### Management of Policies Procedure control sheet

(Non clinical documents only)

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| Target audience | NHSFV wide | Specific Area / service | Neonatal |

### Consultation and Change Record – for ALL documents

**Contributing Authors:** West of Scotland Guidelines NNMCN Guidelines/Dr Sarah Pickel

**Consultation Process:** Forth Valley Neonatal Forum

**Distribution:** Neonatal medical and nursing staff

#### Change Record

<table>
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<tr>
<th>Date</th>
<th>Author</th>
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<tr>
<td>22/04/2015</td>
<td>Dr Sarah Pickel</td>
<td>Enhanced images, addition of a flow chart and addition of appendix on the prognosis of cranial USS lesions</td>
<td>2.0</td>
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<tr>
<td>25/11/2011</td>
<td>Dr Abu-Arafeh</td>
<td>Original document</td>
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Cranial Ultrasound:

This guideline is applicable to medical staff and ANNPs caring for neonates in the West of Scotland. All staff performing cranial ultrasound scans on neonates must first ensure that they have received training in the correct use of the ultrasound scanner and the appropriate images required, as outlined in this document. Except in an emergency, parents should be informed in advance that head scans will be performed on their baby and the reasons for this. This information may be given verbally or in a printed form. The results of the scans should be communicated in a timely manner by a senior member of staff able to interpret the images and understand their prognostic value.

Introduction

This document will primarily cover standard cranial ultrasound techniques for recording periventricular haemorrhage (PVH) and peri-ventricular leukomalacia (PVL), including the measurement of the resistive index and ventricular dilatation.

Cranial ultrasoundography is the most widely used neuroimaging procedure in the neonatal period. It plays a central role in the detection and management of some neonatal neurological disease and can provide prognostic, as well as diagnostic, information to neonatologists. This guideline provides a standard for clinicians in order to detect abnormalities that will alter management and/or guide parental counselling.

Indications for Cranial Ultrasound Scan

There are a diverse group of infants who will require scanning and ultimately a decision to perform a scan on any unwell neonate can be taken by the consultant responsible for that child. Common indications include:

- Premature infants
- Infants with neurological abnormalities (e.g. seizure)
- Infants with antenatally detected abnormalities (e.g. ventriculomegaly)
- Infants with hypoxic ischemic encephalopathy
- Infants with other congenital abnormalities
- Infants with congenital or acquired CNS infection
- Infants with a diagnosis of coagulopathy or thrombocytopenia
- Infants of maternal cocaine use

Timing of Routine Scans for Premature Infants:

The following number of scans should be the minimum and more scans should be done if clinically indicated. Results should be entered into Badger.

Babies born less than 30 weeks gestation:
- Day 1, Day 3 and Day 7 to evaluate for PVH
- Day 28 and term corrected to evaluate for PVL

Babies born between 30-32 weeks gestation:
- Day 1 and Day 7 to evaluate for PVH
- Day 28 and term corrected to evaluate for PVL
Monitoring of Babies at Risk of Post-haemorrhagic Ventricular Dilatation (PHVD)
All babies who are diagnosed with PVH and any infant whose routine measurements of OFC increase across centile lines should have further scans to monitor for evidence of PHVD

- Additional US scans are required in the 2nd-3rd week of life following a diagnosis of PVH. The frequency of these scans will be determined based on the severity of PVH and any indication of the development of PHVD.
- A single scan should be considered in any infant whose OFC crosses centile lines on routine monitoring
- Where possible, a formal radiology scan should ideally be performed in any infant in whom a ventricular drainage procedure is being considered. This may require the transfer of the infant to a tertiary level unit.

What Pictures Should be Taken, Stored and Printed?
Coronal plane (6+ images)
- Frontal lobe: anterior to the frontal horns of the lateral ventricles
- Lateral ventricles: at the anterior horns of the lateral ventricles and Sylvian fissures
- Third ventricle: at the third ventricle and thalami
- Trigone: at the posterior horns of the lateral ventricles (with choroids)
- Occipital cortex: posterior to the choroids (posterior brain substance)
- When there is lateral ventricular dilatation a measurement of the ventriculo-cranial ratio (VCR) should be taken at the level of the foramen of Munro, connecting the third and lateral ventricles.

Sagittal plane (5+ images)
- Mid sagittal view: midline through 3rd ventricle, septum cavum pellucidum, cerebellum with 4th ventricle and foramen magnum
- Parasagittal view: through each lateral ventricle showing the anterior and posterior horns, with the caudothalamic notch imaged if possible (germinal matrix area)
- Tangential parasagittal view: through each hemisphere lateral to the ventricle for deep white matter
- When there is evidence of Hypoxic Ischaemic Encephalopathy (HIE) or ventricular dilatation, the resistance index should be measured using the midsagittal plane. The anterior cerebral artery is identified with colour Doppler at the vertical course, immediately anterior to the genu of the corpus callosum.

Who Should Perform the Scans?
All scans must be performed, or supervised, by a clinician with sufficient experience to ensure the quality of the images produced and their interpretation. Currently consultant paediatricians, middle grade paediatric trainees and Advanced Neonatal Nurse Practitioners are trained to perform and interpret the images. If in doubt ask a more senior colleague.

When Should MRI/CT be Considered?
In infants nearing term with significant intracranial pathology, MRI may be a more appropriate method of neuroimaging and this should always be discussed with the Consultant responsible for that infant’s care.
Frontal Lobe:

The transducer obtains an image through the frontal lobes. The orbital ridge forms the inferior boundary of the image in the centre is seen the interhemispheric fissure which is visible on all images on the coronal plane.

Lateral Ventricles:

The transducer is angled posteriorly. The CSF in the lateral ventricles appears as a dark image, these are often difficult to see in the term infant. Mild asymmetry between the lateral ventricles is common and is within normal limits. The cavum septum pellucidum sits between the lateral ventricles and is often large in preterm infants, this normally reduces in size with brain development and has normally formed the septum pellucidum by term. The corpus callosum which connects the 2 hemispheres appears above the cavum.
Third Ventricle:

With the transducer angled slightly further back, the third ventricle is seen in the midline below the lateral ventricles. It is often difficult to see, but can vary considerably in size. The foramen of Munro (connecting lateral and 3rd ventricles) may be clearly seen. The brainstem may be seen as a tree-like shape. This view with the 3rd ventricle and symmetrical Sylvian fissures is used to measure the ventricular index.

Cerebellum:

Angling back past the third ventricle but anterior to the trigone allows the visualisation of the cerebellum. This appears as a triangular echogenic region at the base of the brain. This view also demonstrates the thalami with the corticospinal tract running through in the internal capsule. This view is very important when looking for evidence of thalamic injury in babies with hypoxic ischemic encephalopathy.
Trigone:

Angling further back cuts through the trigones of the lateral ventricles. The choroid plexus is seen as an echogenic region often filling the lateral ventricles in this view and is particularly prominent in preterm infants. Choroid plexus haemorrhage may be difficult to differentiate from bulky choroid. The white matter around the lateral ventricles may appear quite echodense (bright) in this plane and some refer to this as PV flare. This can only be truly defined if the white matter is at least as bright as the choroid plexus.

Occipital Cortex:

Angling the transducer even more results in an image that slices above the lateral ventricles. In this plane, the occipital cortex may be visualised. This area is important to view when looking for periventricular leukomalacia.
Sagittal Imaging

Mid Sagittal View:

In the centre of the image the corpus callosum is seen running from anterior to posterior as a double tramline. This structure is used to align to a true sagittal view. The cingulated gyrus is visualised above the parallel to the corpus callosum. The cerebellar vermis appears as an echogenic area in the posterior fossa. The 4th ventricle sits anterior to this. The sisterna magna sits below the cerebellar vermis and is not very echogenic. The parieto-occipital sulcus may be seen above the posterior fossa.

Parasagittal View:

The shape of the lateral ventricle is the key landmark for this view, to ensure that the image is straight make sure the posterior horn of the ventricle can be visualised. The caudate nucleus lies below the floor of the frontal horn of the lateral ventricle; the thalamus lies behind and below it- the point of division is seen as a bright echogenic region called the caudothalamic notch. The occipital horn of the lateral ventricle is filled with echogenic choroid plexus.
Tangential Parasagittal View:

Further angulation of the transducer laterally results in a section lateral to the lateral ventricles. The Sylvian fissure is the key landmark in this view.
Appendix 1: Flow Chart of Screening Cranial Ultrasound

Routine Screening Cranial Ultrasound
Clinical judgement to be used if concern or acute deterioration occurs.

Gestational age at Birth

- <30 weeks
  - Routine US at Day 1
  - Routine US at Day 3
  - Routine US at Day 7

- 30-32 weeks
  - Abnormality
    - Yes
      - Abnormality present
      - No
        - US in 2nd-3rd week
        - US at 28 days and 40 weeks CGA (or prior to discharge)

- >32 weeks
  - Abnormality
    - Yes
      - Abnormality present
    - No
      - No additional imaging required

Image if concerns/risk factors including but not limited to:
- Neurologic abnormality including seizures
- Antenatally detected abnormality eg ventriculomegaly
- Concern for HIE
- Congenital abnormalities
- CNS infection (congenital or acquired)
- Coagulopathy or significant thrombocytopenia
- Maternal cocaine use
- OFC crossing percentile lines

If abnormalities or significant concerns present discuss with consultant the role of serial cranial ultrasound and/or MRI
Appendix 2: Abnormalities of Cranial Ultrasound

Background
Abnormal findings in preterm cranial ultrasound include:

- Periventricular haemorrhage PVH
- Periventricular leukomalacia (PVL)
- Ventricular dilatation
- Hydrocephalus

Periventricular haemorrhage
This is most common in the premature population and usually occurs within the first week of life. The incidence of PVH decreases with increasing gestational age, and is rare beyond 34 weeks gestation because of involution of the vascular germinal matrix. The incidence of PVH in infants with a birth weight <1500 grams is decreasing and is quoted in the literature as anywhere between 15% and 30%. Many infants are asymptomatic and these haemorrhages are found on surveillance sonography.

Aetiology/Risk factors for PVH
General pathogenetic factors may include antepartum, intrapartum and neonatal conditions:

<table>
<thead>
<tr>
<th>Antepartum</th>
<th>Intrapartum</th>
<th>Neonatal</th>
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</thead>
<tbody>
<tr>
<td>Prematurity</td>
<td>Low umbilical artery pH</td>
<td>Hyaline membrane disease</td>
</tr>
<tr>
<td>Lack of antental corticosteroids</td>
<td>Delivery outside a tertiary unit</td>
<td>PDA</td>
</tr>
<tr>
<td>Maternal pre-eclampsia</td>
<td>Delivery mode (C-section is protective)</td>
<td>Pneumothorax</td>
</tr>
<tr>
<td>Antepartum haemorrhage</td>
<td>Low 1 minute APGAR</td>
<td></td>
</tr>
<tr>
<td>Chorioamnionitis</td>
<td>Bruising at delivery</td>
<td></td>
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</tbody>
</table>

Grading Periventricular Haemorrhage
PVH may be asymptomatic and without long term consequence. There is a strong association between extensive PVH and early neonatal mortality, neurodevelopmental disability and post haemorrhagic hydrocephalus. See appendix 3 for estimates of the incidence of neurodevelopmental handicap with different severities of PVH.

A full description of the findings should be entered in the notes and logged on Badger. For the purpose of data collection and benchmarking, PVH should be graded using the same system as the Vermont Oxford Network:

- Grade 0: No subependymal or intraventricular haemorrhage
- Grade 1: Subependymal germinal matrix haemorrhage only
- Grade 2: Intraventricular blood, no ventricular dilation
- Grade 3: Intraventricular blood, ventricular dilation
- Grade 4: Intraparenchymal haemorrhage

NB – for Grade 3 PVH, the dilatation of the ventricle refers to dilatation due to the volume of intraventricular blood. Dilatation of the ventricle due to CSF (PHVD) should be recorded as an additional finding.
Grading Periventricular Leukomalacia

Mild degrees of PVL may result in transient periventricular echodensities or mild enlargement of the lateral ventricles. These changes are not associated with a significant increase in neurodevelopmental handicap. In more severe, cystic PVL, the risks of neurodevelopmental handicap are significantly increased as outlined in Appendix 3. The risk of handicap also increases with more extensive and bilateral changes. For the purposes of data collection and benchmarking PVL should be diagnosed only in the presence of cystic PVL.

NB- It is common to find benign periventricular cysts on routine cranial scans. It is important not to mistake these for cystic PVL or porencephaly. The diagram below indicates the typical locations of each type of periventricular cyst.

1 & 2 are germinolytic cysts and pseudocysts (benign) These are at or below the level of the upper part of the lateral ventricle.
3 are cystic periventricular leukomalacia (pathologic). These are mostly above the level of the upper part of the lateral ventricle.
4 are cysts as a result of venous infarct also known as porencephaly (pathologic). These are large and can be above, at or below the upper part of the lateral ventricle.
Assessment of Ventricular dilatation

In addition to routine cranial USS imaging, all premature infants should have measurements of their OFC performed weekly to identify cases of post-haemorrhagic ventricular dilatation (PHVD). All babies with PHVD need regular scans to monitor the progression of the ventricular dilatation and to assess the possible requirement for ventricular drainage. A number of measures have been described to monitor ventricular dilatation and the most widely used is the ventriculo-cranial ratio (VCR and the ventricular index (VI). There is no clear advantage to either measure but it is important to use the same measurement in an individual patient to monitor change over time.

Ventriculo-Cranial Ratio (VCR)
Measurement of the ventricular system needs to be performed on a symmetrical, easily reproducible view. The VCR is the ratio of distance between the lateral sides of the ventricles and the bipartietal diameter. This is usually expressed as a percentage with a normal value of around 33-36% in a preterm infant. This value is of most use in monitoring the degree of change between successive measurements. An increasing VCR should trigger frequent reassessments with measurements of cerebral resistive index.

Ventricular Index (VI)
The VI is the absolute distance between the falx and the lateral wall of the anterior horn in the coronal plane at the level of the third ventricle. Values more than 4mm above the 97th centile for gestational age are indicative of significant ventricular dilatation.
**Resistive Index (RI)**

RI = (S-D)/S where S and D stand for systolic and diastolic velocities measured in the cerebral arteries. The infant’s blood pressure and the carbon dioxide tension need to be taken into account when measuring the RI as these can affect cerebral blood flow. Variations in the RI demonstrate that cerebral blood flow is not well regulated and are often associated with adverse outcomes. It is important to interpret the RI with caution as cerebral blood flow is always changing due to haemodynamic alterations and there is also considerable inter and intra observer variation.

![Resistive Index Diagram](image)

**Interpretation**

**High RI**
A high RI (>0.85) corresponds to low blood flow velocity where vascular resistance is high (eg hydrocephalus). Infants with values higher than this may require ventricular drainage to reduce intracranial pressure.

NB: A high RI must be interpreted with caution in an infant with a PDA as these infants may have a low diastolic velocity due to ductal steal. This will give a high RI value even in infants with normal intracranial pressure.

**Low RI**
A low RI (<0.61) corresponds to high blood flow velocity where vascular resistance is low (eg HIE). In normothermic infants, an RI of <0.55 has a positive predictive value for poor neurological outcome of 84%. However in cooled infants the positive predictive value is lower – 60%.
Appendix 3: Prognosis for USS lesions

**From** - Phumza Nongena, Ash Ederies, Denis V Azzopardi, A David Edwards. Confidence in the prediction of neurodevelopmental outcome by cranial ultrasound and MRI in preterm infants *Arch Dis Child Fetal Neonatal Ed* 2010;95:F388-F390 doi:10.1136/adc.2009.168997

**Table 1**
Prediction of abnormal neuromotor function by cranial ultrasound

<table>
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<tr>
<th>Ultrasound test result</th>
<th>Pre-test probability</th>
<th>Likelihood ratios (95% CI)</th>
<th>Post test probability (95% CI)</th>
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<tbody>
<tr>
<td>Normal scan</td>
<td>9%</td>
<td>0.5 (0.4 to 0.7)</td>
<td>5% (4% to 6%)</td>
</tr>
<tr>
<td>Grade 1 or 2 PVH</td>
<td>9%</td>
<td>1 (0.4 to 3)</td>
<td>9% (4% to 22%)</td>
</tr>
<tr>
<td>Grade 3 PVH</td>
<td>9%</td>
<td>4 (2 to 8)</td>
<td>26% (13% to 45%)</td>
</tr>
<tr>
<td>Grade 4 haemorrhage (any)</td>
<td>9%</td>
<td>11 (4 to 31)</td>
<td>53% (29% to 76%)</td>
</tr>
<tr>
<td>Cystic PVL</td>
<td>9%</td>
<td>29 (7 to 116)</td>
<td>74% (42% to 92%)</td>
</tr>
<tr>
<td>Ventricular dilatation</td>
<td>9%</td>
<td>3 (2 to 4)</td>
<td>22% (17% to 28%)</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td>9%</td>
<td>4 (1 to 13)</td>
<td>27% (10% to 56%)</td>
</tr>
</tbody>
</table>

*Normal scan* refers to absence of haemorrhage within the brain parenchyma or ventricles, cysts or ventricular dilation. The grade of PVH (intraventricular haemorrhage) is given according to the Papile classification. PVL indicates periventricular Leucomalacia. Ventricular dilation indicates moderate to severe ventricular dilation not meeting the criterion for hydrocephalus. Hydrocephalus indicates massive ventricular dilation >4 mm above the 97th centile. Pre-test probability refers to the prevalence of cerebral palsy based on the Epipage study. The likelihood ratio is the probability that a patient with cerebral palsy has a positive test (abnormal ultrasound result). Post-test probability is the probability that a patient with a specific abnormality on cranial ultrasound will have abnormal neuromotor function.


Beek E & Groenendaal F. Neonatal Brain US. The Radiology Assistant by The Radiological Society of the Netherlands: [http://www.radiologyassistant.nl/en/440c93be7456f](http://www.radiologyassistant.nl/en/440c93be7456f)


An audit of 2 year developmental outcomes for infants with PVL. Dr Stewart Guthrie


Northern Neonatal Nursing Initiative Trial Group. Randomised trial of prophylactic early fresh frozen plasma or gelatin or glucose in preterm babies. The Lancet 1996;348:229-232

Benson J, Drayton M, Hayward C et al. Multicentre trial of ethamsylate for prevention of periventricular haemorrhage in very low birthweight infants. The Lancet 1986;ii:1297-1300


Fowlie PW. Prophylactic indomethacin: systemic review and meta-analysis. Cochrane Library


Kendall G. Neonatal Cranial Ultrasound Standard Views lecture at University College London Hospitals December 2014
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