Reading Abdominal X-rays and Head CTs

National Pediatric Nighttime Curriculum

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Learning Objectives

- Develop a standard approach to reading abdominal radiographs and head CTs.
- Compare and contrast signs of small and large bowel obstruction on abdominal radiographs.
- Recognize 2 signs on head CT concerning for increased intracranial pressure.

Case 1

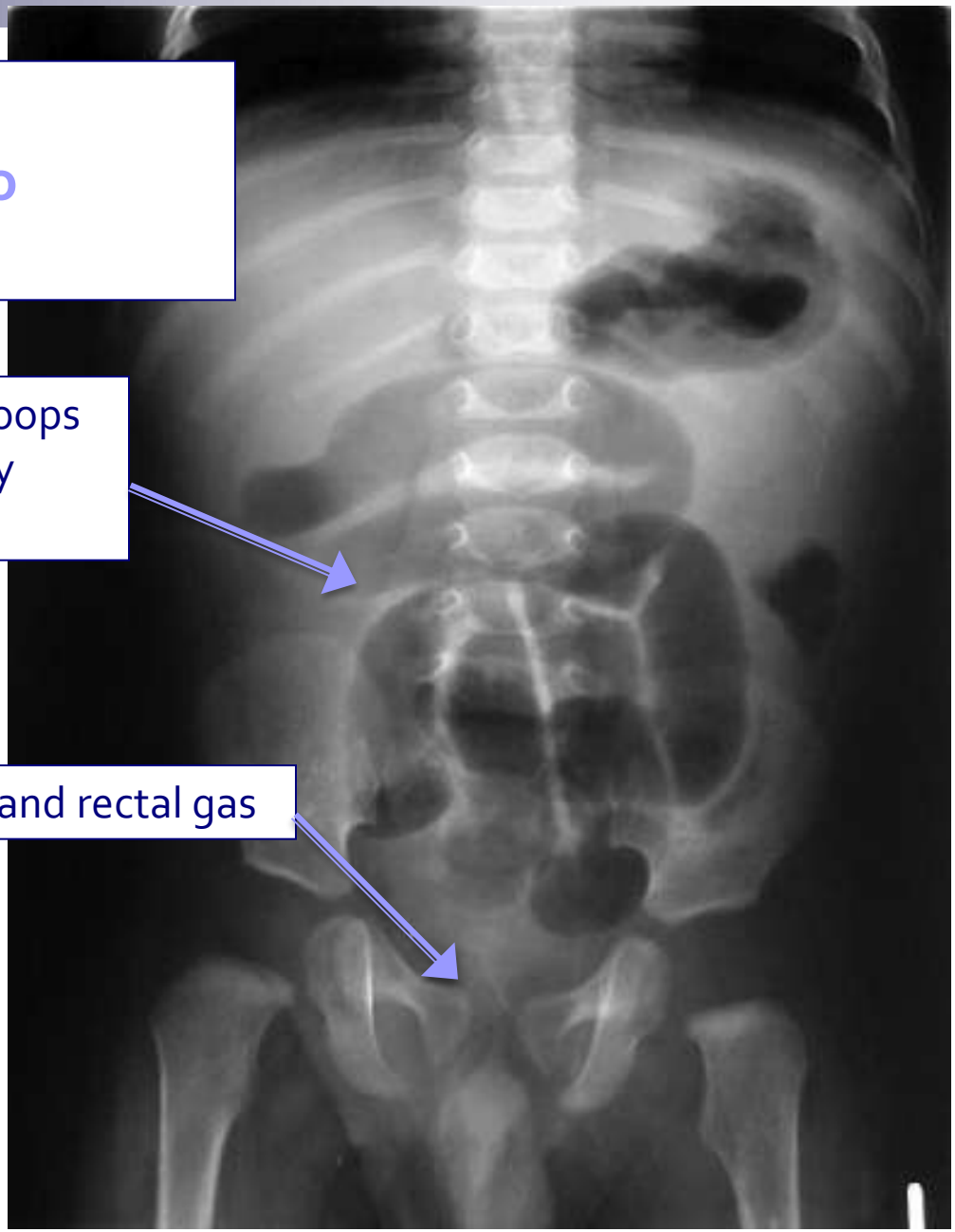
- You admit a 10 month old boy with one day of abdominal pain and non-bilious vomiting. He is unable to tolerate oral feeds, and he is receiving parenteral fluids. The nurse pages to tell you that he has acutely gotten very fussy and appears to be in pain.
  - What is your differential diagnosis?
  - What further questions should you ask?
  - What physical exam findings will cause you concern?
  - What imaging modality would you choose to further assess?

You order a standard abdominal radiograph:

Is this normal or abnormal?
What is your diagnosis?
What specific findings led you to this diagnosis?

Image from Ref: 11

Small Bowel Obstruction (in this case, secondary to Intussusception)



Dilated small bowel loops (many loops, centrally located)

Minimal colonic and rectal gas

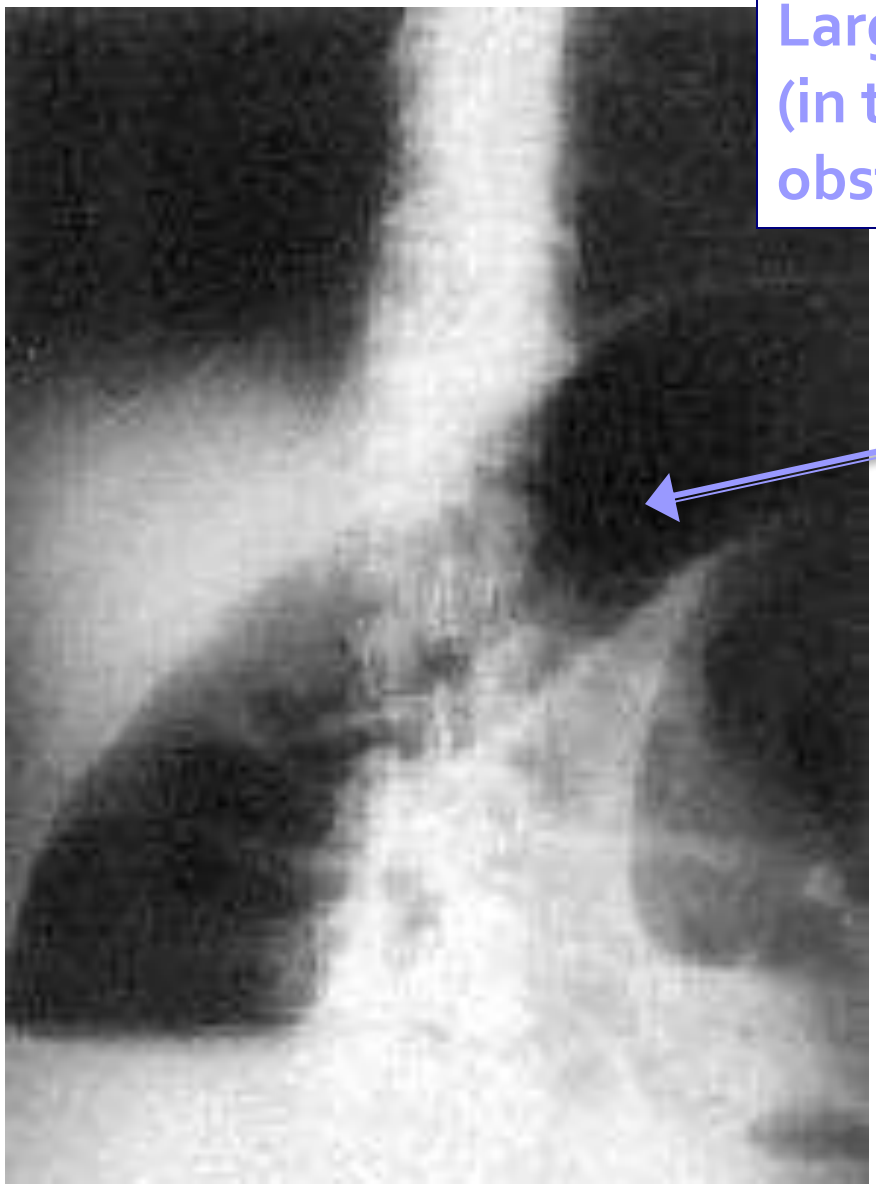
Image from Ref: 11

Small vs. Large Bowel Obstruction

Feature	Small Bowel	Large Bowel
Bowel diameter (in adults)	> 3 cm	> 5 cm
Position of Loops	Central	Peripheral
Number of Loops	Many	Few
Fluid Levels (on erect film)	Many, short	Few, long
Abdominal Markings	Valvulae (all the way across)	Haustra (partially across)
Gas in Large Bowel	No	Yes

Ref: 12, 18

Large Bowel Obstruction (in this case, secondary to obstipation)



Dilated large bowel loops (few loops, peripherally located)

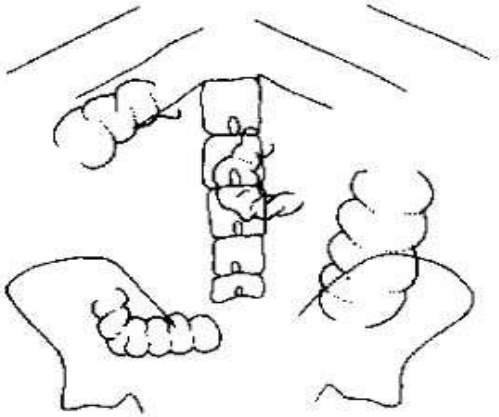
Image from Ref: 12

Abdominal X Rays: The Basics

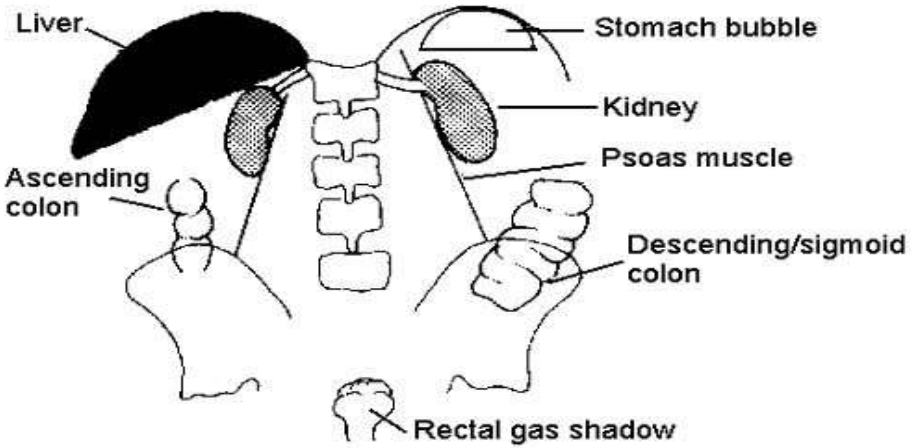
- Standard AXR or "KUB":
  - Large radiation exposure (equivalent to 30-50 chest x-rays)
  - Anteroposterior projection, patient is supine
  - Should include lower ribs and their articulations, lower thoracic and lumbar spine, bony pelvis, proximal femora

- 4 densities:
  - Black = air
  - White = calcified structures
  - Gray = soft tissues
  - Darker Gray = fat
  - Metallic objects appear intense bright white

Normal Abdominal Anatomy



Plain abdo film (structures visible)



Ref: 23

Approach to Interpreting Abdominal X Rays

- Intraluminal gas
- Extraluminal gas
- Calcifications
- Bones and Soft Tissues
- Artifacts

Ref: 17

Intraluminal Gas

- Amount and distribution of gas in the bowels
- Size and distribution of bowel loops
- Fecal matter
  - gas-liquid-solid mixture
  - mixture of gray densities giving mottled appearance

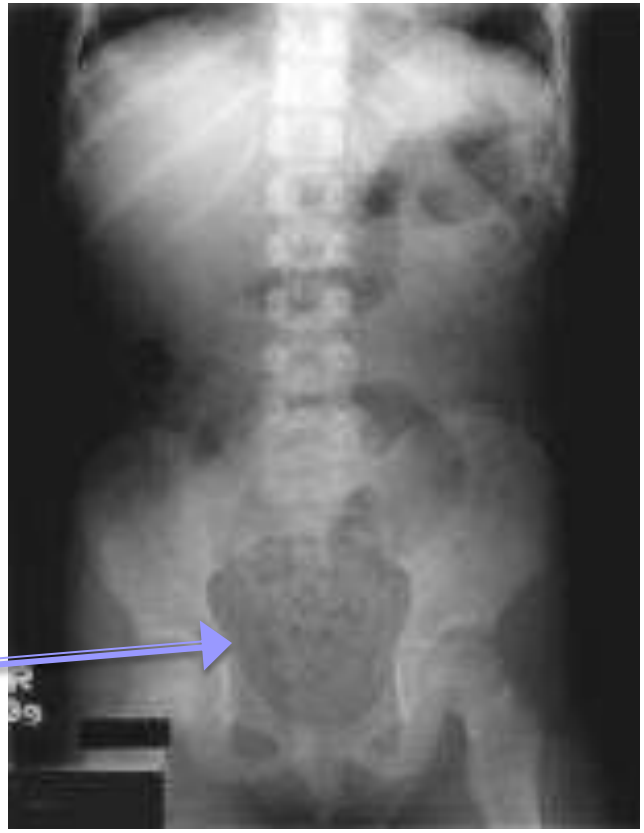
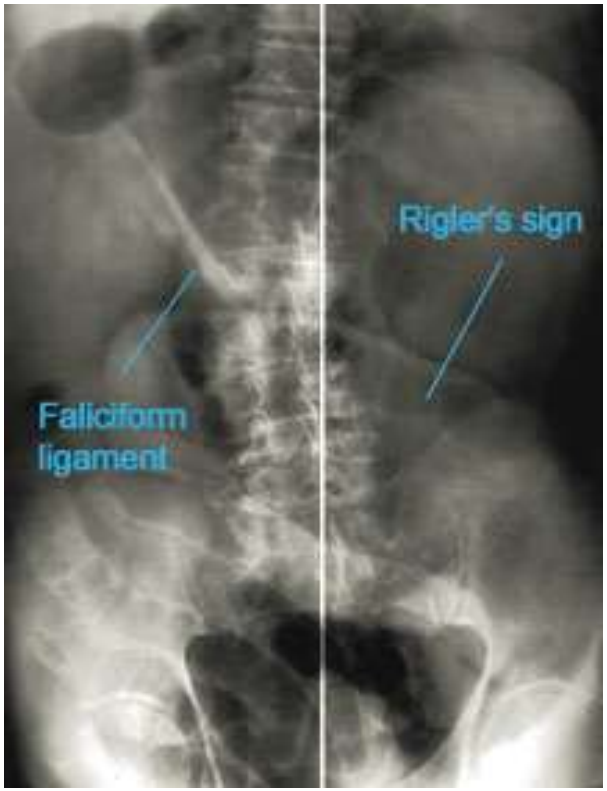
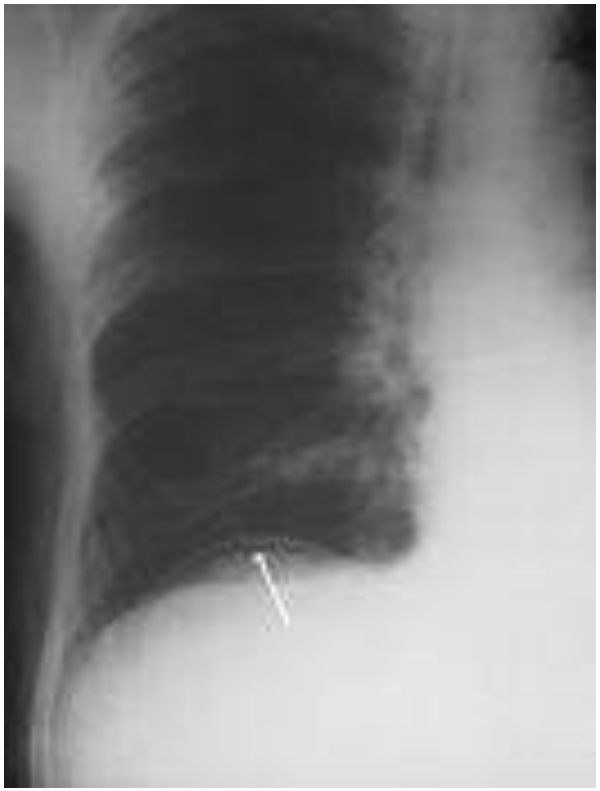


Image from Ref: 13

Extraluminal Gas



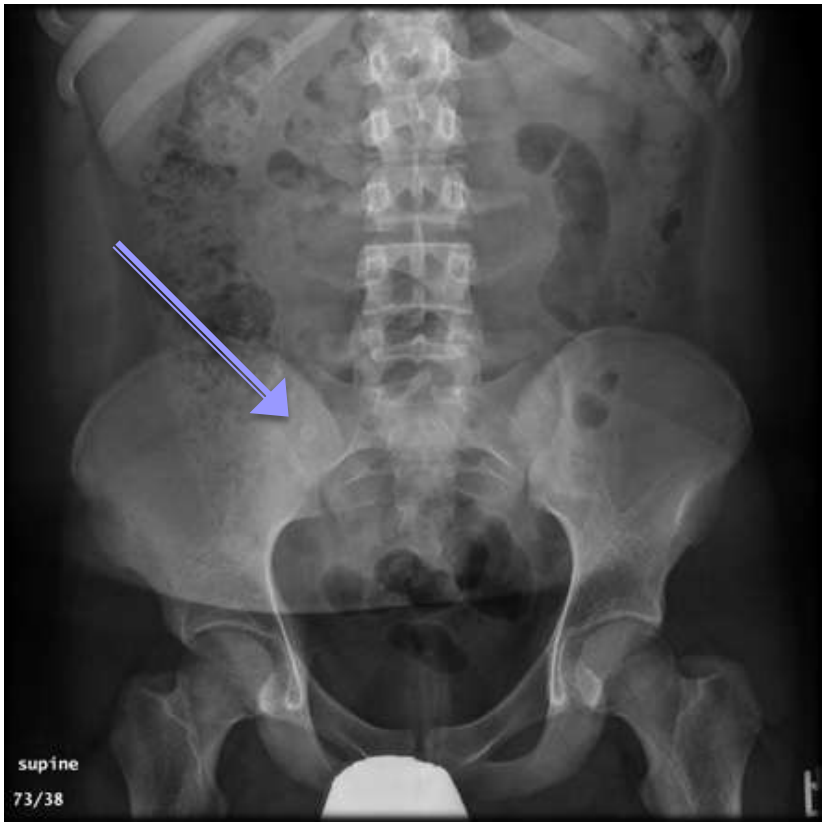


Pneumoperitoneum tends to occur after a perforated abdominal viscus. AXR (left) may reveal the falciform ligament sign, an outlining of the ligament by free air from its origin in the RUQ to its termination at the umbilicus. Rigler's sign occurs when free air outlines serosal surfaces of bowel wall. Pneumoperitoneum is sometimes easiest to see on an upright CXR, under the right hemidiaphragm (right).

Ref: 14, 19

Calcifications

- Calcium *indicates* underlying pathology:
  - Pancreas
  - Renal parenchyma
  - Blood vessels and vascular aneurysms
- Calcium *is* the underlying pathology:
  - Renal calculi
  - Biliary calculi
  - Appendicolith
  - Bladder calculi
  - Teratoma



Appendicolith

Ref: 15, 21

Bones and Soft Tissues

Wilm's Tumor

- Bones
  - Mineralization
  - Fractures or Joint Pathology
  - Sclerotic or Lytic lesions
- Soft tissues
  - Size and shape of organs
  - Fat lines

Ref: 16, 20

Artifacts

Artifacts are objects that appear incidentally, or as a result of iatrogenic placement or accidental ingestion. They can be inside or outside of the patient's body.

Ref: 22

Case 2

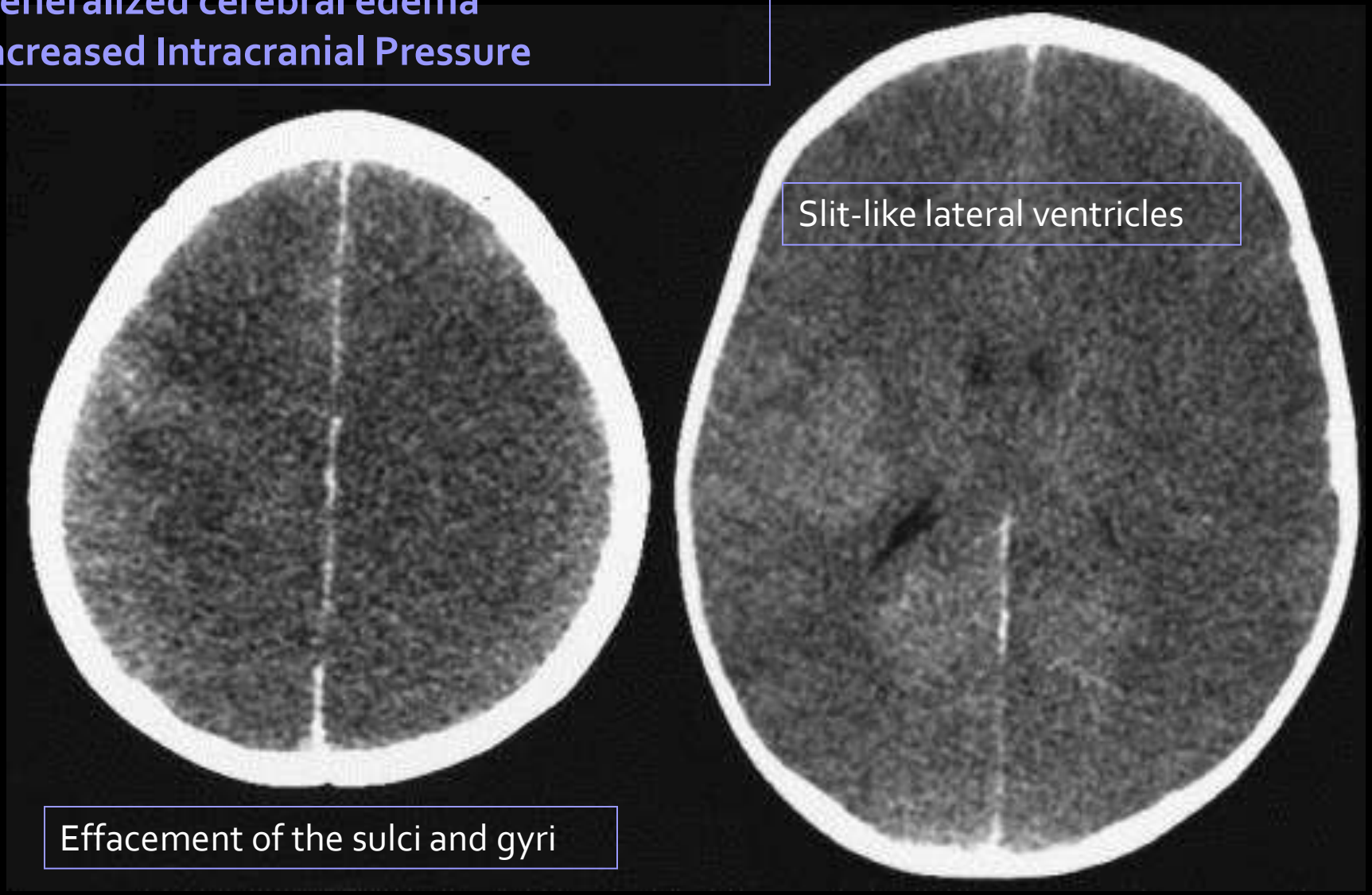
- You admit a 9 year old female with new-onset diabetes mellitus. She is on insulin and receiving IVF. You get called by the nurse 6 hours later because the patient is complaining of a severe headache and acting "kind of sleepy."
  - What is your differential diagnosis?
  - What further questions should you ask?
  - What physical exam findings will cause you concern?
  - What imaging modality would you choose to further assess?

You order a plain head CT:

Is this normal or abnormal?
What is your diagnosis?
What specific CT findings lead you to this diagnosis?

Images from Ref: 10

Generalized cerebral edema
Increased Intracranial Pressure



Slit-like lateral ventricles

Effacement of the sulci and gyri

Effacement and compression of the quadrigeminal cistern

Poor grey-white matter differentiation

Alternatively, CT findings suggestive of Increased Intracranial Pressure in setting of Hydrocephalus

Effacement of the sulci, gyri, cisterns

Increased size of ventricles

Poor grey-white matter differentiation

Effacement and rounded shape of ventricles

Left: Baseline CT in a child with VP shunt;
Right: CT in same child presenting with headache and vomiting, found to have shunt malfunction

Ref: 8

Head CTs: the basics

- What types of head CTs can you order? What information do they tell us?
- What clinical situations may lead you to order an emergent head CT at night?
- Non-contrast:
  - Cerebral edema (generalized or focal)
  - Herniation
  - Ventricle size (increased in hydrocephalus, slit-like in cerebral edema)
  - Mass effect
  - Hemorrhage
  - Bones – fractures
  - Other – sinus and mastoid air spaces, orbits, soft tissue
- Contrast:
  - Inflammation
  - Infection (intraparenchymal, meningeal, extra-axial)
  - Neoplastic processes
  - Abnormal vascular structures (AVM, aneurysm, thrombosis)

Approach to Reading Head CTs

- Midline and symmetry
  - The brain is a symmetrical structure
  - Asymmetric findings are abnormal
  - Shifts across midline suggest displacement by abnormal structure or volume
- Brain window
  - Better detail of brain parenchyma, soft tissue, hemorrhages, CSF spaces
  - Bone detail is obscured
  - CSF and air are black
  - Blood, bone and other calcifications are white
- Bone window
  - Better visualization of bony structures

Approach to Reading Head CTs

Figure 3.
Association of each word in the mnemonic Blood Can Be Very Bad with corresponding emergency

Blood Can Be Very Bad

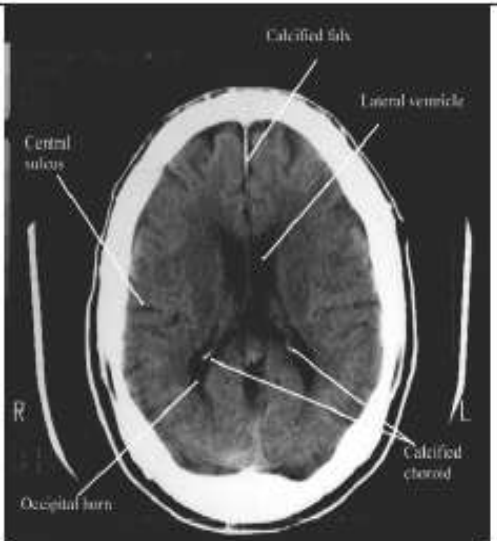
- **Blood:** Acute blood is bright white on CT. Types include:
  - EDH (lens-shaped)
  - SDH (sickle-shaped)
  - Intraparenchymal (especially basal ganglia)
  - Intraventricular (watch for hydrocephalus)
  - SAH (blood in cisterns)
- **Cisterns (Can):** CSF collections jacketing the brain. Look for blood in cisterns (SAH), and effacement (increased ICP). 4 key cisterns:
  - Circummesencephalic (ring around midbrain)
  - Suprasellar (star-shaped) Circle of Willis
  - Quadrigeminal (W-shaped)
  - Sylvian (between temporal and frontal lobes)
- **Brain (Be):** Look for:
  - Symmetry
  - Gray-white differentiation
  - Shift
  - Hyper/hypodensity
  - Pneumocephalus
- **Ventricles (Very):** CSF produced in lateral ventricles (back-to-back comma) → III ventricle (slit-shaped) → aqueduct of Sylvius → IV ventricle (helmet-shaped). Approximately 20 mL/h. Look for:
  - Effacement
  - Shift
  - Blood
- **Bone (Bad):** Note soft tissue swelling. Look for blood in sinuses/mastoid air cells, widened sutures.

EDH, Epidural hematoma; **SDH**, subdural hemorrhage; **SAH**, subarachnoid hemorrhage; **CSF**, cerebrospinal fluid; **ICP**, intracranial pressure.

- Developing a systematic approach to interpreting head CTs will help you remember to look at all structures and miss less findings.
- This mnemonic has been validated in Emergency Medicine residencies to help improve their ability to interpret head CTs (Perron AD, Huff JS et al).
- Reviewing and understanding basic neuroanatomy is helpful.

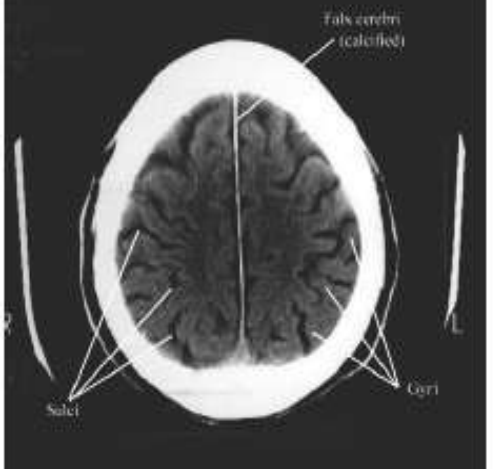
Ref: 5

Normal Neuroanatomy Highlights



Upper Cortex

- Gray-white differentiation
- Lateral ventricles
- Calcified choroid/pineal
- Cortical gyral/sulcal pattern



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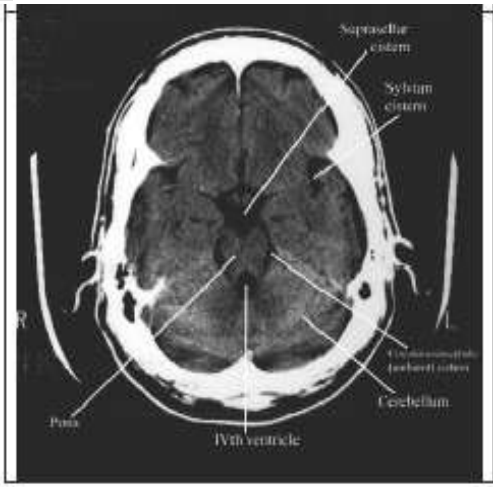
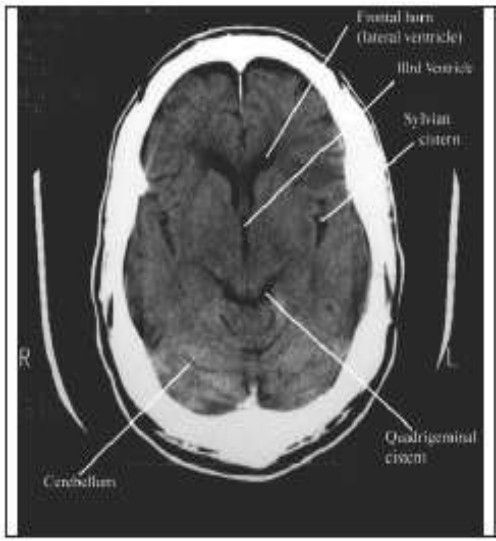


Cerebral Peduncles (2nd Key Level)

- Circle of Willis
- Suprasellar Cistern
- Circummesencephalic cistern
- Clinoids (+/-)
- Sylvian cistern
- Temporal fossa
- IVth Ventricle



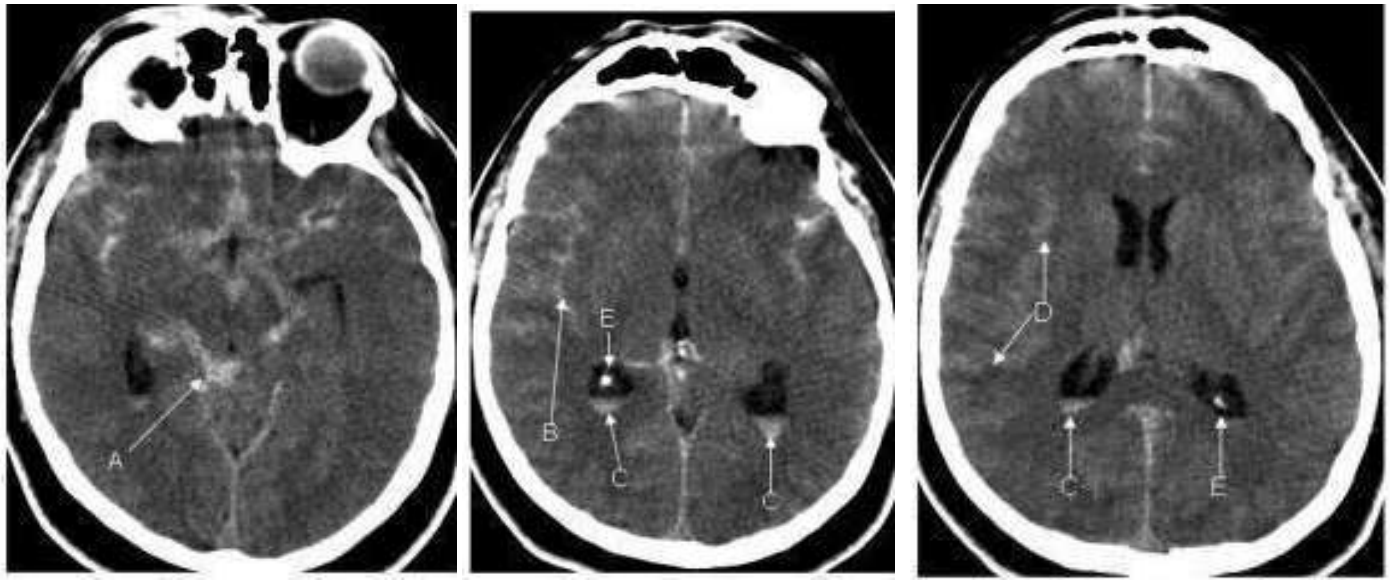
High Midbrain Level (3rd Key Level)

- Lateral ventricles
- IIIrd Ventricle
- Basal ganglia
- Sylvian cistern
- Quadrigeminal cistern

Ref: 6

Blood

- Acute hemorrhage = bright white
- Do not confuse with choroid plexus calcifications, which are a common normal finding and also white on CT

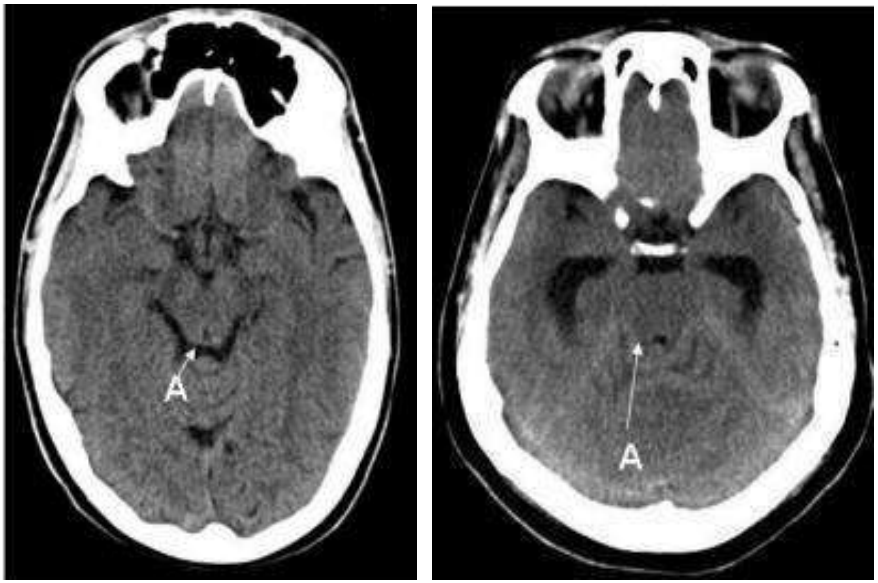


Diffuse subarachnoid hemorrhage is seen with blood in the basilar cistern (A), Sylvian fissure (B), lateral ventricles (C) and sulci (D). Note the brighter white seen in the choroid plexus (E) – these are choroid plexus calcifications, not blood.

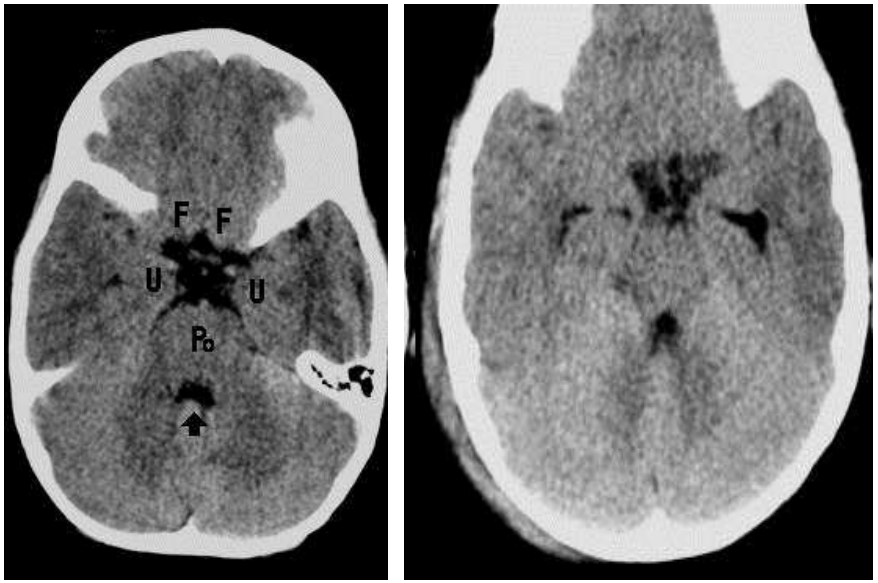
Ref: 1

Cisterns

- Look for blood, symmetry, effacement



Note the normal quadrigeminal cistern (the “smile sign” or “baby’s bottom”) on the left, and compression and effacement on the right due to cerebral edema.

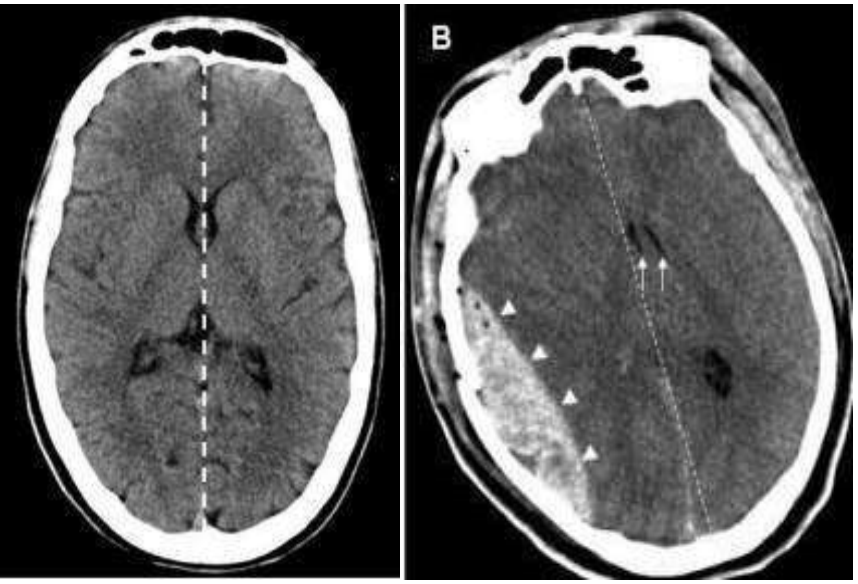


The suprasellar cistern often looks like a star; its borders at the level of the pons is formed by the frontal and uncal temporal lobes and the pons. On the right, note its asymmetry, compression and effacement.

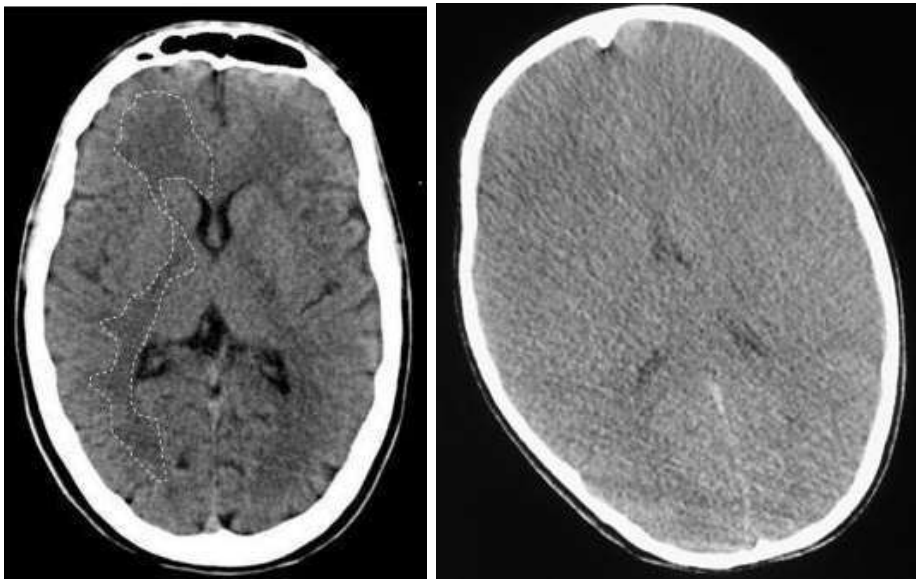
Ref: 1, 10

Brain

- Look for symmetry, midline shifts, grey-white differentiation



Left: a normal CT shows a brain symmetric across an imaginary midline. Right: note a shift of the ventricles and parenchyma to the left of the patient's midline, due to mass effect from the epidural hematoma. The degree of shift may indicate increased risk of herniation, and has some prognostic value in neurosurgical intervention and recovery of neurologic deficits.

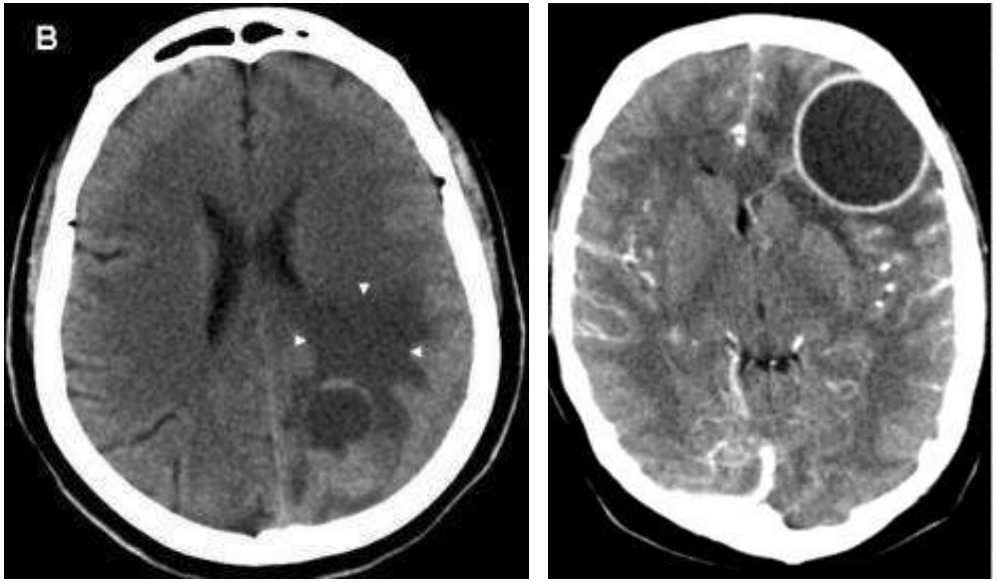


Normal grey-white differentiation is outlined on the left. White matter is myelinated and has more fat, thereby showing up as darker on the CT. In the image on the right, the grey-white interface is obscured due to cerebral edema (note also the slit-like ventricles and loss of sulci).

Ref: 1

Brain

- Look for focal hypo- or hyperdensities, ring-enhancing lesions if with contrast

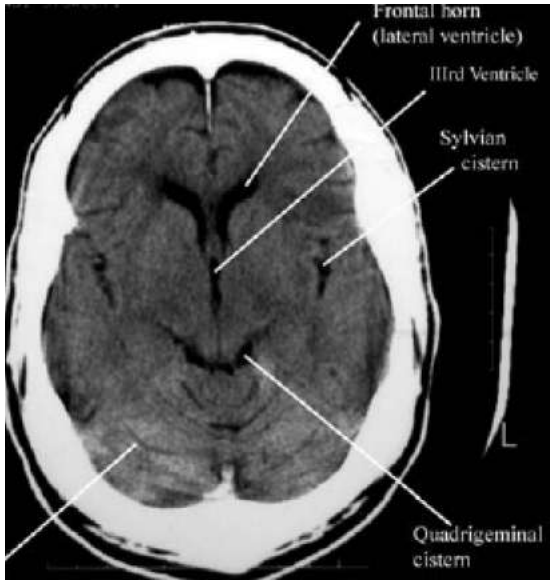


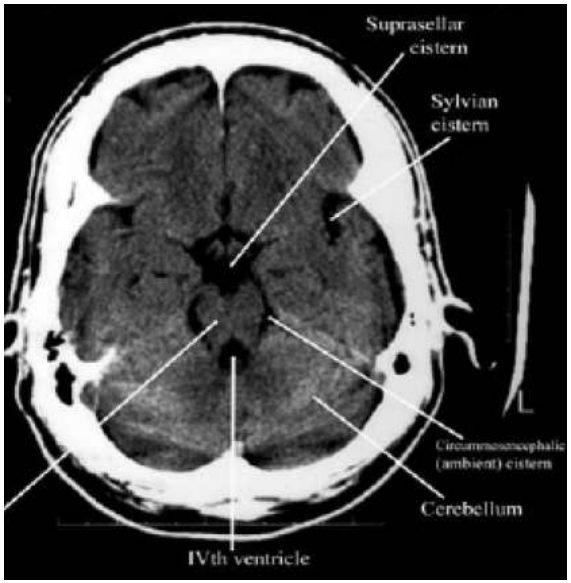
Left: plain CT showing a hypodense mass with surrounding hypodensity representing focal vasogenic edema. An abscess may appear as an ill-defined hypodensity like this without contrast. Right: CT with contrast with focal ring-enhancing cystic lesion consistent with an abscess. Note the hyperdense white signal in the vasculature due to the contrast.

Ref: 1, 3

Ventricles

- Look for size, shape, effacement, shift, presence of blood



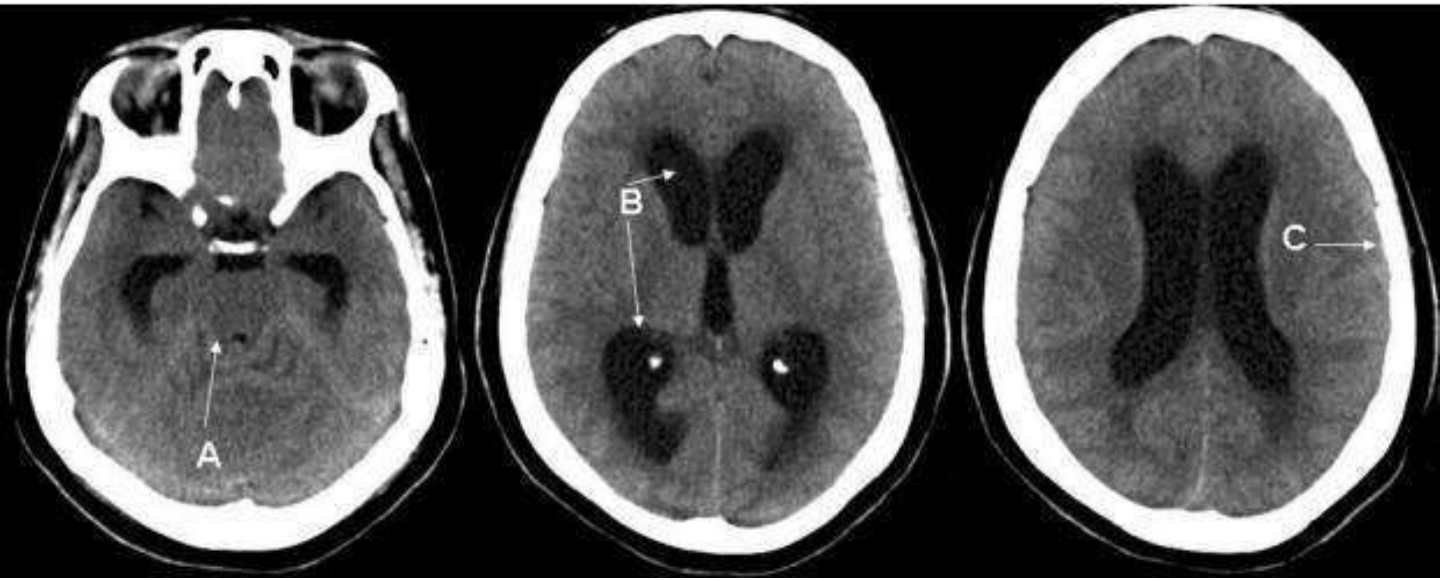


Normal CSF spaces. CSF flow circulates from the lateral ventricles (where it is produced in the choroid plexus) to the 3rd ventricle, through Sylvian aqueduct to the 4th ventricle, before flowing through the Magendie and Luschka foramina to the subarachnoid spaces, where it is absorbed.

Slit-like lateral ventricles secondary to generalized cerebral edema.

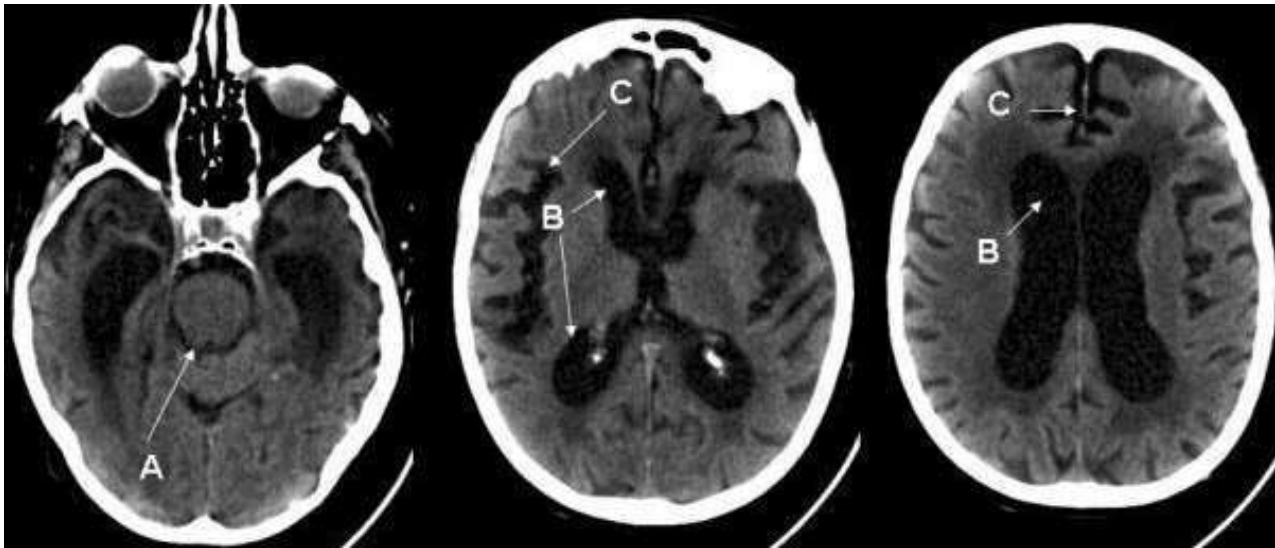
Ref: 6, 1

Ventricles



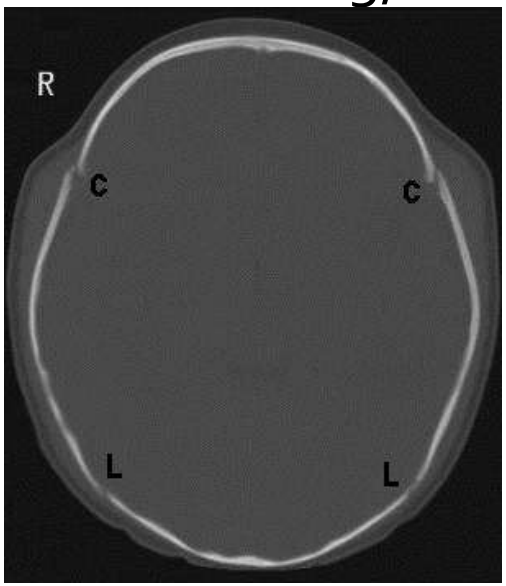
Enlarged ventricles. Above, note that the ventricles (B) are enlarged but cisterns (A) and sulci (C) are effaced, consistent with hydrocephalus**.** To the right, the ventricles (B) are also enlarged, but the cisterns (A) are open and the sulci (C) are prominent, consistent with cerebral atrophy**.**

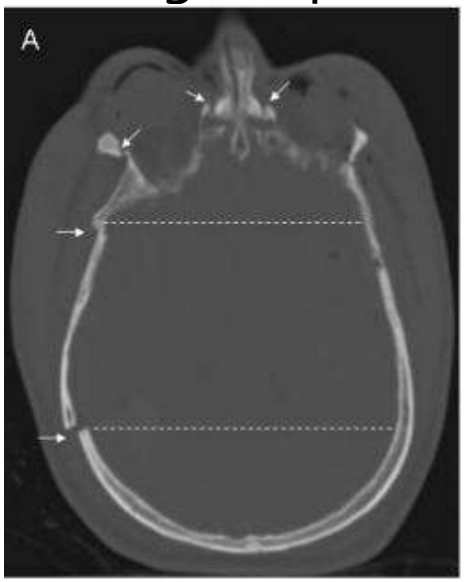
Ref: 1



Bone

- Remember to set on the "bone" window
- Suture lines appear as a small break in bone, so look for symmetry on the contralateral side
- Identifying a fracture may help you identify associated soft tissue swelling, hemorrhage or pneumocephalus





Left: the coronal and lambdoid sutures are identified.
Right: multiple fractures are present. These dotted lines show us there are no sutures present on the contralateral side.

Ref: 9, 1

Take home points

- Use a systematic approach to the interpretation of abdominal radiographs and head CTs to improve the accuracy of your reading.

- The amount and distribution of intraluminal gas, as well as the number and position of bowel loops, can differentiate between small and large bowel obstruction.

- Findings suggestive of increased ICP on head CT include decreased CSF spaces and decreased grey-white differentiation.

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