A concise guide to Cranial Ultrasound

A PEEK THROUGH A DIAMOND HOLE
The role of cranial ultrasound in imaging neonatal and infant brain.

How to perform cranial ultrasound systematically.

Identify normal/variant neonatal neuroanatomy, and common pathology.
Indications

**Initial assessment and serial monitoring of patients at risk of intracranial bleeding**
- Preterm (<32 weeks)
- Low Birth Weight (<1500 g)
- On ECMO support or hypothermia
- Screening before and after surgery
- Coagulopathy

**Others: Initial assessment of**
- Suspected congenital CNS malformation and infection.
- Signs/ symptoms of CNS disorder- seizures, microcephaly, and macrocephaly.
- Suspected hypoxic ischaemic injury
Technical Overview

**Probe Selection**
- **Small Curvilinear Probe**: Linear probe for superficial structure such as superior sagittal sinus, extra-axial collection.
- **Linear Probe**: Adjust frequency accordingly

**Sonographic Window**
- Main window
  - Anterior fontanelle (orange arrowhead)
    - Largest, diamond-shaped
    - Closes 12-24 months
    - Can use other acoustic windows if required for targeted structures.

**Standard views**
- **Coronal Sweeps**
- **Sagittal Sweeps**

*Image: OpenStax College rID: 42758*
1. At the level of frontal lobe
   1. Interhemispheric fissure
   2. Frontal lobe
   3. Orbit
   4. Orbital ridge

2. At the level of frontal horns of lateral ventricle
   1. Corpus callosum
   2. Lateral ventricle
   3. Caudate
   4. Temporal lobe
1. Lateral ventricle
2. Sylvian fissure
3. Foramen of Monro
4. Third ventricle

5. Brainstem
6. Temporal lobe
7. Thalamus
8. Caudate

3. At the level of foramen of Monro and 3rd ventricle

4. At the level of body of lateral ventricle posterior to foramen of Monro
5. At the level of trigone of lateral ventricle

1. Choroid plexus
2. Cerebellum

4. At the level of body of lateral ventricle posterior to foramen of Monro

1. Parietal lobe
2. Occipital lobe
3. Periventricular white matter forming blush - less echogenic than chorid plexus
1. Midline

1. Corpus callosum
2. Cingulate gyrus
3. Occipital lobe
4. Cerebellum
5. Fourth ventricle
6. Brainstem
7. Interthalamic adhesion
Please note normal choroid plexus does not extend anterior to the caudothalamic groove. Haemorrhage should be suspected if echogenic material is seen in such areas. Blood is usually restricted to the caudothalamic groove in Grade 1 germinal matrix haemorrhage.

Periventricular blush is a high echogenic area, usually around the posterior horn of the lateral ventricle. Often seen in preterm and disappears during the first month of life. It should be less echogenic than choroid plexus.
It is helpful to take cine images in coronal and sagittal planes as it is sometimes difficult to differentiate haemorrhage from choroid plexus when reviewing on still images.

3. Extreme parasagittal (Through **Sylvian fissure**)

- It is helpful to take cine images in coronal and sagittal planes as it is sometimes difficult to differentiate haemorrhage from choroid plexus when reviewing on still images.
Linear probe should be used to evaluate superficial structures of the brain (extra-axial space, superior sagittal sinus, etc. Normal extra-axial space.

Colour Doppler flow can be performed to evaluate intracranial vascular patency.
Normal appearances and variations

- Grey matter and white matter have different levels of echogenicity with grey-white matter differentiation. White matter is whiter (more echogenic). Grey matter is darker (less echogenic).
- The Corpus callosum is made of white matter fibres and hence is hypoechoic.
- Gyri and sulci development progresses with age—smoother brain with fewer gyri and sulci in premature babies.
- Cavum septum pellucidum is a midline CSF-filled space. Present in normal newborns. May persist into adulthood.
- The size of the lateral ventricles tends to decrease with gestational age. Mild asymmetric lateral ventricles are common in preterm.
Other Common Variants

- Periventricular blush/flare
- Choroid plexus cyst
- Benign enlargement of the subarachnoid space (BESS) in infancy
Periventricular Blush/Flare

- Preterm baby, 25+5. Respiratory distress and suspected sepsis. D1 cranial US is performed to detect intra-cranial abnormalities, including germinal matrix haemorrhage.
- The symmetric homogenous high echogenicity of periventricular white matter, particularly around the peri-trigonal region (posterior horns of the lateral ventricles), is in keeping with periventricular blush. Note that it is less echogenic than the choroid plexus.
- Commonly seen in premature infants and disappears during the first month of life.
- The differentials include cerebral haemorrhage and periventricular leukomalacia. Serial follow-up cranial ultrasound is required.
A small cyst at the choroid plexus of the right lateral ventricle is in keeping with a choroid plexus cyst. It is usually unilateral with no clinical significance.
Benign enlargement of the subarachnoid space (BESS)

- Widening of bifrontal and anterior interhemispheric subarachnoid space with no flattening of adjacent gyri.
- Hyperechogenic linear structures within the subarachnoid space are in keeping with cortical veins. Needs to demonstrate vascular flow with Doppler ultrasound, which is not shown. Cortical veins are not seen in chronic subdural haematoma, which is the main differential.
Common pathological conditions

- Germinal Matrix Haemorrhage (GMH)
- Periventricular Leukomalacia (PVL)
- Hydrocephalus
Germinal Matrix Haemorrhage (GMH)

- Neurones form at the germinal matrix, which is confined to the caudothalamic groove (28-32 weeks of gestation). GMH occur as it is highly cellular, vascular and vulnerable to insult.
- Unlikely after 34 weeks as the germinal matrix has matured/involuted.
- On ultrasound, it is hyperechoic in the acute phase, changing to iso- and hypo-echoic with time, like other haemorrhages.
- Classified as Grades 1-4

Case: David Gendy rID: 79252
Increased echogenicity confined to GM in the right caudothalamic groove.

Case: Gagandeep Singh rID: 6654

Haemorrhage extending into the non-dilated left lateral ventricle.

Case: Sam Kruger rID: 26740
Echogenic material extending anterior to caudothalamic groove, associated with intraventricular extension and marked ventriculomegaly, as evidenced by increased frontal horn width bilaterally. Increased Thalamo-occipital distance.

Case: Gagandeep Singh rID: 8355
Extensive GMH with bilateral intraventricular extension and ventriculomegaly. Increased right periventricular cerebral parenchymal echogenicity due to secondary venous infarct. Right grade 4 GMH and left grade 3 GMH.

Case: Yoshi Yu rID: 150530
Periventricular white matter injury in premature infants

Common causes include:
- Ischaemia/hypoxia
- Inflammation
- Infection

On ultrasound, it appears as increased periventricular echogenicity persisting for more than 7 days.

Classified as Grades 1-4

Case: Hani Makky Al Salam rID: 14000
Increased periventricular echogenicity persisting for more than 7 days.

The echogenicity resolves into small periventricular cysts.

Case: Hani Makky Al Salam rID: 14000
Grade 3 PVL

Extensive periventricular cysts in the frontoparietal and occipital region

Case: Hani Makky Al Salam rID: 14000

Grade 4 PVL

Extensive subcortical cysts

Case: Kewal Arunkumar Mistry rID: 34798
Ultrasound helps evaluate children with macrocephaly, rapid increase in head circumference or a bulging fontanelle. It helps to confirm, quantify and monitor ventricular dilatation and to look for the cause.

Hydrocephalus can be due to:
- Obstruction to the CSF outflow
- Decreased CSF absorption
- CSF overproduction.
Obstructive hydrocephalus causing dilatation of lateral and 3rd ventricles. Increased ventricular index (VI - from the midline to the lateral most point of the lateral ventricle). Increased bifrontal diameter.
Take Home Points

- Cranial US is very useful diagnostic screening tool for intra-cranial abnormalities as it is portable, quick (no sedation required) and non-invasive.
- A systematic approach to cranial ultrasound allows us to get standard images which are helpful for follow-up.
- Small and smooth micro-movement is essential to get good-quality images while scanning through the small fontanelle.
- Cine images are essential for later review.
- Good knowledge of normal neonatal brain anatomy and common variations is essential to identify commonly encountered pathological conditions seen on cranial ultrasound.


NHS Greater Glasgow and Clyde guidelines- Cranial ultrasound: a guideline for the performance of routine cranial USS for preterm infants