East Midlands Neonatal
Operational Delivery Network

NETWORK GUIDELINE

Guideline:	**Management of Neonatal Encephalopathy (North Hub)**
Version:	**4**
Date:	**March 2018**
Review Date:	**March 2021**
Approval:	**TPN Clinical Governance Group**
Authors:	**Dulip Jayasinghe**
Consultation:	**TPN Clinical Governance Group**
Distribution:	**Neonatal Units within EMNODN North Hub**
Risk Managed:	**Parental distress and concerns, risk of failing to diagnose and appropriately manage encephalopathy**

This document is a guideline. Its interpretation and application remains the responsibility of the individual clinician, particularly in view of its applicability across the different Trusts in the East Midlands Neonatal Operational Delivery Network – North Hub. Please also consult any local policy/guideline document where appropriate and if in doubt contact a senior colleague.

This guideline was previously a Trent Perinatal Network Guideline.

Caution is advised when using guidelines after a review date.

REVIEW AND AMENDMENT LOG

Version	Type of Change	Date	Description of Change
1	-	-	-
2	-	-	-
3	-	-	-
4	-	Mar 2018	-
4	No change	Jan 2019	TPN Guideline transferred to EMNODN Guideline format

1. Introduction

The guideline is organised beginning with definitions of neonatal encephalopathy (general and TOBY), the criteria to identify risk factors of a hypoxic ischaemic delivery and identification of infants who would benefit from therapeutic hypothermia. The second half deals with supportive management and investigation of encephalopathy. A list of abbreviations is presented at the end.

Encephalopathy may arise from many pathologies [1] and consideration should be given to non-HIE aetiology if features of hypoxic-ischaemia are not present. HIE may also co-exist with other pathologies.

1.1. General definition of encephalopathy

Neonatal encephalopathy is a clinical syndrome of abnormalities in level of **consciousness, tone, primitive reflexes, autonomic function** and sometimes seizures[2], graded mild, moderate or severe (I-III) (see for other definitions).

1.2. TOBY trial/register definition of moderate or severe encephalopathy (TOBY B Criteria) [3]

The Toby trial utilises the following as features of encephalopathy:

- Altered state of **consciousness** (reduced response to stimulation or absent response to stimulation) ***and***
- Abnormal **tone** (focal or general hypotonia, or flaccid) ***and***
- Abnormal **primitive reflexes** (weak or absent suck or Moro response)

Table 1 TOBY trial definition of moderate or severe encephalopathy

The presence of clinical **seizures** after hypoxic ischaemic delivery is also an indication for therapeutic hypothermia.

2. Population who would benefit from Neuroprotective Hypothermia

Therapeutic hypothermia is effective at reducing mortality and severe disability in survivors of infants with moderate or severe HIE in term and near term infants less than 6 hours of age [4]. Hypothermia treatment initiated 6-24 hours after birth may be beneficial but its effectiveness is uncertain [5].

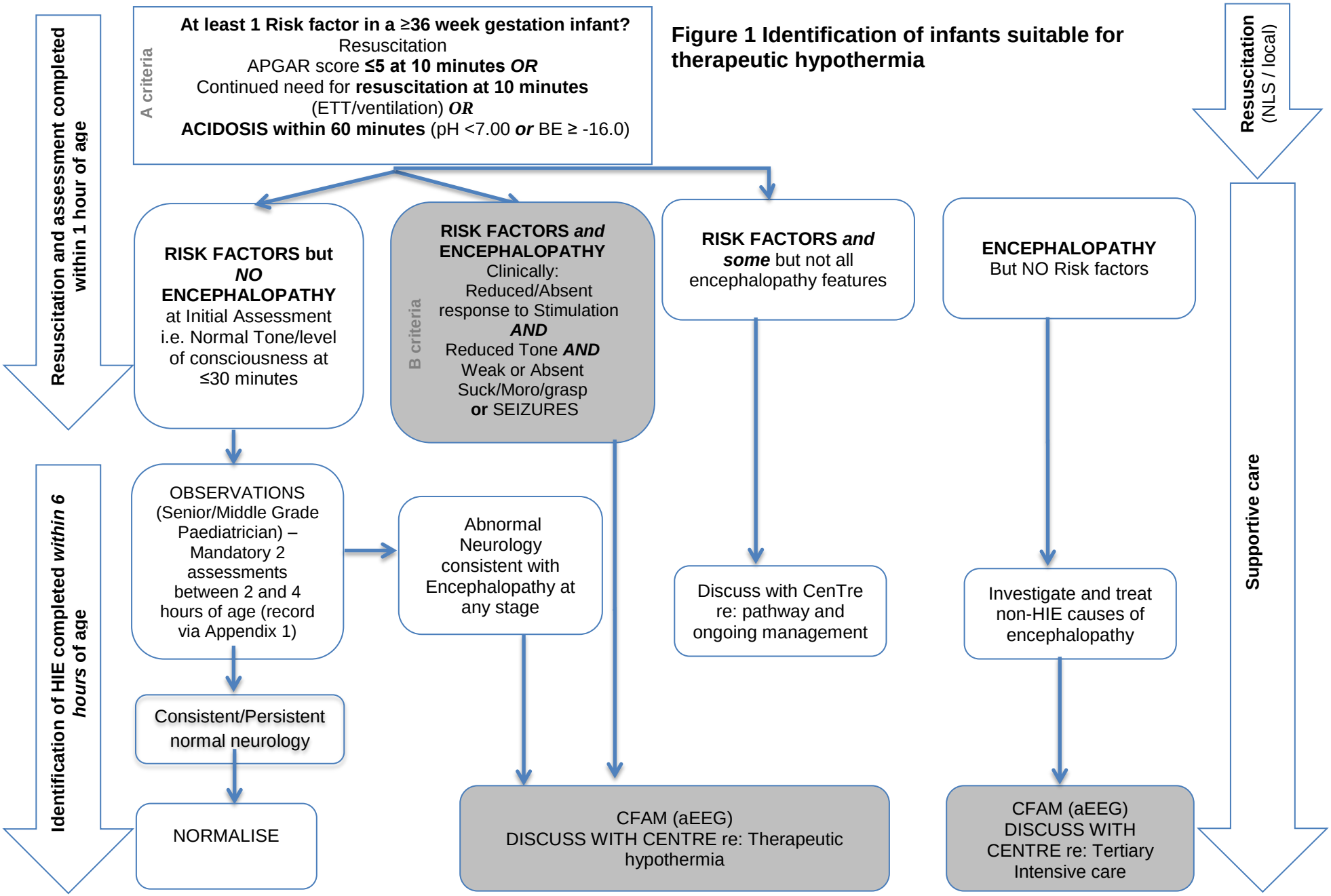
2.1. Procedure for patient selection

Infants of **≥36 completed weeks** gestation and **less than 6 hours of age** with encephalopathy (**all** of the criteria in ; TOBY B) and with evidence of perinatal hypoxic ischaemic risk factors (**any** of the risk factors in Table 2; TOBY A) may be considered for treatment with therapeutic hypothermia. These babies should be referred to the transport service and a conference call held between the referring, transport and receiving consultants.

Therapeutic hypothermia is contra-indicated if:

- The infant is likely to require surgery during the first 3 days after birth
- There are other abnormalities indicative of poor long term outcome

Figure 1 Identification of infants suitable for therapeutic hypothermia



Therapeutic hypothermia may not be appropriate if the infant appears moribund or has persisting extremely severe encephalopathy such that further treatment is likely to be futile but should be discussed with a therapeutic hypothermia centre via the transport service.

If the referring clinician is unsure if a baby is suitable for therapeutic hypothermia this can be discussed in a conference call between the referring, transport and receiving clinicians.

2.2. Non-trial compassionate use of therapeutic hypothermia

Infants who are on the borderlines of the TOBY trial eligibility criteria can be discussed by the referring unit via with CenTre, the Nottingham on-call consultant and possibly the therapeutic hypothermia treatment centre if the infant is not to be treated in Nottingham.

2.3. Resuscitation

Resuscitation should be performed according to NLS standards and in line with the local guideline on resuscitation in the delivery suite or postnatal ward.

2.4. Assessment of Hypoxic Ischaemic risk factors (TOBY A)

Infants with ***all*** of the criteria of Encephalopathy (Table 1; TOBY B criteria) and ***any*** risk factors of Hypoxia/Ischaemia (Table 2; TOBY A) would benefit from therapeutic hypothermia.

- Apgar score of ***≤5 at 10*** *minutes* after birth **or**
- *Continued* ***need for resuscitation***, including endotracheal or mask ventilation, ***at 10 minutes*** after birth **or**
- ***Acidosis within 60 minutes of birth*** (defined as any occurrence of umbilical cord, arterial, venous or capillary **pH <7.00**) **or**
- **Base Deficit ≥ 16 mmol/L** in umbilical *cord or any blood sample* (arterial, venous or capillary) within 60 minutes of birth

Table 2 TOBY trial risk factors of hypoxic ischaemic delivery

2.5. Infants with A criteria but **without** *encephalopathy*

Infants may be born with one of the risk factors above but may not be encephalopathic immediately after birth. The **diagnosis of hypoxic ischaemic encephalopathy is time critical** (cooling should be started by 6 hours) and these infants must be assessed regularly by a suitably trained individual such as a middle grade or senior clinician at least twice between 2 and 4 hours of age, earlier if clinical concerns are present. Admission to the neonatal unit may facilitate regular review and should follow local guidance. This must be recorded appropriately (see appendix 1). Plan for ongoing care should be discussed with the Cooling Centre team and retrieval team via CenTre neonatal transport service (0300 300 0038) as a matter of urgency ie. do not delay whilst completing other aspects of stabilisation (do it in parallel where possible).

2.6. Passive hypothermia

If there is concern that encephalopathy has been as a result of hypoxic ischaemia during labour or delivery then passive hypothermia (**Appendix 2**) should be initiated **once** the infant has attained **cardio-respiratory stability**. If there is loss of cardio-respiratory stability then **rewarm the infant until stability has been re-established**. Continuous temperature monitoring, ideally rectal, should be started if passive or active hypothermia is initiated.

2.7. Consideration of Sub Galeal Haemorrhage.

Consideration should be made to the possibility of Subgaleal (sub-aponeurotic) haemorrhage (SGH) following difficult vacuum or forceps delivery[6]. Features of Subgaleal are presented in Appendix 5.

If there is diffuse generalised expanding scalp bogginess crossing suture lines then repeated head circumference measurements must be included in the assessment; an increase in >1cm of OFC suggests moderate severity SGH and need for volume replacement.

3. Management of Encephalopathy

Multi-organ dysfunction often accompanies encephalopathy following hypoxic-ischaemic delivery [7,8] but may also be a feature of other causes of encephalopathy. Initial management is directed at preventing secondary injury from reduced cerebral oxygen and substrate delivery. Later management is aimed at treating the underlying cause, associated other organ injury or neuroprotective brain therapeutic hypothermia.

As soon as the decision is made to refer for therapeutic hypothermia the referring unit should contact the CenTre neonatal transport service (0300 300 0038).

If the referring clinician is unsure if a baby is suitable for therapeutic hypothermia this can be discussed in a conference call between the referring, transport and receiving clinicians.

Babies with evidence of encephalopathy (criteria B) but not fulfilling criteria A can be discussed with the local service/on call consultant to establish whether therapeutic hypothermia may still be appropriate. It may be appropriate to transfer these infants for further management.

3.1. Supportive management

The management of an encephalopathic child is largely supportive and guided by the aetiology.

3.1.1. Airway and breathing

An on-going need for ventilatory support for airway protection or gas exchange is an indication for intubation and ventilation.

There may be no associated lung injury so avoid over-ventilation and resulting hypocarbic cerebral vasoconstriction; perform frequent blood gases and aim to maintain the $PaCO_2$ between 5-7 kPa and PaO_2 between 8-12 kPa [9]

If ventilation is necessary then ensure adequate analgesia using a morphine infusion, an initial loading dose of 100 micrograms/kg continuing as an infusion at 5-20 micrograms /kg /hr. Babies being cooled but not needing ventilating often require morphine as the experience is unpleasant, typically 5micrograms/kg/hr is required.

3.1.2. Circulation and clotting

Establish invasive BP monitoring if there are concerns about blood pressure, circulation or ventilation or if the baby has been accepted for therapeutic hypothermia. Maintain normal blood pressure (MABP>40 mmHg) to maintain cerebral, renal and cardiac oxygen delivery.

Avoid repeated fluid boluses because cardiac contractility may be impaired and if necessary use inotropes. If a 10ml/kg fluid bolus, repeated once if necessary, fails to improve the BP then commence dopamine at a dose of 10 micrograms /kg/min up to a maximum dose of 15 micrograms /kg /min, then commence dobutamine at 10

micrograms /kg/min up to a maximum of 15 micrograms /kg/min. If the baby is still persistently hypotensive despite dopamine and dobutamine at 15 micrograms /kg/min consider iv hydrocortisone at 100 milligram/kg 8 hourly.

Full blood count and clotting should be monitored and abnormalities corrected as indicated. A cardiac echo may be helpful to guide therapy.

3.1.3. Fluids and renal function

Renal impairment (AKI) may evolve so fluid restrict to 40 ml/kg/day and consider catheterisation. Maintain glucose delivery by the use of a 10% to 20% glucose solution as necessary. Hypoglycaemia is detrimental to later outcome [10] [11]so should be avoided and serum glucose kept in the range 2.6-8.3 mmol/L.

Maintain careful fluid balance and dipstick the urine for evidence of renal impairment (blood and/or protein positive). Electrolytes and liver function [12] tests at 12 hours may prove useful and give evidence of renal and hepatic injury.

If circulatory support or the use of concentrated glucose solutions is anticipated then insert an umbilical venous catheter or percutaneous long line.

3.1.4. Microbiological assessment

Infection may play a role in the development of encephalopathy even in the presence of hypoxic ischaemic markers [13]. A septic screen should be performed and investigations for bacterial sepsis sent including a sample of CSF. If features of hypoxic ischaemia are absent or inconsistent then samples of blood, urine and CSF should be sent for viral PCR including for HSV and the infant started on acyclovir.

3.1.5. Neurological dysfunction

Perform and document in the notes a careful neurological examination including abnormalities of **tone and reflexes (primitive, deep tendon and pupillary) and head circumference.**

The **grade/severity** of encephalopathy **MUST** be documented using Appendix 4. The initial grade serves as the most predictive prognostic marker of outcome and as baseline to compare later changes.

This assessment forms a baseline from which changes can be assessed and has prognostic significance in combination with amplitude integrated EEG (aEEG) monitoring [14].

There is no evidence that prophylactic phenobarbitone is effective in changing the outcome [15,16].

Inspect the infant closely for evidence of external congenital abnormalities that may suggest an underlying malformation or evidence of skull fractures suggesting traumatic injury to the brain.

Consider aEEG monitoring (including continuous recording during therapeutic hypothermia) to assess the level of electrophysiological disturbance and identify seizures. The aEEG record can be categorised into normal, moderately abnormal, suppressed or seizure patterns. Table 3 below contains details of criteria for each category.

- aEEG is useful but **NOT** a required criteria for identification of therapeutic hypothermia candidates.

Category		Upper margin	Lower margin
Amplitude	Normal	>10 □v	>5 □v
	Moderately abnormal	>10 □v	□5 □v
	Suppressed	<10 □v	<5 □v often accompanied by burst suppression
Seizures		Periods of sudden increase in voltage accompanied by narrowing of the band of activity followed by a brief period of suppression	

Table 3 Categorical features of aEEG

4. Thermoregulation

Pyrexia during hypoxic ischaemic encephalopathy is a risk factor for adverse outcome and should be avoided [17,18]. Guidelines developed by TOBY trial on initiating **passive hypothermia** are outlined in appendix 2; cardiorespiratory instability should be discussed with hypothermia centre via Centre.

4.1. Active neuroprotective whole body mild hypothermia

There is evidence from systematic review and meta-analysis that hypothermia commenced as soon as possible after the insult (and certainly within 6 hours), is neuroprotective [19,20].

4.2. Rewarming after passive hypothermia

If no features of encephalopathy are identified by 6 hours after birth then the baby may be re-warmed by turning on the incubator and setting the incubator air temperature to 30°C.

5. Parental Discussion

Clinicians should always discuss therapeutic hypothermia treatment with parents and seek parental **assent** as soon as practically possible. Details of all discussion with parents about their baby's treatment with therapeutic hypothermia should be documented in the baby's notes. A patient information leaflet is available from the TOBY register website https://www.npeu.ox.ac.uk/downloads/files/tobyregister/TOBY-Register-Cooling-PIL-2010.pdf

6. Investigation and Determination of Cause

Avoid commenting on the midwifery or obstetric management of the delivery and direct parents towards the appropriate professional if they have questions about the perinatal period.

Perform a cranial ultrasound looking for mass lesions causing midline shift such as intracranial haemorrhages and congenital brain parenchymal abnormalities.

Perform first line investigations as soon after admission and repeat as necessary.

If there is no/circumstantial evidence of Hypoxic ischaemia during delivery or the baby presents after 12 hours than perform the second line investigations.

	Investigation				
Timing	**Haematology**	**Biochemistry**	**Bacteriology**	**Metabolic** [21]	**Imaging**
First line (On admission on all with encephalopathy)	FBC, clotting	Glucose, U&E at 6 to 12 hours, Calcium, Magnesium, LFT	Blood culture; LP (M, C&S)	urine toxicology screen blood gas	Cranial ultrasound to identify space occupying lesion
Second Line (*Additional* tests to be performed where features of hypoxia/ischaemia -A criteria- are absent)		Paired CSF/serum lactate, CSF glycine, thyroid function tests, CK, plasma homocysteine and acyl carnitine	CSF HSV PCR, serum Coxsackie virus, HSV PCR Urine CMV	Serum: NH_3 and amino acids, 3 hydroxybutyrate Urine: organic and amino acids, sulphite oxidase, reducing substances and glycosaminoglycans	MRI with spectroscopy if T1 and T2 imaging normal

Table 4 Investigations to establish aetiology

7. Neuro-Developmental Outcome

All infants with encephalopathy require neurodevelopmental surveillance follow-up until at least two years of age in their local hospital.

8. Audit Standards

- At least two neurological assessment performed and documented between 2-4 hours of age during the first 6 hours of life. (**standard 100%)**
- Infants where therapeutic hypothermia may be indicated are referred for discussion, advice and/or transport by latest 120 minutes of age. (**Standard 100%)**
- Infants with HIE where therapeutic hypothermia is instituted will have a rectal temperature within the target range (33-34°C) by 6 hours of age. (**Standard 100%)**
- All infants with evidence of perinatal hypoxia (any A Criteria) have a neurological assessment. (**standard 100%).**
- All infants with any evidence of hypoxic ischaemia (Criteria A) should have clear resuscitation documentation (such as Appendix 3) completed and filed in the baby and maternal notes.
- All infants with encephalopathy have a grade/severity recorded (100%).

9. Evidence Table [22]

Guideline	Evidence	Recommendation	References
Early (<6h) Treatment with mild hypothermia is neuroprotective	A	Strong	[4,20]

10. References

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11. Appendix 1 Record Sheet

Are there Risk Factors for Neonatal Encephalopathy in whom encephalopathy has not yet developed?

Case Identifier		**Consider HIE if**
Location		
Problem List		*Any abnormal neurology* *Need for Cardiorespiratory support*
High Risk Antenatal Factors		*Reduced Fetal Movements* *Maternal pyrexia* *Category 1 Section* *LBW* *Prolonged 2nd stage* *Abnormal CTG* *Acute intra-partum event** *Malpresentation, IDDM*
All Antenatal Factors Communicated	Yes/No	
Cord pH (arterial)	pH BE Lactate	*Ph<7.0, BE≥-16* ***(Criteria A)***
Condition at Birth *Apgars* *Time to 1st gasp* *Time to regular breathing* *Tone*	@1, @5, @10	*Apgar≤ 5* ***at 10 minutes*** ***(Criteria A)*** *Continued need for respiratory support 10 minutes* ***(Criteria A)*** *Persistent floppiness*
Significant Resuscitation		*Intubation* *Cardiac Compressions*

- ***Acute intra-partum event:*** *haemorrhage, maternal seizure, uterine rupture, snapped cord, born before arrival.*

Does regular Clinical Review suggest Neonatal Encephalopathy?

The reviews must be detailed and record in the note any departure from complete normality.

If the infant has TOBY criteria B features (shaded rows) especially seizures they must be referred to CenTre.

Age (Time of birth=0)	1h	2h	3h	4h	5h	6h
Time						
Resting Posture						
Focal or general low tone ***(Criteria B)***						
Altered consciousness/Irritability ***(Criteria B)***						
Absent /weak Suck or gag reflex ***(Criteria B)***						
Abnormal movements/seizures ***(Criteria B)***						
Abnormal Temperature						
Apnoea's/Respiratory Support						
Encephalopathy present or possibly present (Y/N)						

Appendix 1 Table 1 Neurological signs suggestive of encephalopathy.

What additional information suggests Neonatal Encephalopathy and possible benefit of being offered Hypothermia?

CFAM Available or done		*Baseline<5µV or Upper margin<10 µV*
D/W Tertiary Service		*Tertiary advice supports transfer*
Decision to cool/not cool made		
Early Course		*Other organ involvement Abnormal results*
Seizures		*Any Seizures* ***(Criteria B)***
Local Consultant Review		

Appendix 1 Table 2

Clinical Assessment of Encephalopathy

Any cases where HIE is suspected should have a detailed neurological review by a suitably trained individual such as a middle grade or senior doctor (see Appendix Table 2)

All babies with a cord arterial pH of <7.00 OR APGAR< 5 @ 5min must have at least two reviews within 6 hours of age

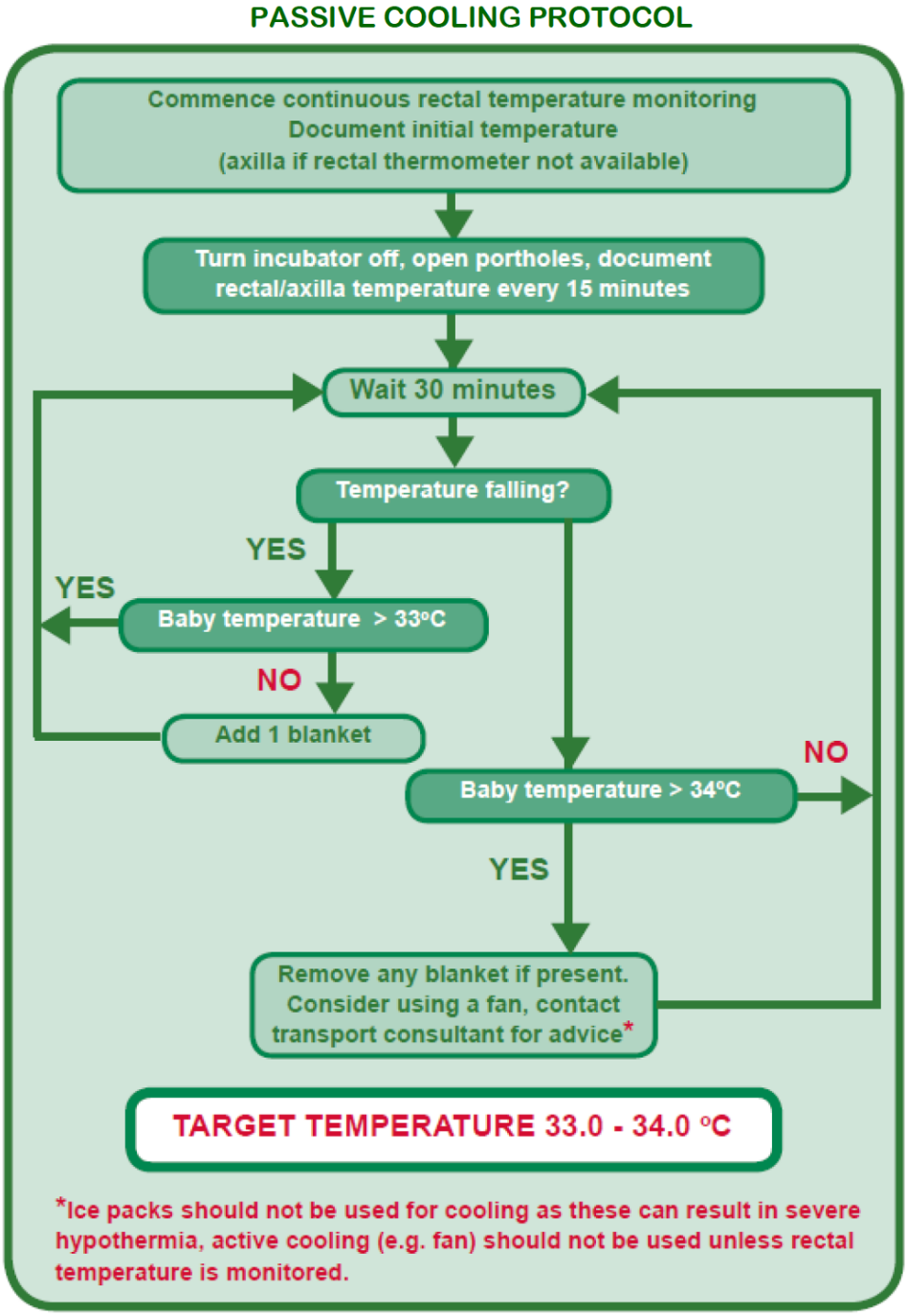
Any baby who is admitted for floppiness, regardless of cord pH should have two reviews in the first 6 hours. *Babies with a history of reduced fetal movements or late second stage obstruction may have 'falsely' reassuring cord gases*

Passive therapeutic hypothermia should be the 'default' where HIE is a possibility. The decision to allow re-warming should be an active decision made once the clinical concerns of HIE have resolved.

Guidance for Discussion with Tertiary Services
All babies with cord or first blood gas with pH<7.00 ***(Criteria A)***
All babies with persistent abnormal neurology after 30 minutes
All babies with possible seizures/definite seizures ***(Criteria B)***

Passive hypothermia Advice
Start Passive hypothermia if HIE is a possible diagnosis (Appendix 2).
Advice available from: https://www.npeu.ox.ac.uk/downloads/files/tobyregister/TOBY-Register-Transport-Protocol.pdf

12. Appendix 2 TOBY Passive Hypothermia Protocol



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UK TOBY Cooling Register
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13. Appendix 3 Resuscitation Record

NEWBORN RESUSCITATION RECORD

(for any baby requiring > 30 seconds of inflation breaths at birth)

Staff present at resuscitation

Name	Role	Time of arrival

Baby Details *(Affix label here)*

Name _____

Sex _____

DOB _____

Time of birth _____

Est. Weight _____ **Gestation** _____

Consultant _____

History of Event *(Please include condition of baby and current resuscitation on arrival)*
Date: **Location:**

Cord Gases	**Arterial**	**Venous**	**APGAR**	Time (mins)	Heart rate	Resp Rate	Tone	Grimace	Colour	Total
pH				1						
pCO_2				5						
BE				10						

Intervention	**Facial O_2**	**Mask IPPV**	**Suction**	**Intubation**	**Surfactant**	**ET IPPV**	**Chest compressions**	**UVC/ intra-osseous**	**Drugs**	**Fluid bolus**	**Blood**	**Chest Drain**	**Passive cooling**
Tick													

Time	**Contemporaneous record of events**	**Signature**

Complete all resuscitation details & file in baby's (original) and maternal (photocopy) medical notes *v2*

Page 1 of 2 *Dr D Sharkey Nottingham Neonatal Service*

Time	Contemporaneous record of events	Signature

Continuation sheet for this resuscitation YES / NO (delete as appropriate)

Indications for considering cooling (***A Criteria***)(*Tick any that apply, one criterion is sufficient).*

- Near term (≥36 weeks) □
- Acidosis (pH<7.00 or BE ≥-16 mmol/L) □
- Need for resuscitation(mask or ETT) at 10 minutes □
- Apgar score ≤5 at 10 minutes □

Time resuscitation started _____ Time resuscitation completed _____

Name _____ Designation _____

Signature_____ Date _____

Photocopy of this record put in maternal notes (initial and date) :_____

Notes to assist completion of this form:

- Remember to date, time and sign all entries. Use additional resuscitation continuation paper if required
- Staff members can document individual actions or one person can be designated (only if all team present throughout) to document the resuscitation actions and all team members sign the record as accurate
- Useful information to include: initial heart rate, time of first heart rate >100bpm, time of first gasp, intubation attempts, drug times and doses, compressions, air/oxygen concentration etc.
- Record if encephalopathy was considered and if this altered temperature management

14. Appendix 4 Definitions and Sarnat Grading

Definitions
aEEG: amplitude integrated electroencephalograph (also known as CFAM –cerebral function monitor)

AKI: Acute kidney injury

HIE: Hypoxic ischaemic encephalopathy

Therapeutic hypothermia: central temperature of 33-34 °C to induce neuroprotection

Passive hypothermia: permitting the babies temperature to fall by removing external heating whilst maintaining continuous central temperature monitoring to prevent temperature falling below 33°C.

Seizures: Repetitive stereotyped movements reflecting synchronised cerebral electrical discharges.

Therapeutic hypothermia centre: A neonatal intensive care unit that provides therapeutic hypothermia

NLS: Newborn life support resuscitation training course

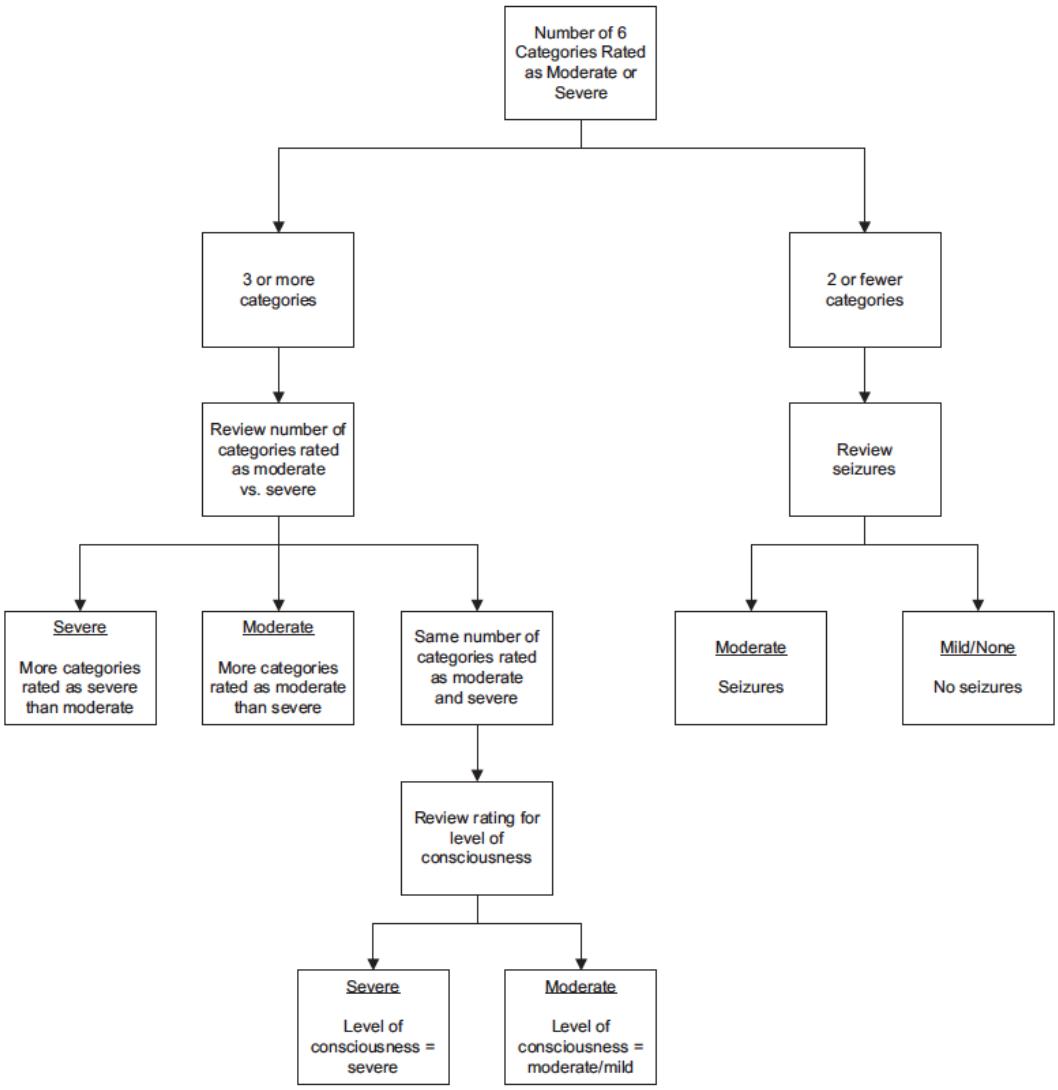
OFC: Occipito-frontal circumference

Criteria for attribution of Grade/Severity of encephalopathy
Encephalopathy was defined as the presence of moderate or severe encephalopathy in at least 3 of the following 6 categories in the NICHD trial [23].

		Moderate (II)	**Severe (III)**
Level of consciousness *(B Criteria)*		Lethargy	Stupor or coma
Spontaneous activity		Decreased	No activity
Posture		Distal flexion, complete extension	Decerebrate
Tone *(B Criteria)*		Hypotonia (focal or general)	Flaccid
Primitive reflexes *(B Criteria)*	Suck	Weak	Absent
	Moro	Incomplete	Absent
Autonomic system	Pupils:	Constricted	Deviated, dilated or non-reaction to light
	Heart rate	Bradycardia	Variable
	Respiration	Periodic breathing	Apnoea

Classification of Encephalopathy

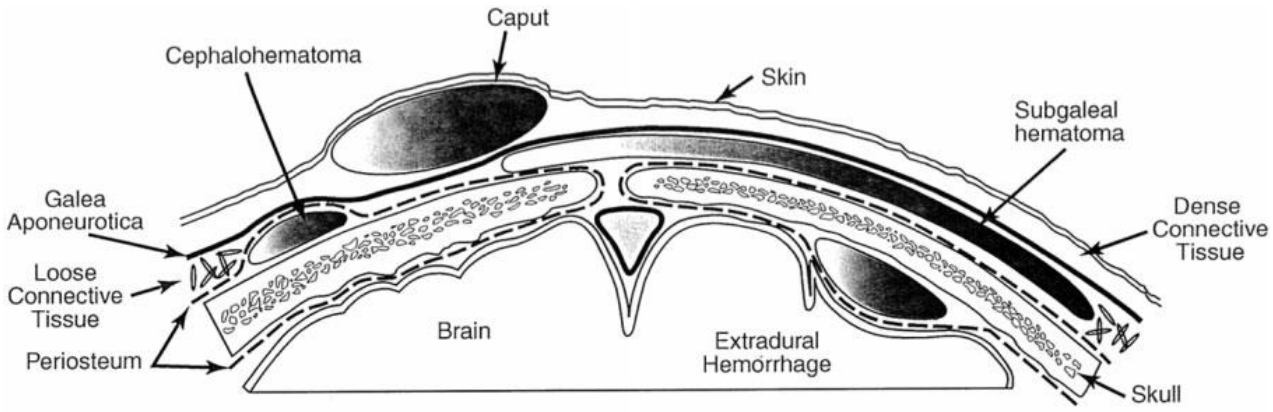
Encephalopathy can be graded into Moderate (II) or Severe (III) based on the number of the 6 categories which fall into the moderate or severe groups, see flow chart [23]**over.**



Taken from [23]: *Evolution of Encephalopathy during Whole Body Hypothermia for Neonatal Hypoxic-Ischemic Encephalopathy*.

15. Appendix 5 Features of Subaponeurotic or Galeal Haemorrhage

Features of subaponeurotic haemorrhage



Schematic representation of the five anatomic layers of the scalp and their relationship to various haemorrhages that may develop within these tissue planes [6]

Feature	Caput succedaneum	Cephalhematoma	**Subgaleal haemorrhage**
Location	At point of contact; can extend across sutures	Usually over parietal bones; does not cross sutures	**Beneath epicranial aponeurosis; may extend to orbits, nape of neck**
Timing	Maximal size and firmness at birth; resolves in 48–72 h	Increases after birth for 12–24 h; resolution over 2–3 wk	**Progressive after birth; resolution over 2–3 wk**
Volume of blood	Minimal	Rarely severe	**May be massive, especially if there is an associated coagulopathy**

Distinguishing features of different neonatal extracerebral fluid collections [24]