Scope
This guideline is aimed at all Health care professionals involved in the care of infants within the Neonatal Service.

Legal Liability (standard UHL statement)
Guidelines issued and approved by the Trust are considered to represent best practice. Staff may only exceptionally depart from any relevant Trust guidelines providing always that such departure is confined to the specific needs of individual circumstances. In healthcare delivery such departure shall only be undertaken where, in the judgement of the responsible healthcare professional, it is fully appropriate and justifiable - such decisions to be fully recorded in the patient’s notes.

Key Points

Prematurity
- Formal routine cranial USS are performed by the radiologists on Monday, Tuesday, Wednesday and Friday at LRI and Wednesday at LGH (where cover is not available, the scan will be performed on the next scanning day).
- Consultant neonatologists and SpRs with the appropriate competency may perform scans at other times
- Urgent cranial USS should be discussed with consultant radiologist
- All infants < 30 weeks (up to 29+6 weeks) should have a screening cranial USS within 3 – 5 days
- All infants <33 weeks (up to 32+6 weeks) should have a cranial USS at around 36 weeks corrected gestation age

Infants 33 weeks and above (including Term)
- Cranial imaging should be performed in all infants with abnormal neurology
- Infants with grade II or III Hypoxic Ischaemic Encephalopathy (HIE) should have a cranial USS within 48 hours of birth and at 1 week.
- An MRI scan should ideally be done between 5-14 days in infants with HIE

Aim/indications
- To screen for evidence of intracranial pathology associated with extreme prematurity
- Detection of cerebral damage following significant hypoxic or hypotensive episode
- Detection of intracranial haemorrhages
- Detection of cerebral anomalies associated with congenital disorder / malformations

The guideline includes
- Cranial Ultrasound Screening Protocol for Asymptomatic Preterm Infants
- Standard ultrasound views (Appendix 1)
- Ventricular index chart (Appendix 2)
**Background**

**Preterm Infants**

**Intraventricular haemorrhage (IVH)**

There is an inverse relationship between gestational age and intraventricular haemorrhage with the majority occurring in infants <29 weeks within 72 hours of birth [1]. Intraventricular haemorrhage is now classified as in the table below [2,3].

<table>
<thead>
<tr>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small: Haemorrhage limited to germinal matrix (sub-ependymal) or choroid plexus. (May develop into a pseudocyst).</td>
<td>Intraventricular haemorrhage but no ventricular dilatation</td>
<td>Intraventricular haemorrhage with ventricular dilatation</td>
<td>Haemorrhagic parenchymal infarct (IVH with increased parenchymal echodensity. Develops into porencephalic cyst)</td>
</tr>
</tbody>
</table>

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**Ventricular dilatation**

Mild ventricular dilatation or asymmetry is common. Significant ventricular dilatation is more likely to follow a grade 3 IVH but may also follow a grade 2 haemorrhage. Ventricular dilatation or hydrocephalus may also follow meningitis.

The ventricular index of Levene is a well validated method for documenting ventricular dilatation [4,5,6]. This is a measurement taken in the coronal view through the plane showing the 3rd ventricle and measures the distance from the falx (midline) to the lateral border of the lateral ventricle (shown below). This should be plotted regularly in infants at risk of hydrocephalus (Appendix 2).
**Periventricular leukomalacia (PVL)**
A periventricular "blush" is common but a true periventricular flare is as bright as the choroid and is seen in both coronal and sagittal planes. These areas should be carefully reassessed as they may develop into cystic areas. Infants < 32 weeks are at risk regardless of birthweight [7].

PVL may be rarely present at birth following an antenatal insult or may not appear until 6 weeks postnatal age [7-10]. Risk factors include chorioamnionitis and postnatal hypotensive episodes [11]. It is important to classify it as unilateral or bilateral and to assess the extent of parenchymal involvement as these facts guide prognosis. A small localised area of infarction has a better prognosis [12].

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**TORCH Infections**
Congenital cytomegalovirus (CMV), toxoplasmosis and rubella infections, of which CMV is currently the most common, may result in intracranial calcification. A CT scan is the imaging technique of choice for calcification but this is rarely indicated and significant calcification can be detected with cerebral ultrasound.

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**Term Infants**

**Cerebral sinus and venous thrombosis**
This may occur in association with dehydration, sepsis, trauma and leads to raised intracranial pressure, seizures, hypertonia and unexplained lethargy.
CT or MRI are required for diagnosis.

**Arterial infarction**
Infarction of a cerebral artery (commonly middle cerebral) is increasingly recognised. Initial USS may be normal but focal changes are apparent from 5 days [13]. An MRI will confirm the diagnosis.

**HIE**
In HIE there may be acute cerebral oedema visible on USS and this may be followed by evidence of cerebral damage including basal ganglia infarction. An MRI performed at the correct time can give valuable information about the prognosis in an individual case [14-17].
**Haemorrhage**

Intracranial (and extracranial) haemorrhage occurs less commonly in the term infant and the pattern of haemorrhage is more heterogeneous than in the preterm infant [18]. This is summarised in the table below:

<table>
<thead>
<tr>
<th>Haemorrhage type</th>
<th>Risk factors</th>
<th>Symptoms</th>
<th>Imaging techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subdural (SDH)</td>
<td>Instrumental delivery, trauma, thrombocytopenia, coagulopathy</td>
<td>Seizures, fever, tense fontanelle, hypotonia, lethargy, facial palsy. Others depending on site.</td>
<td>USS poor CT (MRI)</td>
</tr>
<tr>
<td>• Supratentorial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Posterior fossa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subarachnoid (SAH)</td>
<td>Thrombocytopenia, coagulopathy</td>
<td>Seizures, fever</td>
<td>USS</td>
</tr>
<tr>
<td>• Primary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Secondary to intraventricular haemorrhage</td>
<td></td>
<td></td>
<td>USS – resembles space occupying lesion</td>
</tr>
<tr>
<td>Convexity Haemorrhage</td>
<td>Exchange transfusion and coagulopathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Large SAH)</td>
<td></td>
<td></td>
<td>USS</td>
</tr>
<tr>
<td>Intraventricular haemorrhage</td>
<td>Maternal or fetal coagulopathy</td>
<td>Seizures, fever, raised intracranial pressure</td>
<td>USS</td>
</tr>
<tr>
<td>Intraparenchymal</td>
<td>Coagulopathy, trauma, hypoxia, ischemia, Arteriovenous malformation, aneurysm, tumour.</td>
<td>Sudden onset of symptoms in previously well infant</td>
<td>USS</td>
</tr>
<tr>
<td>Cerebellar haemorrhage</td>
<td>Breech delivery, trauma</td>
<td>Lethargy, apnoea, bradycardia, poor suck, raised ICP</td>
<td>USS</td>
</tr>
<tr>
<td>Thalamic haemorrhage (unilateral)</td>
<td>HIE</td>
<td>Severe abnormality at 2-14 days. Ocular signs</td>
<td>USS</td>
</tr>
<tr>
<td>Subaponeurotic</td>
<td>Afrocaribbean infant, vacuum extraction, vit K def.</td>
<td>Severe hypovolemia, selling of cranium across suture lines</td>
<td>USS CT/MRI</td>
</tr>
</tbody>
</table>

Subdural haematoma with midline shift and bowing of the interhemispheric fissure [19].

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Guideline title: Cranial Imaging in the Preterm and Term Infant
Authors: Robin Miralles, Maggie Meeks
Contact: Neonatal Guidelines Lead
Approved by: Neonatal Services Governance Group / Neonatal Guidelines Group
Guideline Register No: C64/2004
Page 4 of 15
Written: October 2008
Last Review: July 2018
Next Review: July 2021

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Recommendations

Personnel performing scans
Ultrasound is a good bedside imaging technique than can detect IVH and PVL with a high degree of accuracy [20]. The cranial USS are performed and reported by the Consultant Radiologist where possible and when appropriate. Additional scans may be performed (or supervised) by the neonatal consultant or an SpR that has the appropriate competency.

NB: It is easy to misinterpret ultrasound appearances [21].

The following should be documented:
- Check patient details
- Date and time of scan
- Name and position of person performing scan
- Findings
  - Always perform a full sweep from anterior to posterior and left to right
  - The views to be recorded are shown in Appendix 1
  - Document anatomy (normal/abnormal) and any evidence of haemorrhage or ischaemia

- All abnormal USS should be discussed with the attending neonatal Consultant and Consultant Radiologist to allow parents to be counseled appropriately.
- If post-haemorrhagic ventricular dilatation is suspected the ventricular index should be plotted (Appendix 2).

Preterm infants

Asymptomatic
A chart of recommendations is shown on the following page.
- If possible a scan should be performed within 24 hours in infants < 1000g.
- Infants in whom IVH is identified will be rescanned the following week.
- Infants with additional concerns will be dealt with on an individual basis

Infants > 32+6 weeks are not routinely screened but may be scanned if there is an indication.

Symptomatic
An urgent cranial ultrasound scan is indicated in the following circumstances:
- Blood pressure instability
- Significant fall in haemoglobin
- Seizures
- Cardiopulmonary arrest
- Metabolic acidosis (pH < 7.2, Base deficit > 10, increased lactate)
- Persistent apnoeas

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33 weeks and above (includes Term Infants)
Cranial imaging (type to be discussed with Consultant Radiologist) should be urgently performed in all term infants with skull fractures or abnormal neurology e.g.
- Seizures
- Extreme lethargy
- Meningitis
- Evidence of raised intracranial pressure

To look for evidence of:
- Haemorrhage
- Cerebral sinus and venous thrombosis
- Arterial infarction

**HIE**
Infants with grade II or III HIE should have a cranial USS within 48 hours of birth and at 1 week. An MRI scan should ideally be done between 5-14 days. [15]

The important views on MRI are
- T1 and T2 weighted transverse images
- T1 sagittal image
- Diffusion imaging
- Spectroscopy may add information [15]
Cranial Ultrasound Baseline Screening Protocol for Asymptomatic Preterm Infants

Less than or equal to 29+6 weeks (or less than 1000g)

<table>
<thead>
<tr>
<th>Radiology Scan request</th>
<th>Neonatal Team Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Day 3 to 5 (up to day 7)</strong></td>
<td>First 48 hours</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Day 28 (up to day 35)</strong></td>
<td>Day 10 to 14 (up to day 21)</td>
</tr>
<tr>
<td>36 weeks corrected*</td>
<td></td>
</tr>
</tbody>
</table>

(Radiology requests: First week, first month and 36 weeks corrected)

Symptomatic infants may need more frequent scanning (see previous pages)

From 30+0 to 32+6 weeks gestation

<table>
<thead>
<tr>
<th>Radiology Scan request</th>
<th>Neonatal Team Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>36 weeks corrected</strong>*</td>
<td><strong>Day 3 to 5 (up to day 7)</strong></td>
</tr>
</tbody>
</table>

*The 36 week ultrasound scan correlates with outcome and can pick up pathology not seen on earlier scans. If discharge is planned before 36 weeks corrected please request a pre-discharge ultrasound scan, particularly if the infant is already more than 34 weeks gestation.

If the radiologists are unable to perform the scan on routine scanning days then the scan should be booked to be performed as an outpatient.

In the early stage of ventricular dilatation, twice weekly scanning should be performed until it is clear that the situation has stabilised. Measurement of ventricular index can be readily performed by the neonatal team, so that there should be no need for radiology scans to be requested more than once a week.
**Prognosis**
Please do not discuss with parents without clarifying the USS findings with the attending consultant.

**Recommended Information when requesting scans**
- Include gestational age at birth, days post-delivery & corrected gestational age
- Current medical issues (e.g. intensive care, ventilated, inotropic support)
- Previous treatments and significant issues (e.g. steroids for CLD, surgery for NEC)
- Any significant findings on previous scans.
- The reason for requesting the scan (e.g. seizures, fall in haemoglobin)
- What is being looked for (e.g. white matter damage two or weeks after a serious deterioration, possible haemorrhage or ischaemia)

**Audit Criteria**
1. All infants < 30 weeks (up to 29+6 weeks) should have a screening cranial ultrasound scan within 3 – 5 days (100%)
2. All infants <33 weeks (up to 32+6) should have a ‘36 week’ cranial ultrasound.

**References:**

7. Townsend SF et al. Late neurosonographic screening is important to the diagnosis of periventricular leukomalacia and ventricular enlargement in preterm infants. Pediatr Radiol, 1999. 29(5): 347-52


Appendices

Appendix 1: Standard Ultrasound Views [19]

Appendix 2: Ventricular Index Chart [5]
Appendix 1: Standard Ultrasound Views

Frontal lobes

Anterior horns of the lateral ventricles

Third ventricle
Posterior thalamus - hippocampus
cerebellum

Trigone

Occipital lobes