Learning objectives

Cranial ultrasound is a valuable and accessible tool in paediatric imaging. This imaging technique is predominantly employed to diagnose and monitor intracranial conditions, such as hydrocephalus and intracranial haemorrhage, and to screen for congenital abnormalities.

The use of high frequency sector probes and the ability to scan through the open neonatal fontanelles results in detailed high resolution images of the brain.

This pictorial review demonstrates the normal cranial ultrasound appearances of the neonatal brain. Commonly encountered pathologies including hydrocephalus and haemorrhage (subependymal, intraventricular and parenchymal) are discussed and illustrated with case examples.
Background

Cranial ultrasound imaging is used widely, not only by radiologists and sonographers but also by paediatricians and neonatologists. It is usually the first line investigation in the initial assessment of the premature and term neonatal brain as it is non-invasive, inexpensive, does not require sedation and does not involve the use of ionising radiation. In addition, it is a portable modality which can be performed at the bedside which is of utmost importance when imaging the sick neonate.

It is important for radiologists in training to have an understanding of its use in clinical practice, the normal ultrasound appearances of the neonatal brain and the typical findings of some of the more common abnormalities.
Imaging findings OR Procedure details

Technique

A standard cranial ultrasound series includes coronal views of the frontal lobes, the lateral and third ventricle and the occipital lobes. Midline sagittal and right and left para-sagittal views demonstrating the caudothalamic groove and temporal lobes are also obtained. Other techniques such as high resolution colour and pulse wave doppler imaging of the superior sagittal sinus are also routinely performed. These images are usually acquired through the anterior fontanelle.

Scanning through the anterior fontanelles results in excellent imaging of the cerebral hemispheres and ventricles; views of the posterior fossa are usually more challenging. However, scanning through the posterior fontanelle often results in better delineation of the supra and infra-tentorial posterior fossa structures.

Images may also be acquired by scanning through the posterolateral fontanelle by gently displacing the pinna inferiorly and orientating the probe transversely in the acoustic window found in the region of the mastoid. This technique yields excellent axial images of the cerebellar hemispheres, fourth ventricle, cisterna magna and pons.

Normal brain (fig. 1-7):

Fig 1 : Coronal view at the level of the frontal lobes.

Fig 2: Coronal view at the level of the third ventricle. Note the lateral ventricles with an intervening cavum septum pellucidum (normal anatomical variant).

Fig 3: Coronal view at the level of both trigones, showing the echogenic choroid plexuses bilaterally.

Fig 4: Midline sagittal view. The corpus callosum is present with the cingulate gyrus coursing superior to it. The cavum septum pellucidum is again seen as a hypoechoic cavity. The 3rd ventricle is triangular in shape with its apex pointing towards the pituitary fossa. The pons, medulla and the hypoechoic triangular 4th ventricle posterior to the brainstem are also demonstrated.
Fig 5, 6 & 7: Coronal view of the superior sagittal sinus (SSS), showing normal appearance of a patent venous sinus on B mode, colour doppler and spectral wave form imaging.

**Hydrocephalus (fig. 8-12):**

The coronal and sagittal US images show gross hydrocephalus in a neonate, with dilatation of the lateral, third and fourth ventricles (communicating hydrocephalus) (fig. 8-11). Axial CT (fig. 12) shows dilated lateral and third ventricles in an older child for comparative illustration of hydrocephalus.

The clinical presentation of hydrocephalus varies according to the age of the paediatric patient. In children younger than two years of age, it usually presents with a progressive increase in head circumference, often in association with other features such as separation of the sutures, a bulging anterior fontanelle, frontal bossing and dilated scalp veins. As the sutures fuse, they present with raised intracranial pressure.

As shown, the presence of hydrocephalus is well demonstrated on ultrasound in neonates and young infants, and on CT in older children. However, the most sensitive modality for the investigation of the cause of hydrocephalus is MRI at any age. Causes of hydrocephalus include the over production of CSF as in choroid plexus tumours, intraventricular obstruction which results in non-communicating / obstructive hydrocephalus and extraventricular obstruction which causes a communicating hydrocephalus.

**Subependymal haemorrhage (fig.13-19):**

Coronal and sagittal US images show a hyperechoic focus in the subependymal region of the left lateral ventricle, measuring 4mm in the transverse plane, in the region of the caudothalamic groove. Appearances are in keeping with a small subependymal / germinal matrix haemorrhage (GMH Grade I).

Germinal matrix haemorrhage (GMH) / intra-ventricular haemorrhage (IVH) is seen most commonly in pre-term infants of less than 32 weeks gestation. The germinal matrix is a highly vascular structure that lines the entire ventricular system early on in gestation and gradually involutes, remaining as a small area over the caudate nucleus at the end of the gestational period.
The germinal matrix in the caudothalamic groove is the classical site of haemorrhage in the pre-term infant. Ultrasound is the primary modality for the diagnosis of GMH-IVH. When this is identified biplanar imaging (sagittal/transverse) should be acquired so as to confidently distinguish this pathology from other normal echogenic structures such as the normal choroid plexus.

Normal choroid is hyperechoic and of similar echogenicity to haemorrhage however, choroid does not extend into the frontal horns beyond the foramen of Monro, and hyperechogenicity here is consistent with haemorrhage. In the sagittal plane the choroid tapers anteriorly towards the caudothalamic groove and any bulbous enlargement or hyperechogenicity anterior to the termination of the choroid is consistent with haemorrhage.

Choroid plexus haemorrhage is more common in the term neonate following birth trauma. Normal choroid should appear smooth and continuous. Asymmetry and nodularity or thickening of the choroid suggests haemorrhage within the choroid.

Colour doppler can also help to differentiate the hypervascular choroid from avascular haematoma.

Complications of GMH-IVH include hydrocephalus, ventriculitis, porencephalic cyst, trapped 4th ventricle and spinal canal dilatation.

**Intraventricular haemorrhage and porencephalic cyst (fig. 20-26):**

Figs 20-23 demonstrate a large irregular cystic area within the left frontoparietal region extending into the occipital region, which has an irregular wall and contains echogenic material. Echogenic material is seen in both of the lateral ventricles and is consistent with haemorrhage. The cystic lesion communicates with the anterior part of the left lateral ventricle and appears separate from it posteriorly. This represents an acquired porencephalic cyst resulting from haemorrhage and cell death. The choroid plexus can be identified posteriorly within the left lateral ventricle. There is a degree of midline shift toward the right on coronal views. Sagittal and axial MR images (fig 24-26) for the same patient confirm the above findings.
Fig. 1: Normal brain

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Fig. 2: Normal brain

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Fig. 3: Normal brain

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Fig. 4: Normal brain

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**Fig. 5:** Normal brain

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Fig. 6: Normal brain

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Fig. 7: Normal brain

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Fig. 8: Hydrocephalus

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Fig. 9: Hydrocephalus

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Fig. 10: Hydrocephalus

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Fig. 11: Hydrocephalus

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Fig. 12: CT appearances of hydrocephalus

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Fig. 13: Subependymal haemorrhage

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**Fig. 14:** Subependymal haemorrhage

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**Fig. 15:** Subependymal haemorrhage

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Fig. 16: Subependymal haemorrhage

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Fig. 17: Subependymal haemorrhage

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Fig. 18: Subependymal haemorrhage

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**Fig. 19:** Subependymal haemorrhage

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Fig. 20: Intraventricular haemorrhage and porencephalic cyst

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Fig. 21: Intraventricular haemorrhage and porencephalic cyst

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Fig. 22: Intraventricular haemorrhage and porencephalic cyst

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Fig. 23: Intraventricular haemorrhage and porencephalic cyst

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Fig. 24: MR (T1W IR) appearances of intraventricular haemorrhage and porencephalic cyst

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Fig. 25: MRI (T1W) appearances of intraventricular haemorrhage and porencephalic cyst

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Fig. 26: MRI(T1W) appearances of intraventricular haemorrhage and porencephalic cyst

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Conclusion

Ultrasound of the neonatal brain is sensitive and safe. The open fontanelles provide the ideal acoustic window resulting in high quality images which are instrumental in guiding further imaging / patient management.
References

