Cranial ultrasound (CUS) is a quick, reliable, clinically valuable neuromaging examination in babies with a patent fontanelle and has a complementary role to that of magnetic resonance imaging (MRI). This overview summarises the techniques, normal imaging findings and common pathologies encountered with CUS. CUS may be performed by sonographers, radiologists and paediatricians with appropriate training. It has many uses and is an excellent tool in the assessment of intraventricular haemorrhage (IVH), ventricular dilatation and hypoxic ischaemic encephalopathy (HIE). The major use of CUS is therefore in preterm infants most at risk of these conditions. CUS can also be used to look at blood flow within the brain, to confirm the presence or absence of structures within the brain (eg the corpus callosum) and to look for haemorrhage in the subarachnoid or subdural space.

CUS complements the use of computed tomography (CT) and MRI and has many advantages over these more sophisticated modalities. CUS is readily available, quick to perform and can be completed at the bedside with little disturbance to the neonate. This is particularly important in the intensive care patient who may be ventilated or may not be stable enough to transfer to a CT/MRI scanner. CUS is inexpensive and free from ionising radiation. Additionally, serial imaging can be performed and is very useful in monitoring progress and/or resolution once an abnormality is discovered.

MRI provides superior delineation of certain structures within the brain and is of particular use in defining complex congenital abnormalities. It is also regarded as a superior imaging test in suspected HIE. However, MRI requires that the baby be transferred, often ventilated and is time-consuming to perform and very expensive. This limits patient throughput and thus MRI is not a suitable “workhorse” for infant neuroimaging. CUS can be used as a screening tool in order to identify babies that would benefit from MRI.

There is some debate regarding the timing and frequency of CUS in preterm infants, especially if they are asymptomatic. Serial imaging may identify abnormalities which predict adverse long-term neurodevelopmental outcomes such as cerebral palsy. Local protocols should maximise sensitivity while taking into account availability of resources. At our centre there is a CUS schedule for neonates <32 weeks gestation or birth weight <1500g. CUS is performed on day 0 (as soon as clinically stable) and then at two to three days, seven days, at two to four weeks and at term or prior to discharge. If the baby becomes unwell then imaging is performed sooner, and some may proceed to MRI, depending on imaging findings.'

CUS is performed using a wide-sector, mid-frequency 5, 7.5 or 10 megahertz (MHz) probe with a small footprint. The anterior fontanelle is the main acoustic window and this is located at the junction of the sagittal and coronal sutures. It gets progressively smaller as the child grows and closes at around 12 months of age. CUS is therefore best performed early in life when the fontanelle is widely patent. In order to obtain high quality images you should ensure that the appropriate optimised examination setting has been selected on the US machine, ie ‘neonatal head’ USS for example, and that depth penetration has been optimised in order to facilitate adequate visualisation. We traditionally begin in the coronal plane (ensure the probe marker is on the baby’s right) and take five or six standard views followed by a further five views in the sagittal plane. However, with modern-day improvements in picture archiving and communications systems (PACS), dynamic clips are encouraged. While it is sufficient to scan through the anterior fontanelle only, additional information may be obtained by using an alternative acoustic window such as the posterior or mastoid fontanelles. The latter allows excellent visualisation of the cerebellum.

Finally, the venous sinuses should be evaluated for patency using a higher frequency, eg 10 MHz probe. The basic approach involves assessing the superior sagittal sinus via the anterior fontanelle using colour Doppler flow. Venous sinus thrombosis is present if there is an absence of colour Doppler flow within the venous sinus (figure 1).

For the operator who may be new to cranial ultrasound, we would like to suggest a few useful tips. Firstly, it is important to note areas of asymmetry, as this is often an indicator of pathology. Importantly, however, symmetry does not always reflect normality. Where pathology is encountered, imaging should be performed in two planes, and comparison made with previous studies, if available.

The pathologies encountered are dependent upon whether the neonate is pre-term or term. Premature babies are more prone to hypoxic, inflammatory and haemorrhagic pathologies, particularly IVH and HIE. Stroke, in particular venous infarction, is more common in term infants.

IVH is readily diagnosed and graded with CUS. The caudothalamic groove (CG) marks the boundary of the anterior thalamus and echobright posterior choroid plexus (figure 2). This is best seen with a para-sagittal view. The presence of increased echogenicity anterior to the CG is diagnostic for IVH (figure 3). Therefore it is imperative to examine the CG on both sides in all CUS studies. The severity grading system for IVH is based on the absence/presence of ventricular dilatation and the extent of haemorrhage.

The most severe grade of IVH includes ventricular dilatation and extension of the haemorrhage into the brain parenchyma. Ventricular dilatation can be assessed using a parameter called the bifrontal index. This is the ratio of the distance from the lateral aspects of the frontal horns at the level of the foramen of Monroe (coronal section) to the transcranial diameter, and should be less than 0.5.

HIE may have variable appearances, but is often seen as periventricular ‘flare’ on CUS. This is increased echogenicity in the periventricular white matter, best seen in coronal section (figure 4). In severe cases of HIE, cysts form in the periventricular regions over time and this is associated with a much poorer neurodevelopmental outcome for the child.

In summary, cranial ultrasound remains a valuable diagnostic tool in neonatal and infant neuroimaging that offers exquisite spatial resolution and dynamic imaging including blood flow assessment. It is the initial neuroradiological modality of choice in preterm infants, with many advantages over MRI.
FIGURE 1
Coronal image with colour Doppler. There is absent flow in an expanded superior sagittal sinus, in keeping with venous sinus thrombosis.

FIGURE 2
Left parasagittal image showing the normal appearance of the caudothalamic groove (CG). The high echogenicity choroid plexus is posterior to the CG.

FIGURE 3
Right parasagittal image showing abnormal high echogenicity anterior to the CG. This is diagnostic for intraventricular haemorrhage.

FIGURE 4
Coronal image showing increased echogenicity in the periventricular white matter, in keeping with periventricular flare. This can be seen in hypoxic ischaemic encephalopathy.

References