East of England Neonatal ODN
(Hosted by Cambridge University Hospitals)

Clinical Guideline: East of England Regional Guideline: Neuroimaging the Preterm Infant

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For use in: EoE Neonatal Units
Guidance specific to the care of neonatal patients.

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Neonatal Clinical Oversight Group	
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Ratified by ODN Board:

Date of meeting	

Audit Standards:

- All babies < 32 weeks or BW <1500gms have an ultrasound scan on day 1 unless clinically indicated to wait.
- All babies eligible for routine ultrasound scans, follow recommended pathway according to clinical need.

Contents

1. Introduction

Neuroimaging is important for the early detection of brain injury to guide management and prognosis. This guideline provides recommendations for the use of cranial ultrasound (CUS), and MRI in preterm infants.

Preterm infants are at risk of developing intraventricular haemorrhage (IVH), and white matter injury such as periventricular leucomalacia (PVL). The risk of severe IVH is inversely related to gestational age, with infants born at less than 24 weeks gestation at highest risk (Szpecht 2016).

PVL is a disorder of the periventricular cerebral white matter that may be cystic or diffuse in nature. Most cystic PVL occurs in infants born between 26 and 30 weeks gestation. This initially appears as increased echogenicity in the periventricular region described as a flare, with cystic development over the following weeks. In recent years, the incidence of cystic PVL has decreased (van Haastert 2011) and a more subtle, non-cystic and diffuse pattern of injury is better recognised using MRI (de Vries 2013, Agut 2020).

2. Objectives

- To establish a consistent approach to neuroimaging in preterm infants across the East of England region
- To ensure the early detection of intracranial abnormalities in preterm infants in order to guide appropriate management

3. Cranial Ultrasound

Cranial ultrasound (CUS) is the most widely used technique of neuroimaging in preterm infants. It is safe and sensitive at detecting brain abnormalities.

3.1. Indications

- **Routine scanning:** All preterm infants born at <32 weeks gestation or birth weight <1.5kg
- **Targeted scanning:** Preterm infants ≥32 weeks with any of the following:
  - *Neonatal encephalopathy*
  - *Suspected meningitis*

- *Seizures*
- *Congenital viral infection*
- *A sudden drop in haemoglobin*
- *Abnormal head growth: crossing centiles in either direction out of proportion to changes in weight*
- *acute collapse/sepsis/ necrotising enterocolitis*
- *congenital anomaly or suspected genetic syndromes which can be associated with cerebral anomalies*

3.2. Timing

In infants who develop IVH, around 50% present on the first day after birth, 25% on day 2, and 15% on day 3 (Volpe 2017). Around 20%-40% of these infants have progression of haemorrhage over 3-5 days (Volpe 2017).

PVL occurs around 2-6 weeks post ischaemia or infection/inflammation (Leijser 2010). Periventricular cysts present on day 1 is indicative of injury occurring antenatally. Periventricular cysts may also develop much later in the neonatal course, such as weeks following an acute illness such as NEC or severe infection (Perlman 2000).

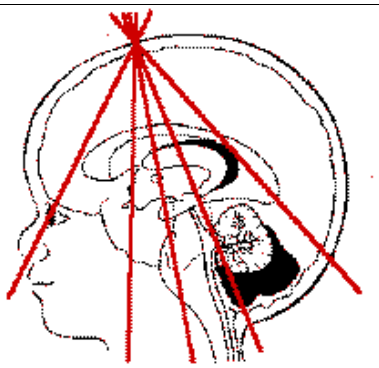
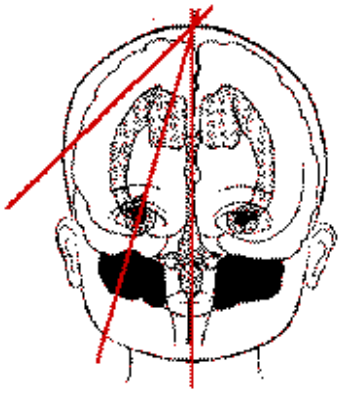
The table below summarises the recommended timelines for CUS scanning:

Routine Scanning: GA <32 weeks or BW < 1.5kg	**Targeted Scanning:** GA ≥ 32 weeks or BW ≥ 1.5kg with criteria as indicated above in section 3.1
Initial: Day 1, Day 3*, Day 7 Day 14 If abnormal** At clinicians' discretion or weekly Day 28 (if born at ≤ 28weeks gestation) CGA 36 weeks or at discharge (whichever is earlier)	Initial: On admission or at time of event Subsequent scans guided by findings and anticipated evolution e.g. Repeat scan 10-14 days following acute collapse/ sepsis/ NEC/ meningitis/ IVH And at discharge if abnormal*
* The Incidence if IVH increases with decreasing gestational age, Reducing IVH care bundles have shown to reduce the incidence of IVH in babies 30weeks gestation and under. All babies requiring a day 1 head scan should have one performed if clinically stable as soon as possible after birth. If the baby is clinically stable day 3 scan can be performed at the end of the 72 hour window. See EoE reducing IVH in preterm babies. **Abnormal: Intraventricular haemorrhage, periventricular flare, periventricular cyst Note: For post-haemorrhagic ventricular dilatation, refer to EoE regional guidance: Management of post-haemorrhagic ventricular dilatation for the frequency of scanning.	

Refer to Appendix 1 for a quick reference guide for indications and timelines for CUS scanning.

3.3. Standard Images

The head should be scanned in coronal (frontal) and sagittal/parasagittal (lateral) planes through the anterior fontanelle as summarised in the table below. See Appendix 2 for sample images for standard views.

Coronal Plane (5 images) 1. Anterior to the frontal horn of the lateral ventricles. 2. At the level of the third ventricle and thalami (midline). 3. Through the body of the lateral ventricle. 4. At the level of the posterior horns of the lateral ventricles (with choroids). 5. Posterior to the choroids.	
Sagittal Plane (5 images) 1. Midline through the 3rd ventricle, cavum septum pellucidum, cerebellum with 4th ventricle and foramen magnum. 2. Through each lateral ventricle showing anterior and posterior horns, with the caudothalamic notch imaged if possible. 3. Through each hemisphere lateral to the ventricle for deep white matter.	

3.4. Abnormal Findings and Interpretation

Abnormal findings in a preterm cranial ultrasound include:

- Intraventricular haemorrhage
- Periventricular leucomalacia (PVL)
- Ventricular dilatation
- Hydrocephalus

In infants with congenital viral infection, calcification, ventriculitis or abscesses may be seen. Refer to the EoE guidance: Management of post-haemorrhagic ventricular dilatation for the interpretation of ventricular dilatation and hydrocephalus.

3.4.1. Intraventricular haemorrhage (IVH)

The Papile grading system (Papile 1978) is the most commonly used IVH grading system. The severity of haemorrhage is based on the extent of bleeding, parenchymal involvement, and the presence of ventricular distension:

- **Grade 1 IVH:** haemorrhage is limited to the germinal matrix
- **Grade 2 IVH:** involves blood in the ventricles
- **Grade 3 IVH:** blood filing and distending of the ventricular system
- **Grade 4 IVH:** extensive bleeding in the ventricles with periventricular haemorrhagic infarction

While the Papile grading system is widely used for categorising the severity of IVH, it is recommended that a detailed descriptive report of imaging findings is provided to enhance communication and clinical decision-making.

3.4.2. Periventricular Leucomalacia (PVL)

PVL on CUS can be described with four grades of severity (de Vries 1992):

- **Grade 1 PVL:** transient periventricular areas with increased echogenicity for 7 days or more
- **Grade 2 PVL:** small, localised fronto-parietal cysts
- **Grade 3 PVL:** extensive periventricular cystic lesions
- **Grade 4 PVL:** areas of increased echogenicity in deep white matter which are evolving into extensive cystic lesions

Similarly, a descriptive report of the location and extent of periventricular cysts is more informative than only reporting the grade of severity.

3.5. Prognosis for CUS lesions

The primary prognostic value of routine serial cranial ultrasound scanning in preterm lies in providing reassurance that infants with consistently normal sequential scans, without grade 3-4 IVH, parenchyma haemorrhage, cystic PVL, or post-haemorrhagic ventricular dilatation, have a low risk of developing cerebral palsy.

While negative predictive value of serial cranial ultrasound for major motor disabilities (cerebral palsy) is high, the predictive accuracy for cognitive, language and behavioural outcomes remains limited. This reflects the inherent complexity of predicting high-order cognitive function from structural brain imaging alone, as these outcomes are influenced by multiple factors including subtle white matter changes and environmental stimulation, which may not be detectable on routine cranial ultrasound.

The probabilities of cerebral palsy (CP) at 2 years of age associated with specific imaging findings are shown in the table below (Nongena 2010).

Table 1 Prediction of abnormal neuromotor function by cranial ultrasound

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

Note: CP is broadly categorised as abnormal neuromotor development (estimated as the presence of cerebral palsy or a low Bayley Psychomotor Developmental Index of below 70) or cognitive impairment (estimated as a low Bayley Mental Developmental Index of below 70 or a Griffiths Developmental Quotient of below 85). Ventricular dilatation indicates moderate to severe ventricular dilation not meeting the criterion for hydrocephalus. Hydrocephalus indicates massive ventricular dilation >4mm above the 97th centile. Pre-test probability refers to the prevalence of CP based on the Epipage study (Zamora 2006). The likelihood ratio is the probability that a patient with CP has a positive test (abnormal CUS result). Post-test probability is the probability that a patient with a specific abnormality on CUS will have abnormal neuromotor function.

The specific location of cystic PVL has been reported to be of predictive value in some but not all studies. Descending fibres from the motor cortex are generally located superior and lateral to the lateral ventricles, and those fibres that are closely related to lower extremity function are adjacent to the lateral ventricles. Therefore, PVL in those areas is linked to the development of spastic diplegia.

4. MRI

MRI at term equivalent age (TEA) provides more anatomic detail than CUS, which has led to:

- A greater appreciation of the nature and extent of periventricular white matter abnormalities (Maalouf 1999; Dyet 2006; Inder 2003; Cornette 2002).
- Detailed visualisation of the posterior limb of the internal capsule and cerebellar injury, both of which may carry prognostic significance (de Vries 1999; Tam 2010).
- The appreciation of basal ganglia and thalamic injury.

However, MRI is not routinely indicated for all preterm infants as available evidence indicates it only adds modest value to CUS for predicting outcomes, which has to be balanced against the logistics and cost of scanning. The optimal timing for MRI of the preterm infant is 40-44 weeks postmenstrual age because this allows for assessment of brain maturation and myelination. (BAPM 2023; Guillot 2020; Hand 2020). For further information on preterm MRI, click on this link for Neonatal Brain Magnetic Resonance Imaging: clinical indications, acquisition and reporting.

Neonatal units should ensure access to appropriate facilities, either on-site or through established pathways. MRI should be reported by a consultant radiologist with expertise in neonatal brain MRI interpretation. MRI scans should be stored in compliance with Data Protection Act and should be easily retrievable for later case review if needed.

4.1. Indications

MRI should be considered in the following:

- Evidence of parenchymal injury on CUS (large IVH, haemorrhagic parenchymal infarction, cystic PVL, post haemorrhagic ventricular dilatation, or focal pathology including cerebellar lesions)
- Abnormal neurological signs
- To aid diagnosis

4.2. Timing

Optimal timing for preterm infants is at least TEA (40-44 weeks) as this enables the assessment of brain maturation and myelination.

Earlier MRI may be indicated in the following cases:

- Neurometabolic disease
- Congenital infection
- CNS malformation
- Assist surgical planning (e.g. for post haemorrhagic ventricular dilatation treatment)
- Unexplained abnormal signs
- Inform end-of life decisions

4.3. Prognostic value

4.3.1. Prediction of neuromotor outcome

The ePrime RCT showed that MRI predicted moderate to severe functional motor impairment at 20 months only slightly better than CUS: AUC 0.74 (CI 0.66-0.83) for MRI versus 0.64 (CI 0.56-0.72) for CUS (Edwards 2018).

4.3.2. Prediction of cognitive outcome

The ePrime study reported that MRI has high specificity 88.9% (95% CI 85.2-91.9) but low sensitivity 27.9% (95%CI 19.8-37.2) for predicting scores <85 on the Bayley III cognitive domain at 2 years (Edwards 2018). The area under the receiver operator characteristic curve is <0.6 for both CUS and MRI. These findings are consistent with a low sensitivity of MRI for predicting cognition at 5 years of age after very preterm birth (Setanen 2013).

5. References

Szpecht D, Szymankiewicz M, Nowak I, Gadzinowski J. Intraventricular hemorrhage in neonates born before 32 weeks of gestation-retrospective analysis of risk factors. Childs Nerv Syst. 2016;32(8):1399–1404

van Haastert IC, Groenendaal F, Uiterwaal CS, et al. Decreasing incidence and severity of cerebral palsy in prematurely born children. J Pediatr 2011;159(1):86–91.e1.

de Vries LS, Benders MJ, Groenendaal F. Imaging the premature brain: ultrasound or MRI? [critique]. Neuroradiology. 2013;55(Suppl 2):13-22. http://1.107.195.164.

Agut T, Alarcon A, Cabañas F et coll. Preterm white matter injury: ultrasound diagnosis and classification. Pediatr Res. 2020;87(1):37-49. doi:10.1038/ s41390-020-0781-1

Volpe JJ, Inder TE, Darras BT, de Vries LS, du Plessis AJ, Neil JJ, Perlman J. (2017). Volpe's Neurology of the Newborn, 6e éd. Philadelphie, PA: Saunders Elsevier, doi:10.1016/c2010-0-68825-0

Leijser LM, de Bruine FT, van der Grond J, Steggerda SJ, Walther FJ, van Wezel- Meijler G. Is Sequential Cranial Ultrasound Reliable for Detection of White Matter Injury in Very Preterm Infants? Neuroradiology 52(5):397–406 doi.org/10.1007/ s00234-010-0668-7.

Perlman JM, Rollins N. Surveillance protocol for the detection of intracranial abnor- malities in premature neonates. Arch Pediatr Adolesc Med 2000;154(8):822–6.

Papile LA, Burstein J, Burstein R, Koffler H. Incidence and evolution of subependymal and intraventricular hemorrhage: A study of infants with birth weights less than 1,500 gm. J Pediatr 1978;92(4):529–34.

de Vries LS, Eken P, Dubowitz LM. The spectrum of leukomalacia using cranial ultra- sound. Behav Brain Res 1992;49(1):1–6.

Nongena P, Ederies A, Azzopardi D, Edwards AD. 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.

Zamora J, Abraira V, Muriel A, et al. Meta-DiSc: a software for meta-analysis of test accuracy data. BMC Med Res Methodol 2006;6:31.

Maalouf EF, Duggan PJ, Rutherford MA, et al. Magnetic resonance imaging of the brain in a cohort of extremely preterm infants. J Pediatr 1999;135(3):351-7. doi: 10.1016/s0022- 3476(99)70133-2 [published Online First: 1999/09/15]

Dyet LE, Kennea N, Counsell SJ, et al. Natural history of brain lesions in extremely preterm infants studied with serial magnetic resonance imaging from birth and neurodevelopmental assessment. Pediatrics 2006;118(2):536-48. doi: 10.1542/peds.2005-1866 [published Online First: 2006/08/03]

Inder TE, Wells SJ, Mogridge NB, et al. Defining the nature of the cerebral abnormalities in the premature infant: a qualitative magnetic resonance imaging study. J Pediatr 2003;143(2):171-9. doi: 10.1067/S0022-3476(03)00357-3 [published Online First: 2003/09/13]

Cornette LG, Tanner SF, Ramenghi LA, et al. Magnetic resonance imaging of the infant brain: anatomical characteristics and clinical significance of punctate lesions. Arch Dis Child Fetal Neonatal Ed 2002;86(3):F171-7. doi: 10.1136/fn.86.3.f171 [published Online First: 2002/04/30]

De Vries LS, Groenendaal F, van Haastert IC, et al. Asymmetrical myelination of the posterior limb of the internal capsule in infants with periventricular haemorrhagic infarction: an early predictor of hemiplegia. Neuropediatrics 1999;30(6):314-9. doi: 10.1055/s-2007-973511 [published Online First: 2000/03/08]

Tam EW, Rosenbluth G, Rogers EE, et al. Cerebellar hemorrhage on magnetic resonance imaging in preterm newborns associated with abnormal neurologic outcome. J Pediatr 2011;158(2):245- 50. doi: 10.1016/j.jpeds.2010.07.049 [published Online First: 2010/09/14]

Neonatal Brain Magnetic Resonance Imaging: Clinical indications, acquisition and reporting. A Framework for Practice. BAPM Nov 2023

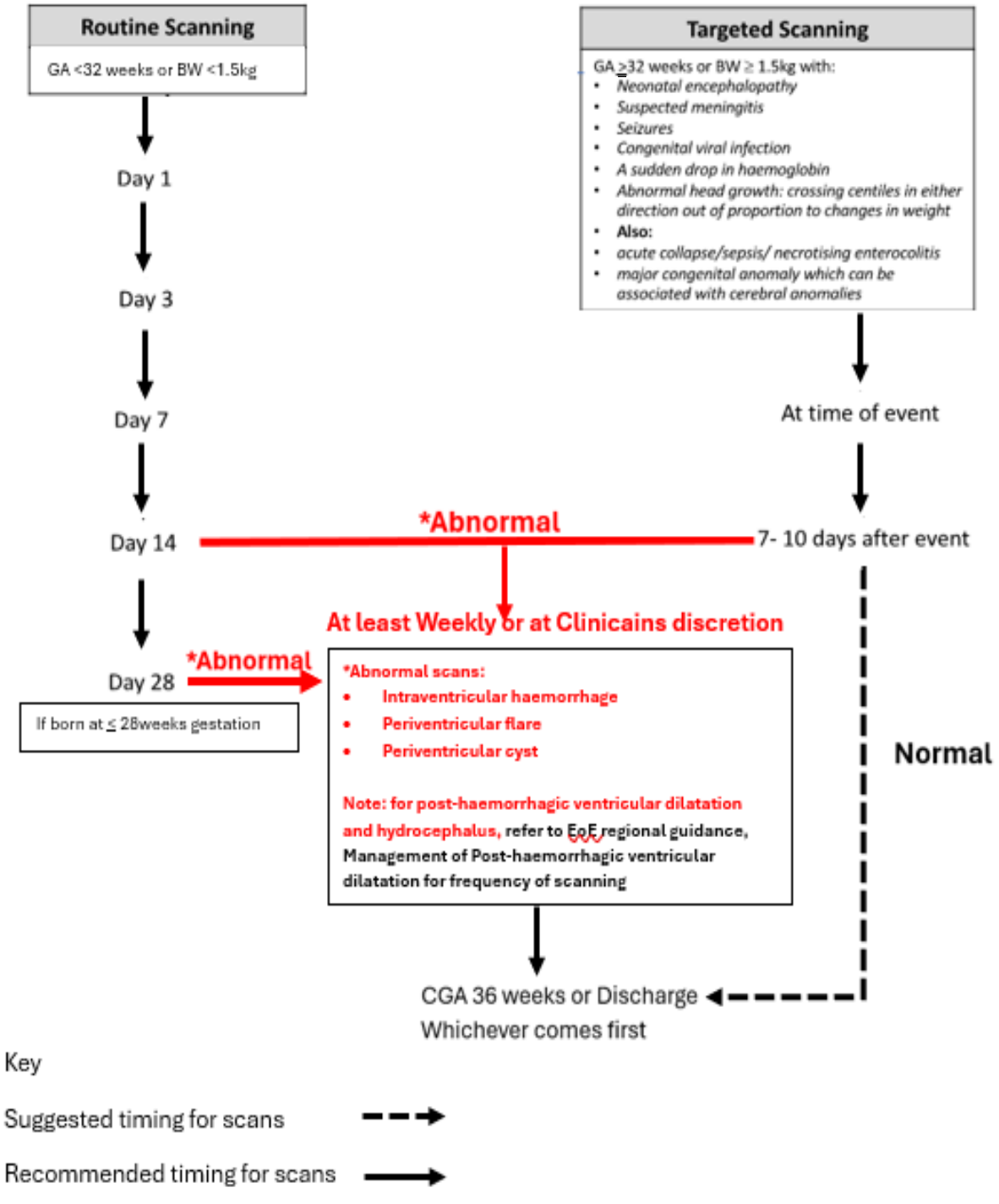
Guillot M, Chau V, Lemyre B. Routine imaging of the preterm neonatal brain. Paediatr Child Health. 2020 Jun;25(4):249-262. doi: 10.1093/pch/pxaa033. Epub 2020 Jun 10. Erratum in: Paediatr Child Health. 2021 May 24;26(4):259. doi: 10.1093/pch/pxaa126. PMID: 32549742; PMCID: PMC7286736.

Hand IL, Shellhaas RA, Milla SS; COMMITTEE ON FETUS AND NEWBORN, SECTION ON NEUROLOGY, SECTION ON RADIOLOGY. Routine Neuroimaging of the Preterm Brain. Pediatrics. 2020 Nov;146(5):e2020029082. doi: 10.1542/peds.2020-029082. PMID: 33106343.

Edwards AD, Redshaw ME, Kennea N, et al. Effect of MRI on preterm infants and their families: a randomised trial with nested diagnostic and economic evaluation. Arch Dis Child Fetal Neonatal Ed 2018;103(1):F15-F21. doi: 10.1136/archdischild-2017-313102 [published Online First: 2017/10/11]

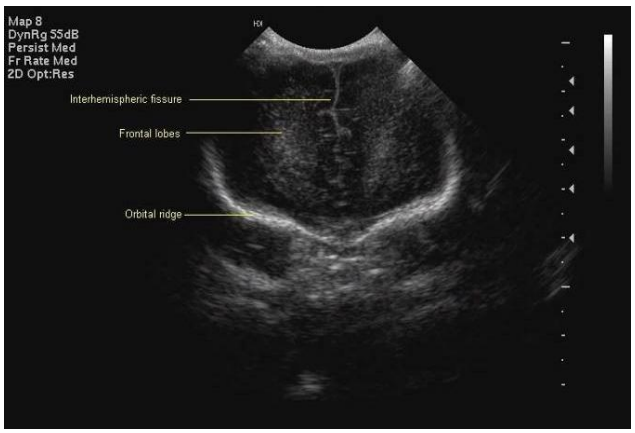
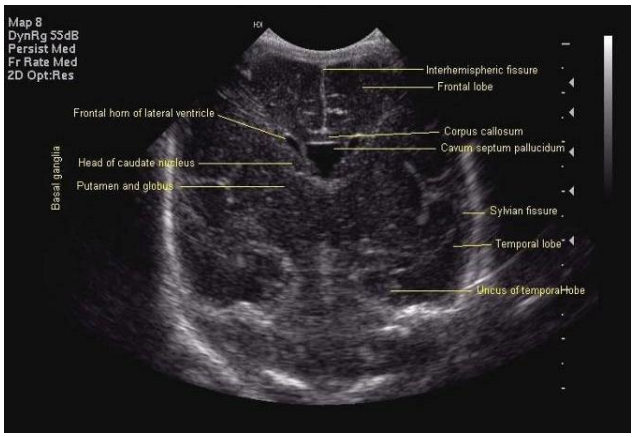
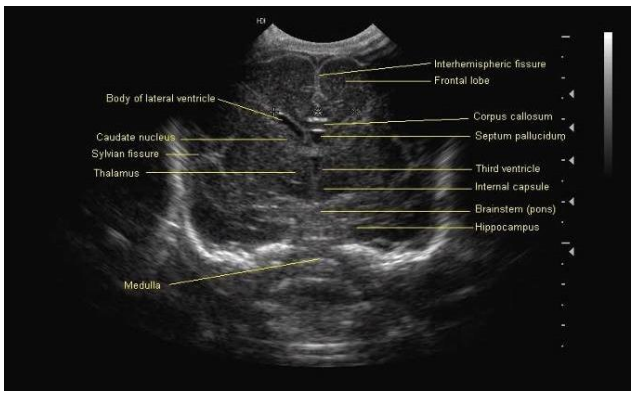
Setanen S, Haataja L, Parkkola R, et al. Predictive value of neonatal brain MRI on the neurodevelopmental outcome of preterm infants by 5 years of age. Acta Paediatr 2013;102(5):492-7. doi: 10.1111/apa.12191 [published Online First: 2013/02/13]

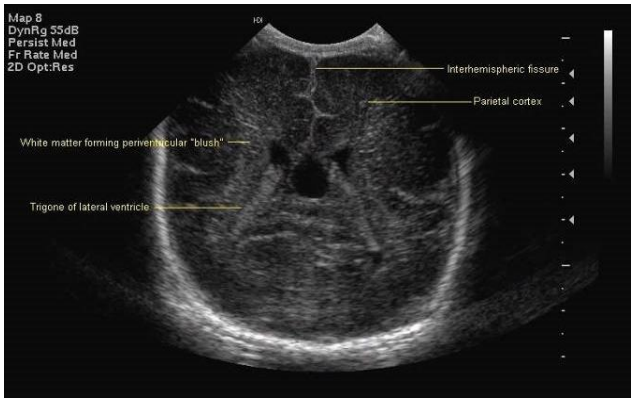
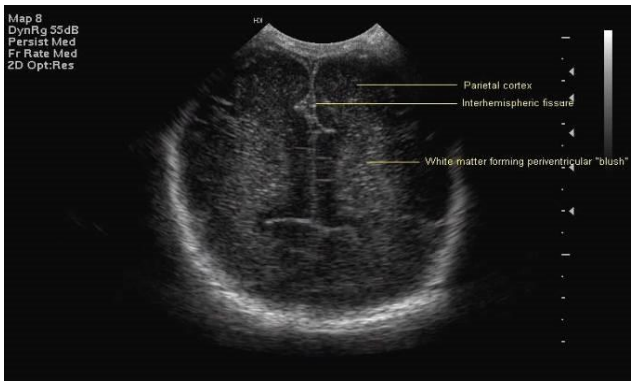
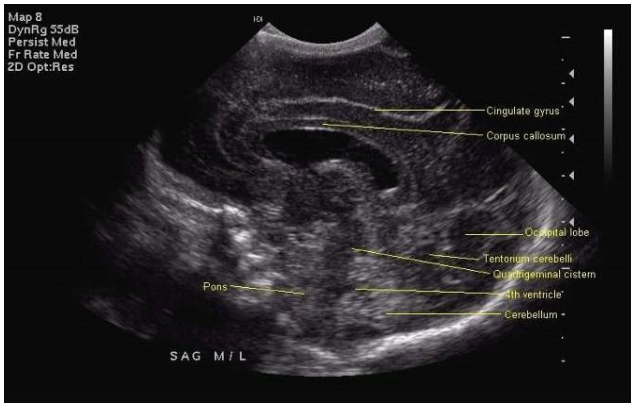
Appendix 1: Quick reference guide for cranial ultrasound scanning

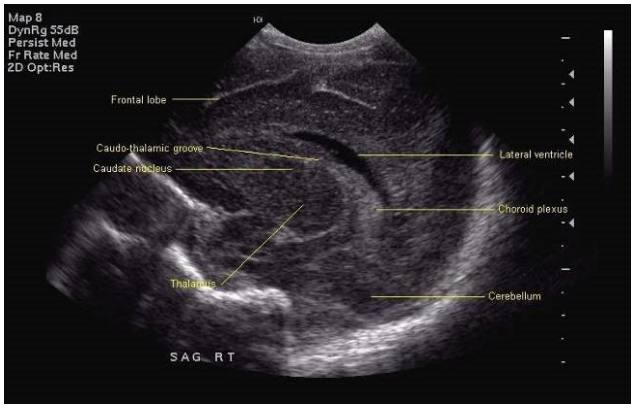
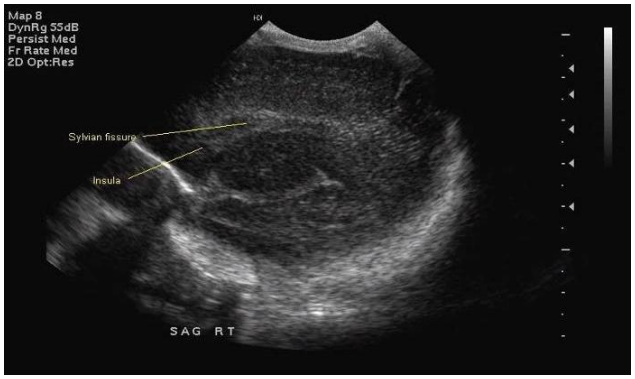


Appendix 2: Sample images of standard cranial ultrasound images

Images and descriptions from Starship Child Health

Frontal Lobes The transducer obtains an image through the frontal lobes. The orbital ridge forms the inferior boundary of this image.	
Anterior Horns of the Lateral Ventricles The transducer is angled back. The CSF in the lateral ventricles appears as a dark image. The lateral ventricles are larger in preterm infants than in term infants. Asymmetry between the lateral ventricles is common and is not necessarily abnormal. The cavum septum pallucidum sits between the lateral ventricles and is often large in preterm infants. The corpus callosum appears above the cavum.	
The Third Ventricle With the transducer shifted slightly further back, the third ventricle appears below both lateral ventricles and the septum pallucidum. It is often small and difficult to see, but can vary considerably in size. The foramen of Monro (connecting lateral and 3rd ventricles) may be clearly seen. The brainstem may be seen as a tree-like shape.	

Trigone Angling further back cuts through the trigones of the lateral ventricles. The choroid plexus fills the lateral ventricles in this view and is 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 is sometimes called a "blush" or "flare". Angling the transducer even more results in an image that slices above the lateral ventricles. In this plane, the occipital cortex may be visualised.	
	
Midline Sagittal This identifies useful landmarks. The cerebellar vermis shows up as an echogenic image in the posterior fossa. The 4th ventricle sits in front of this. The cisterna magna sits below the cerebellar vermis and is not very echogenic. The corpus callosum is seen sweeping from anterior to posterior with the cingulate gyrus above and parallel to it. The parieto-occipital sulcus is seen well above the posterior fossa.	

Angled Parasagittal The shape of the lateral ventricle is the key landmark for this view. The caudate nucleus lies below the floor of the frontal horn of the lateral ventricle; the thalamus lies behind and below it. The occipital horn of the lateral ventricle is filled with choroid plexus. The choroid tucks up in the caudothalamic groove in the floor of the lateral ventricle and may be echogenic.	
Tangential Parasagittal 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.	

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Exceptional Circumstances Form

Form to be completed in the **exceptional** circumstances that the Trust is not able to follow ODN approved guidelines.

Details of person completing the form:	
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Rationale why Trust is unable to adhere to the document:	
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