NHS
Norfolk and Norwich University Hospitals
NHS Foundation Trust

NHS
James Paget University Hospitals
NHS Foundation Trust

Joint Trust Guideline for Cranial Ultrasound Scanning of Infants in NICU

A clinical guideline recommended

For use in:	Neonatal Intensive Care Unit (NICU)
By:	NICU Consultants, SpRs, Specialty Trainees, and ANNPs; Radiologists
For:	Infants cared for in the NICU
Division responsible for document:	Women and Children's Division
Key words:	Cranial Ultrasound, Intraventricular Haemorrhage, Periventricular Leukomalacia
Name of document author:	Dr Paul Clarke, Dr Priya Muthukumar
Job title of document author:	Consultant Neonatologists
Name of document author's Line Manager:	Dr Joaquin Nieto
Job title of author's Line Manager:	Chief of Division
Supported by:	Dr Mary Anne Morris, Chief of Service Paediatrics (NNUH) Dr P Ambadkar, Consultant Paediatrician (JPUH)
Assessed and approved by the:	Clinical Guidelines Assessment Panel (CGAP) If approved by committee or Governance Lead Chair's Action; tick here ☑
Date of approval:	06/09/2021
Ratified by or reported as approved to (if applicable)**:**	Clinical Safety and Effectiveness Sub-Board
To be reviewed before: This document remains current after this date but will be under review	06/09/2024
To be reviewed by:	Authors
Reference and / or Trust Docs ID No:	1291
Version No:	3
Compliance links: *(is there any NICE related to guidance)*	No
If Yes - does the strategy/policy deviate from the recommendations of NICE? If so why?	N/A

Trust Guideline for Cranial Ultrasound Scanning of Infants in NICU

Version and Document Control:

Version No.	Date of Update	Change Description	Author
1	16 June 2014	Change of header and reference to joint hospital version.	THCGAP
2	14 October 2016	Amendments to flowchart request for radiology, RIS added to ICE entry and key people amended.	CGAP
2.1	18/05/2020	6 month extension granted – due to Covid-19 crisis.	Dr Paul Clarke, Dr Priya Muthukumar
3	06/09/2021	As nearly all NICU's neonatal head scans are now done in house by the neonatal medicine team, and it is unusual for radiologist head scans on the NICU, the relevant section has been amended accordingly.	Dr Paul Clarke, Dr Priya Muthukumar

This is a Controlled Document

Printed copies of this document may not be up to date. Please check the hospital intranet for the latest version and destroy all previous versions.

Trust Guideline for Cranial Ultrasound Scanning of Infants in NICU

Quick reference guideline

Birth Gestation <32 weeks
or
Birth weight <1500g

*Serial cranial USS to be done '**IN HOUSE**' for all infants according to following schedule:*

Within first 24 hours
Day 3 -7
Additional scan at day 10-14 if one of:

- –Born at <28 weeks
- –pCO_2 <3 kPa
- –Hypotension required inotropes
- –Chorioamnionitis
- –Sepsis or necrotising enterocolitis
- –Previous scan abnormal (eg grade 2-4 IVH, ventriculomegaly, PVL/ periventricular flare)

Day 28 (±5 days)

If <30 weeks and/or birth weight <1000 g:
Final scan at 36 weeks postmenstrual age (±1 week)

Birth Gestation ≥32 weeks
and
Birth weight ≥1500g

*At least one cranial USS to be done '**IN HOUSE**'*

any preterm baby 32^{+0} to 36^{+6} weeks gestation who required admission for any period of intensive or high-dependency care
Any baby with one of the following diagnosis/risk factors:

- **Neonatal encephalopathy/hypothermia therapy**
- **Seizures**
- **Meningitis**
- **Metabolic disease**
- **Maternal cocaine use in pregnancy**
- **Congenital viral infection**
- **necrotising enterocolitis* (treated for ≥10 days)**
- **Septicaemia***
- **Suspected or proven Chorioamnionitis***

**scan at ~2-3 weeks in case of*

Requests for Radiologist Scans

A first or additional cerebral ultrasound may reasonably be requested to be done by a radiologist for the following indications:

Significant abnormal cranial USS finding on a previous scan (e.g. suspected grade 3-4 IVH, PVL, significant ventriculomegaly)
Antenatally-detected intracranial abnormality
In the following conditions when an abnormality has been suspected from an in-house scan, or at the request of the consultant neonatologist: **- Neonatal encephalopathy/ hypothermia therapy**

- **Seizures**
- **Treated for meningitis**
- **Metabolic disease**
- **Maternal cocaine use in pregnancy**
- **Congenital viral infection**
- **necrotising enterocolitis * (treated for ≥10 days)**
- **Septicaemia***

Chorioamnionitis
*ideally ~2-3 weeks later, to exclude white matter injury
At request of consultant neonatologist in miscellaneous cases where an expert radiologist's opinion is needed

Objectives of guideline

- To indicate which infants should undergo routine cerebral ultrasound scans in the NICU.
- To guide the appropriate timing of cranial USS in these infants
- To identify germinal matrix haemorrhage (GMH), intraventricular haemorrhage (IVH), periventricular haemorrhage (PVH) and periventricular leukomalacia (PVL) in high-risk infants.
- To guide proper requesting, performing, transmission, reporting, and documentation of cranial USS done on the NICU.

Rationale for the recommendations

Neonatal cranial ultrasound examination has been available since the 1970s and has proved to be a safe, sensitive and specific screening method for detection of perinatal brain injury in high-risk premature and VLBW (very low birth weight) infants[1,2]. Infants at greatest risk are those less than 32 weeks gestation and/or less than 1500g at birth[1,3,5,6].

Chorioamnionitis is also a significant risk factor for cerebral damage[3,4]. Serial cranial ultrasound scans to screen for GMH/IVH and PVL provide valuable information to help counsel parents regarding the prognosis for neurodevelopmental outcome of their infant, and may influence the appropriateness of continuing intensive care.

Optimal timing of follow-up cranial ultrasonography is important in the overall care of at-risk infants. The following recommendations are made based on currently-available evidence[5,6].

This guideline is for the routine screening of at-risk infants. We acknowledge that these guidelines are not exhaustive as there may be other indications for neonatal cranial USS.

Broad recommendations

The indication for cerebral ultrasound and required schedule for scanning varies according to gestational age at birth, birth weight, and clinical condition. The schedule is shown in the ‘Quick Reference Guideline’ on page 2.

Who should perform Cranial USS?

Cranial USS may be performed by radiologists, neonatal consultants, advanced neonatal nurse practitioners (ANNPs) or specialist trainee doctors. Neonatal ST trainees and ANNPs are encouraged to perform cranial USS under supervision on NICU. Severe haemorrhages or PVL should always be confirmed by a consultant radiologist or consultant neonatologist.

Procedure for requesting Cranial USS

All requests for cranial USS (both in-house and formal radiologist scans) should be made electronically via the ICE and RIS (Soliton Radiology) systems. All cranial USS requests must provide sufficient pertinent clinical information. Requests for a radiologist scan must ensure complete clinical details and the reason for the request are included (e.g. simply stating 'preterm on vent' is inadequate).

The requester must ensure that the correct ICE examination code is used for the required cranial USS, namely:

- For in-house ('Neonatologist') head scan (i.e. to be done by SpR/ ST/ ANNP/ Consultant), tick: ☑ **NICU scan Paed. brain**
- For Radiologist scan, tick: ☑ **Ultrasound Paed Brain**

i) Radiologist Scan

Requests for radiologist scans should be made by contacting one of the duty consultant radiologists (Dr Fiaz, Dr Gladwell, or Dr MacIver).

ii) In-house Scan

Request the cranial USS on ICE, as detailed above. Note that if a 'NICU scan paediatric brain' request is made on ICE, the radiologists will always assume that the scan will be undertaken by the NICU staff. In house requests will therefore be ignored by the radiologists and furthermore will be deleted from the system if the request on ICE remains unused for longer than a day.

Procedure for undertaking cranial USS

Strict infection control precautions must be adhered to, which includes hand washing and thorough cleaning of the transducer probe with a suitable disinfectant before and after each procedure. A 7.5 MHz transducer is recommended[6]. The curved linear array C5-8 transducer is suitable for neonatal cranial USS.

Sending in-house cranial USS images to PACS

Images should be recorded onto the hard drive of the US machine using the 'Acquire' button. At the end of the examination, the study images should be uploaded to Synapse PACS by a trained member of staff. In-house scan images should be sent to PACS as soon as possible after the scan is done, and in any event within 24 hours of the scan. It is the responsibility of whoever does the scan to ensure that their images are successfully sent to Synapse PACS.

Reporting and documentation of cranial USS findings

i) Radiologist cranial USS It is the responsibility of the neonatal ST Trainee/ANNP to chase radiologist reports on any scans done on the neonatal unit, and to ensure that they are properly documented in each infant's casenotes (i.e. on the cranial USS record sheet) in a timely manner.

ii) In-house cranial USS It is the responsibility of whoever does the scan to ensure that their report always accompanies the cranial USS images. Reports on scans done in-house should be documented as follows:

- On the cranial USS record sheet (gold-coloured) in the patient notes
- Electronically via the RIS system/ radiology iWeb, so that the formal report appears on Synapse PACS/ ICE

Quality Control of in-house cranial USS

Any scan done by a specialist trainee doctor or ANNP must be reviewed by one of the consultant neonatologists (usually the neonatologist on service) so that a report can be agreed. This should be done in every case and it is the responsibility of the junior or middle grade doctor who performed the scan to ensure that their images are looked at by the attendant neonatologist. When reporting on RIS, the report should be left as 'unauthorised' until a consultant has reviewed both images and the draft report. Thereafter the agreed report can be changed to 'authorised'.

Informing parents about cranial USS findings

Parents must always be updated on the cranial USS report of their infant. Parents should be informed of the scan findings within 48 hours of the scan. Parents of infants with significantly abnormal cranial USS should be counselled by the NICU consultant (i.e. where scans show grade 3 or 4 IVH, PVL, cerebral oedema, or major structural abnormality). Mild cranial USS abnormalities and subsequent scans done on infants with already-known significant abnormality may be communicated by neonatal specialist trainee or ANNP. Cranial USS which are reported as "Normal" can be communicated to parents by either medical or nursing staff.
It should be documented on the cranial USS record sheet when the cranial USS results have been given to any parent/s.

Parents should be made aware of the limitations of cranial USS in predicting neurodevelopment. A normal cranial USS is not a guarantee of normal neurological outcome. All infants in high risk groups should have neurodevelopmental monitoring as part of their long term follow up[11].

Clinical audit standards

- All infants born at <32 weeks, or of VLBW (<1500g) or with suspected maternal chorioamnionitis undergo serial cranial USS in line with the schedule described in this guideline.
- More mature infants born at a birth gestation of >32 weeks and who are of birth weight ≥1500g and who required any period of intensive or high dependency care receive at least one USS before discharge (including one at

age ~2-3 weeks where chorioamnionitis was suspected).

- Quality of documentation is such that all cranial USS undertaken on the NICU are properly reported, documented, and conveyed to parents in a timely manner and as described in this guideline.

Summary of development and consultation process undertaken before registration and dissemination

The authors on behalf of the Department of Neonatal Medicine have drafted this guideline. During its development it was presented and discussed at the Neonatal Unit Guidelines Meeting and was circulated for comment to consultant neonatologists, consultant Radiologists, the PACS & Radiology IT Manager, SpRs, ST Trainees, and ANNPs. All had an opportunity to review the guideline and offer feedback. The development of a previous version of this guideline was assisted thanks to the kind advice of Professor Linda de Vries (Wilhelmina Children's Hospital/University Medical Center Utrecht, Netherlands), Dr Gerda van Wezel-Meijler (Department of Neonatology, LUMC, Leiden, Netherlands, and Dr Frances Cowan, Senior Lecturer in Perinatal Neurology Imperial College and NICU Hammersmith Hospital, London.

In august 2021 Dr. Paul Clark reviewed and amended and Dr. Priya Muthukumar agreed the changes.

This version has been endorsed by the Clinical Guidelines Assessment Panel.

Distribution list / dissemination method

NICU and hospital intranet.

References/ source documents

1. Papile LA, Burstein J, Burstein R, Koffler H. Incidence and evolution of subependymal and intraventricular hemorrhage: a study of infants with birthweights less than 1500 g. *J Pediatr.1978; 92 :529 –534.*

2. Maalouf EF, Duggan PJ. Comparison of Findings on Cranial Ultrasound and Magnetic resonance Imaging in Preterm Infants. *Pediatrics. 2001 April; 107 (4):719-27*

3. Bernhard R, Vollaard E. Risk factors and Determinants of Neurodevelopmental Outcome in Cystic Periventricular Leucomalacia*. Eur J Paedr 2000.159:663-670.*

4. Locatelli A, Ghidini A, Paterlini G et al. Gestational age at preterm premature rupture of membranes: A risk factor for neonatal white matter damage. *Am J Obstet Gynecol. 2005 Sep;193(3 Pt 2):947-5.*

5. Perlman JM, Rollins M. Surveillance protocol for the detection of intracranial abnormalities in premature neonates. *Arch Pediatr Adolesc Med. 2000 Aug;154(8):822-6.*

6. De Vries L et al. Ultrasound abnormalities preceding cerebral palsy in high-risk preterm infants. *J Pediatr. 2004 Jun;144(6):815-20.*

7. De Vries L et al. The spectrum of leukomalacia using cranial ultrasound. *Behav Brain Res 1992 Jul 31;49(1):1-6.*

8. van Wezel-Meijler et al. Magnetic resonance imaging of the brain in premature infants during the neonatal period. Normal phenomena and reflection of mild ultrasound abnormalities. *Neuropediatrics. 1998 Apr;29(2):89-96.*

9. Levene MI. Measurement of the growth of the lateral ventricles in preterm infants with real-time ultrasound. *Arch Dis Child. 1981 Dec;56(12):900-4.*

10. Grasby DC, Esterman A, Marshall P. Ultrasound Grading of Ventricular Dilatation in Preterm Neonates. *J Paediatr Child Health. 2003.39: 186-190*.

11. Marlow N. Introduction: Neurodevelopmental follow up after preterm birth. *Early Hum Dev. 2006 Mar;82(3):149-50*.

12. Volpe JJ, Intraventricular hemorrhage and brain injury in the premature infant. Diagnosis, prognosis, and prevention. *Clin Perinatol 1989 Jun;16(2):387-41.*

13. Volpe JJ, Intraventricular hemorrhage and brain injury in the premature infant. Neuropathology and pathogenesis**.** *Clin Perinatol 1989 Jun;16(2):361-86.*

14. Costeloe K, Hennessy E, Gibson AT et al, The EPICure study: outcomes to discharge from hospital for infants born at the threshold of viability*. Pediatrics 2000 Oct;106(4):659-71*.

15. Murphy BP, Inder TE, Volpe JJ et al, Posthaemorrhagic ventricular dilatation in the premature infant: natural history and predictors of outcome. *Arch Dis Child 2002.87(1):F37-F4.*

16. Levene MI. Cerebral Ultrasound and Neurological Impairment. *Arch Dis Child 1990;65:469-71*

17. Levene MI et al. prediction of Cerebral Palsy in Very Low Birth Weight Infants: Prospective Ultrasound Study. *Lancet 1987; ii:593-6*

18. Pierrat V, de Vries L et al. Ultrasound diagnosis and neurodevelopmental outcome of localised and extensive cystic periventricular leucomalacia. *Arch Dis Child Fetal Neonatal Ed. 2001 May;84(3):F151-6.*

19. Vergani P, Locatelli A, Strobelt N et al. Clinical Outcome of mild fetal ventriculomegaly. *Am J Obst Gynecol 1998:F175-8.*

20. Brouwer A, Groenendaal F, van Haastert IL, Rademaker K, Hanlo P, de Vries L. Neurodevelopmental outcome of preterm infants with severe intraventricular hemorrhage and therapy for post-hemorrhagic ventricular dilatation. *J Pediatr*. 2008 May;152(5):648-54.

21. Pal BR, Preston PR, Morgan ME, et al. Frontal horn thin walled cysts in preterm neonates are benign. *Arch Dis Child Fetal Neonatal Ed 2001:85:F187-F193.*

Further reading

Govaert P, de Vries LS. An Atlas of Neonatal Brain Sonography. London; Mackeith Press, 1997.

Natarajan M, Moorcraft M. A Practical Guide to Cerebral Ultrasound Scanning. *Current Paediatrics 2002 August, 394-400.*

Roberton's Textbook of Neonatology, 4th Edition. Rennie JM (Ed). *Elsevier Churchill Livingstone, 2005.*

Appendices

Appendix I

Definitions and Classifications of Cranial Ultrasound Abnormalities

Germinal Matrix Haemorrhage (GMH)
Haemorrhage in the germinal layer. GMH is visualised as an echogenic area between the caudate nucleus and the ventricle.

Intraventricular Haemorrhage (IVH)
Haemorrhage extending into the ventricles with or without dilation of the ventricles. Seen as echogenic areas within the ventricles. Classification as below:

Classification of GMH/IVH (Papile et al, 1978)[1]

Grade 1	Germinal layer (subependymal haemorrhage)
Grade 2	Intraventricular haemorrhage <50% of ventricular space
Grade 3	Intraventricular haemorrhage + ventricular dilatation
Grade 4	Intraparenchymal haemorrhage

Grade 1 and 2 haemorrhages represent 75% of all IVH

Periventricular Leukomalacia (PVL)
Ischaemic injury of white matter resulting in the appearance of bright areas in the white matter surrounding the ventricles. Description and classification as below.

Description of Periventricular Leukomalacia

Without cysts	echogenic periventricular margins (flare)
Cystic	single or multiple periventricular cysts
Porencephaly	large intraparenchymal cyst(s) in communication with the ventricle

Classification of Periventricular Leukomalacia (de Vries et al, 1992)[7]

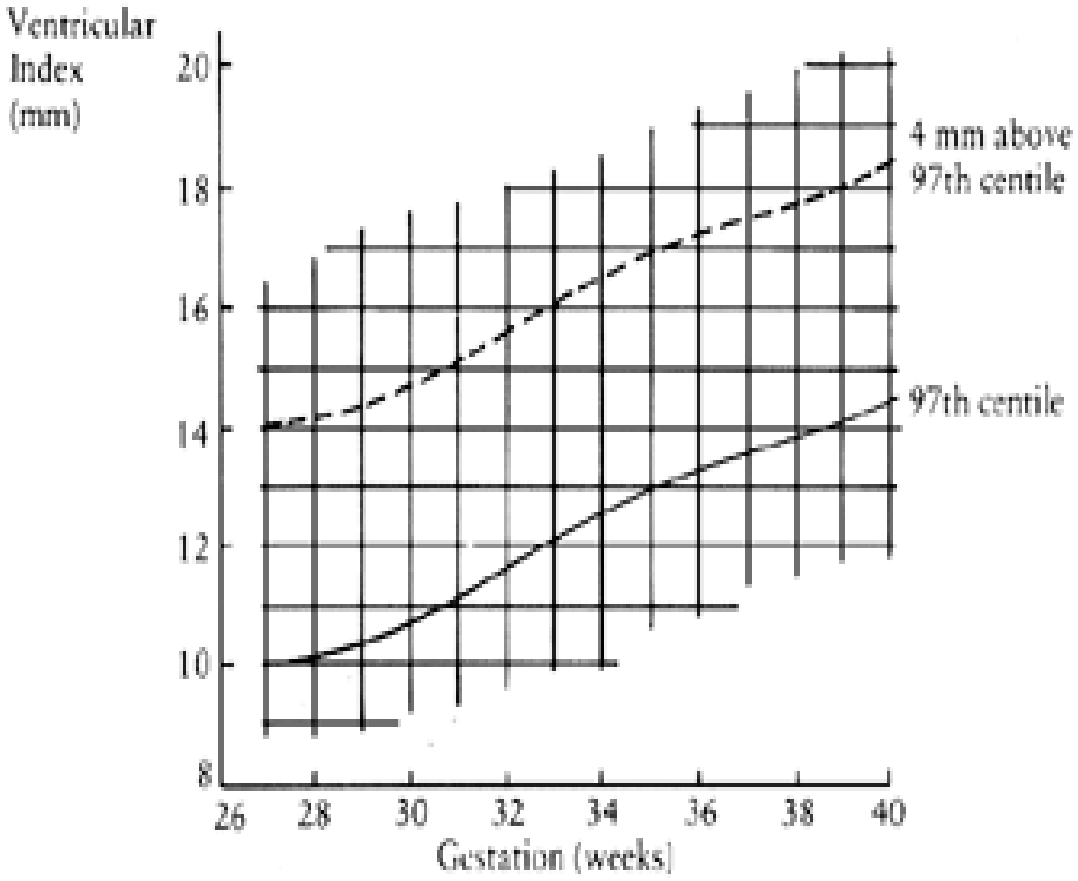
Grade I	Persistent flare ≥ 7 days, without cystic evolution
Grade II	Small localized frontoparietal cystic PVL
Grade III	Multiple extensive parieto-occipital cystic PVL
Grade IV	Subcortical cystic PVL extending into deep white matter

Classification of echogenicity of Cranial USS (van Wezel-Meijler, 1998)[8]

0	normal echogenicity of the periventricular white matter (less white than choroid plexus)
1	moderately increased echogenicity of the periventricular white matter (as white as choroid plexus)
2	markedly increased echogenicity (much brighter than choroid plexus)

Ventricular dilatation

The ventricular index (measurements from the lateral wall of the body of the lateral ventricle to the falx at the level of foramina of Munro) can be used in assessing the progression of ventricular dilatation[9]. However, in mild dilatations, the ventricular index is less sensitive compared to expert opinion in determining ventricular dilatation[10]. Serial head circumference measurements should also be recorded and plotted in the appropriate growth charts.



Trust Guideline for Cranial Ultrasound Scanning of Infants in NICU

Appendix II

Summary of evidence: abnormalities and outcome

Germinal matrix haemorrhage per se is not associated with significant neurodevelopmental abnormality[12,13].

Grade 2 IVH tends to resolve completely in most cases[13]. The EPICURE study reports that IVH without ventriculomegaly occurred in 41.9% of infants discharged home who were born at <26 weeks[14]. Uncomplicated grade 2 IVH generally has a very good prognosis[12].

Grade 3 IVH may resolve, but leads to post haemorrhagic ventricular dilatation (PHVD) in 75% of VLBW infants[15]. Mortality rate is estimated at 31% with 32% of survivors requiring neurosurgical intervention[15]. The incidence of cerebral palsy in infants with grade 3 IVH is 12% in surviving infants born at ≤32 weeks gestation [6].

Grade 4 IVH is associated with severe neurodisability[16,17]. The associated mortality rate is estimated at 50%, and 47% of survivors require neurosurgical intervention[15]. Of infants born at ≤34 weeks gestation with grade 4 IVH and who survive, approximately half will develop cerebral palsy. In the study of Brouwer et al., 44/120 infants with grade 4 IVH died (most after their intensive care was discontinued); 37 (~49%) of the 76 of survivors developed cerebral palsy; 51% did not develop cerebral palsy[20]. There are few data detailing the outcome for infants with bilateral grade 4 IVH; many such infants die/ often following withdrawal of intensive care. For infants with bilateral grade 4 who survive, cerebral palsy would be expected in the vast majority. The more extensive the bleeding/ parenchymal echodensities, the greater the chance of poor outcome.

Cystic periventricular leukomalacia. The presence of cystic PVL has been reported as an accurate predictor of cerebral palsy, with sensitivity between 67-86% and specificity of 96-99%[6,16,17]. Grade I PVL is very common and is not usually associated with a poor outcome: in one study only 15/331 (4.5%) infants with grade I PVL developed cerebral palsy[6]. Single cysts confined to the frontal region (grade II PVL) appear to have a significantly better outcome than multiple parieto-occipital cysts (grade III PVL) which are invariably associated with the development of cerebral palsy[6] and a high risk of visual impairment[16]. The EPICURE study reports that parenchymal cysts occur in 14% of extremely premature infants who are discharged from hospital[14].

Predictive value of major ultrasound abnormalities for development of cerebral palsy vs. normal outcome. 'Major' US abnormalities may be classed as grades 3 or 4 IVH, cystic PVL (any grade), subcortical leukomalacia, basal ganglia lesions, and focal infarction[6]. For surviving infants born at ≤32 weeks gestation with major US abnormalities, De Vries et al.[6], showed that approximately half developed cerebral palsy (58/121; 48%) and half did not develop cerebral palsy (63/121; 52%).

Other ultrasound findings. Antenatally-diagnosed isolated ventriculomegaly in the absence of other abnormalities is not a strong predictor of cognitive or motor delay[19]. Frontal horn cysts in isolation seen during the first week of life appear to be benign and spontaneously resolve[21].