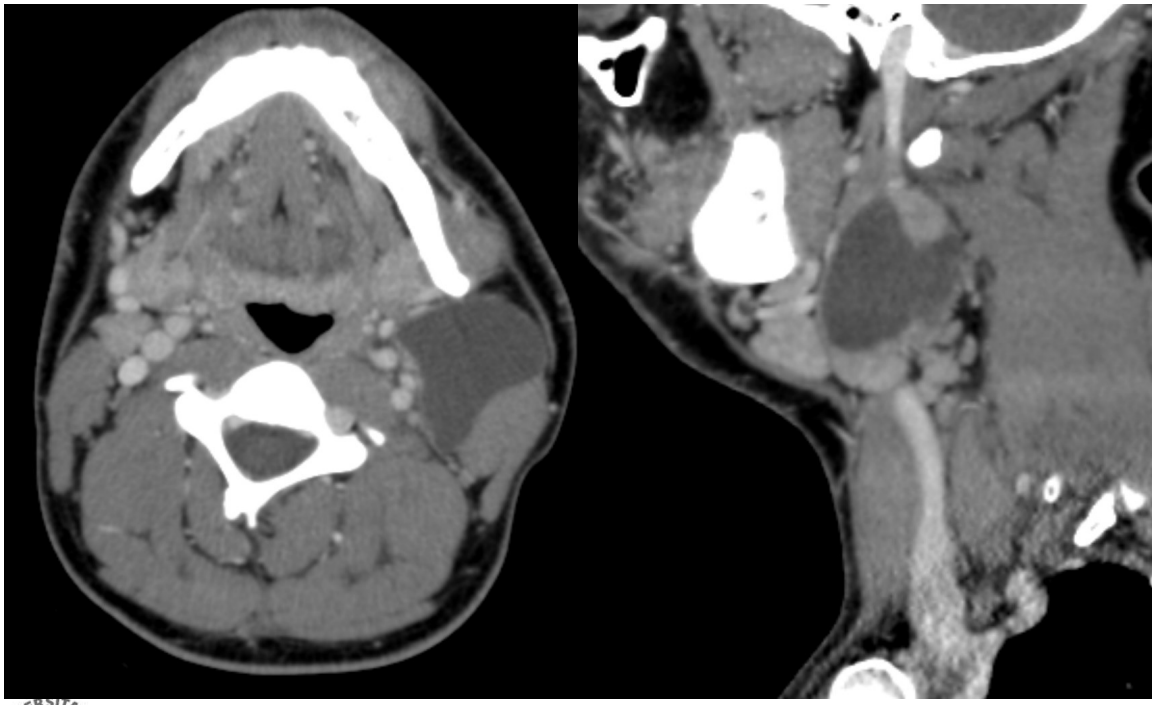
Radiopaedia, courtesy Hidayatullah Hamidi





Radiopaedia, courtesy Frank Gaillard

Neck imaging: swelling

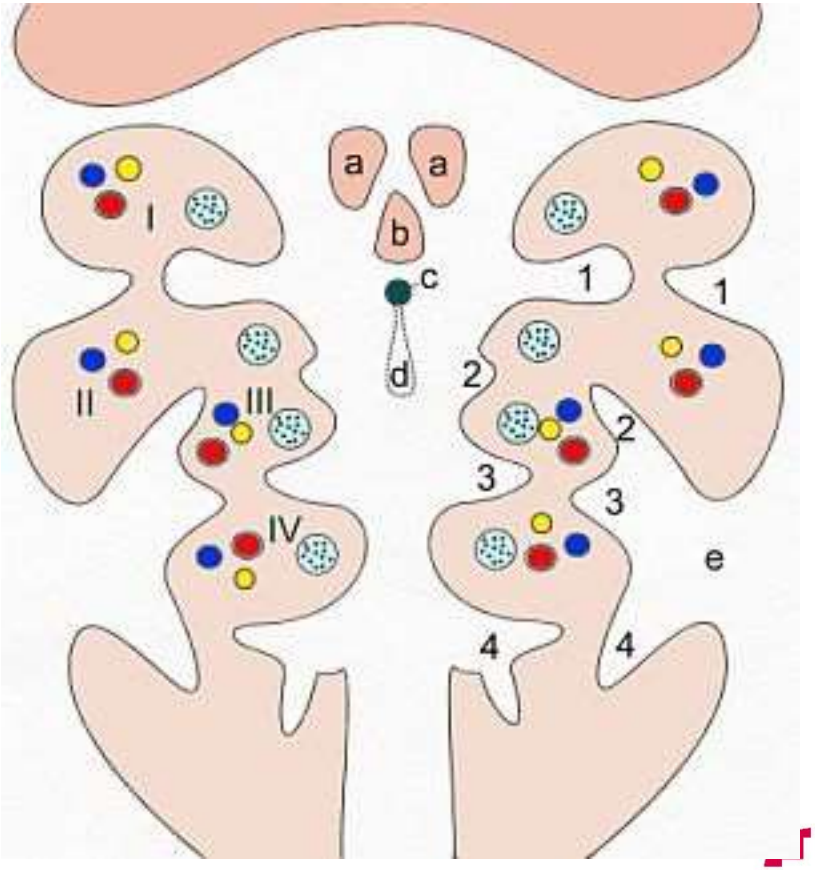


- Recurrent fluctuating unilateral swelling of the neck
- Existing for years
- May or may not get infected
- → **Branchial cleft cyst**

Image courtesy Berit Verbist

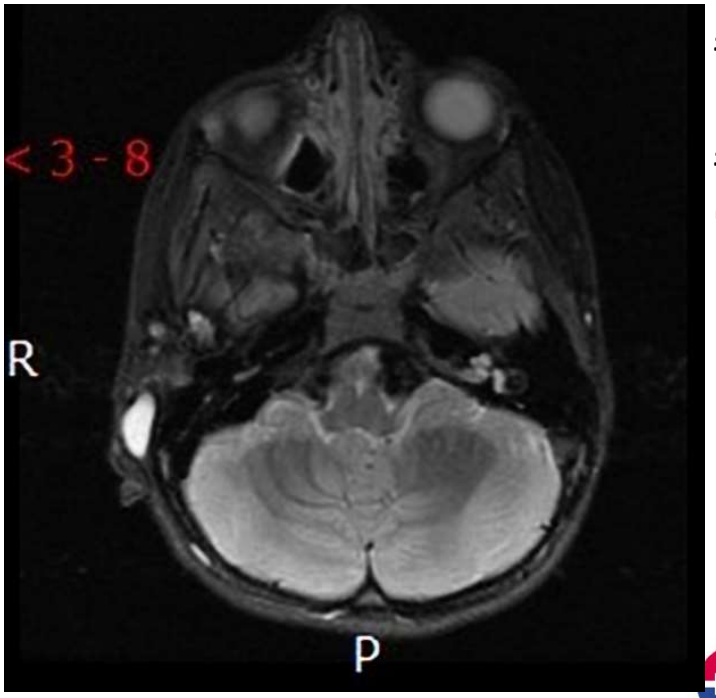
Branchial cleft anomalies

- 6 arches, 5 clefts, 5 pouches
- 2nd arch migrates caudally and covers a.o. 3rd en 4th clefts
- Persisting of cervical sinus of His → branchial cleft anomaly (cyst, fistula, sinus)
- From tragus via the frontal side of the SCM towards the clavicle



Branchial cleft anomalies

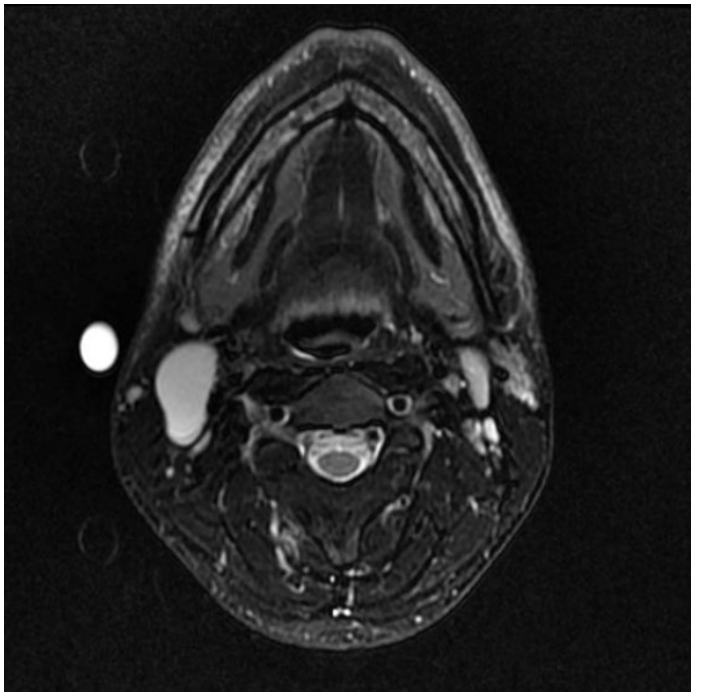
- 1st branchial cleft (5-8%)
  - Presentation: often asymptomatic in middle-aged women; if symtomatic periauricular or intraparotid swelling, chronic otorrhea, recurrent parotid gland abscesses, <10 years
  - *Type 1*: posteroinferior to the auricle
  - *Type 2*: along n. VII into parotid gland
  - *Type 3*: periparotid



Radiopaedia

Branchial cleft anomalies

- 2nd branchial cleft (90-95%)
  - Presentation: painless swelling lateral neck in child or young adult (majority <5 years, second peak 20-40 years)
  - Four types (Bailey classification 1929), type II most prevalent
  - Diagnostic hint: **posterolateral to submandibular gland, lateral to the carotis, anterior to the SCM**, often near the mandibular angle



Radiopaedia

Branchial cleft anomalies

- 3rd branchial cleft (<3%)
  - Presentation: swelling posterolateral neck, often at adult age
  - Location; upper neck posterior cervical space (medial to SCM), lower neck anterior to SCM

- 4th branchial cleft (1-2%)
  - Presentation: recurrent neck abscesses, recurrent suppurative thyreoiditis, fluctuating swelling, mostly at pediatric age (F>M)
  - Location: inferior 1/3 part of the neck posteromedial to SCM, more often on the left

Questions?