Neonatal EEG service evaluation - Recommendations

BSCN and ANS Audit meeting

Ronit Pressler, Bryony Carr, Daniela P. Quayle,
Khazina Waraich, Kelly Bill, Emma Dean, Matthew Sparkes,
Tatyana Yermakova, Gareth Payne, Rachel Thornton, Sushma Goyal

Birmingham, 2nd May 2025

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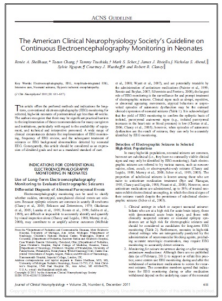
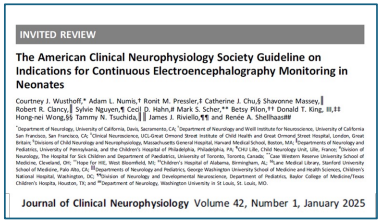
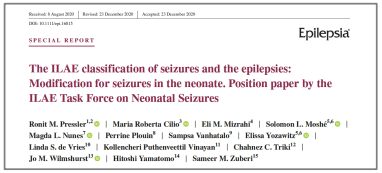
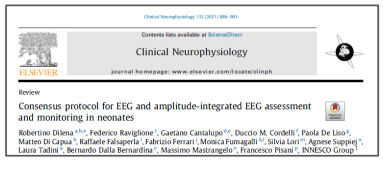
Recommendations for neonatal EEG monitoring

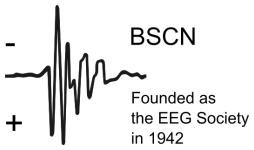
- **ACNS EEG monitoring recommendations** (Wusthoff et al 2025)
- **Italian Consensus protocol for EEG/aEEG** (Dilena et al 2021)
- **French technical recommendations** (Malfilâtre et al 2021)
- **Terminology and reporting of neonatal EEG**
  - Tsuchida et al 2013: ACNS glossary
  - Kane et al 2017: IFCN glossary of terminology, 2017 revision
  - Bourel-Ponchel et al 2021: updated French glossary
- **Classification of seizures** (Pressler et al 2021)





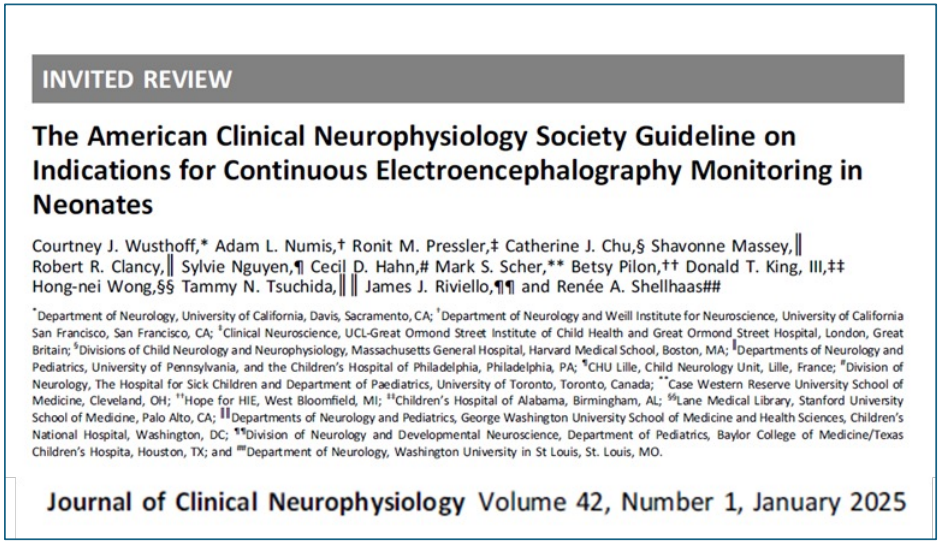






ACNS GUIDELINE: Indications for cEEG

- Update of the 2011 guidelines (Shellhaas et al 2011)
- Members of ACNS plus patient representative
- Based on Systematic review
  - Seven priority questions
  - Identification of evidence
  - Evaluation of evidence (GRADE)
  - Evaluation on quality of evidence
  - Recommendations



INVITED REVIEW

The American Clinical Neurophysiology Society Guideline on Indications for Continuous Electroencephalography Monitoring in Neonates

Courtney J. Wusthoff,* Adam L. Numis,† Ronit M. Pressler,‡ Catherine J. Chu,§ Shavonne Massey,‖ Robert R. Clancy,‖ Sylvie Nguyen,¶ Cecil D. Hahn,# Mark S. Scher,** Betsy Pilon,†† Donald T. King, III,‡‡ Hong-nei Wong,§§ Tammy N. Tsuchida,‖‖ James J. Riviello,¶¶ and Renée A. Shellhaas##

*Department of Neurology, University of California, Davis, Sacramento, CA; †Department of Neurology and Weill Institute for Neuroscience, University of California San Francisco, San Francisco, CA; ‡Clinical Neuroscience, UCL-Great Ormond Street Institute of Child Health and Great Ormond Street Hospital, London, Great Britain; §Divisions of Child Neurology and Neurophysiology, Massachusetts General Hospital, Harvard Medical School, Boston, MA; ‖Departments of Neurology and Pediatrics, University of Pennsylvania, and the Children's Hospital of Philadelphia, Philadelphia, PA; ¶CHU Lille, Child Neurology Unit, Lille, France; #Division of Neurology, The Hospital for Sick Children and Department of Paediatrics, University of Toronto, Toronto, Canada; **Case Western Reserve University School of Medicine, Cleveland, OH; ††Hope for HIE, West Bloomfield, MI; ‡‡Children's Hospital of Alabama, Birmingham, AL; §§Lane Medical Library, Stanford University School of Medicine, Palo Alto, CA; ‖‖Departments of Neurology and Pediatrics, George Washington University School of Medicine and Health Sciences, Children's National Hospital, Washington, DC; ¶¶Division of Neurology and Developmental Neuroscience, Department of Pediatrics, Baylor College of Medicine/Texas Children's Hospita, Houston, TX; and ##Department of Neurology, Washington University in St Louis, St. Louis, MO.

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- Update of the 2011 guidelines (Shellhase et al 2011)
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PICO

1: In neonates presenting with clinically suspected seizures, does cEEG monitoring improve accuracy of diagnosis?

2: In neonates presenting with clinically suspected seizures, does cEEG monitoring improve accuracy of diagnosis as compared to spot EEG alone?

3: In neonates presenting with aEEG events suspicious for seizures, does cEEG monitoring improve accuracy of diagnosis?

4: What is the yield of cEEG monitoring for neonates at risk for seizures in the absence of clinically evident seizures?

5: What is the yield of cEEG monitoring in neonates with definite seizures (whether clinically or by EEG) to assess seizure control after treatment?

6: What clinically relevant information can be gained from cEEG used as part of the evaluation of encephalopathy?

7: What clinically relevant information can be gained from cEEG used to evaluate brain function in preterm neonates other than for seizures?

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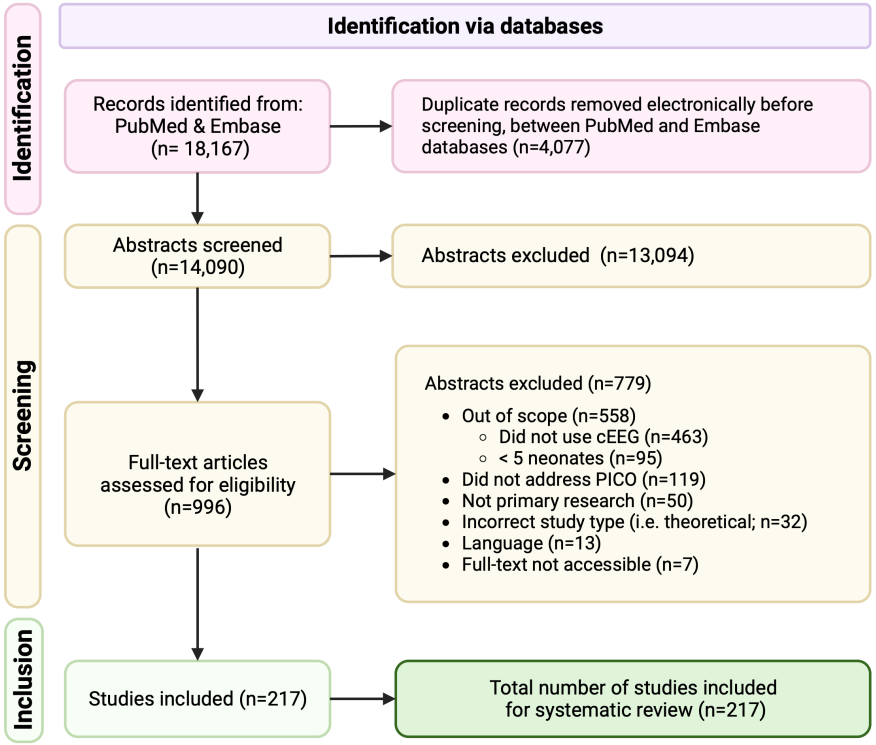

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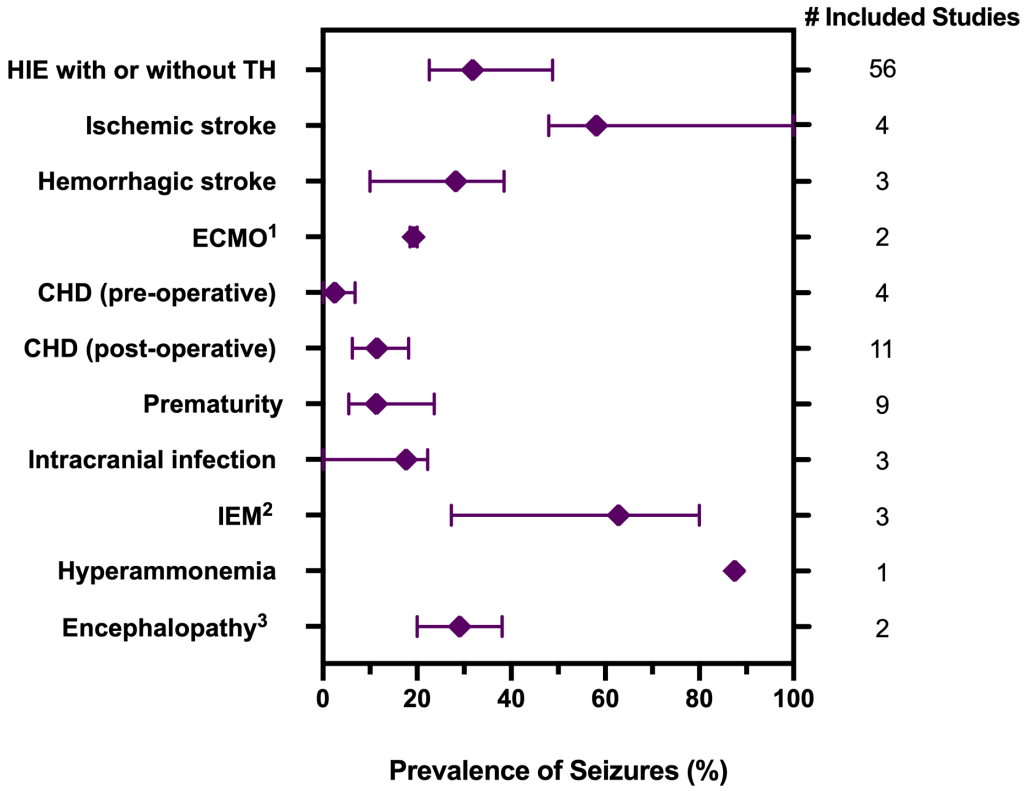

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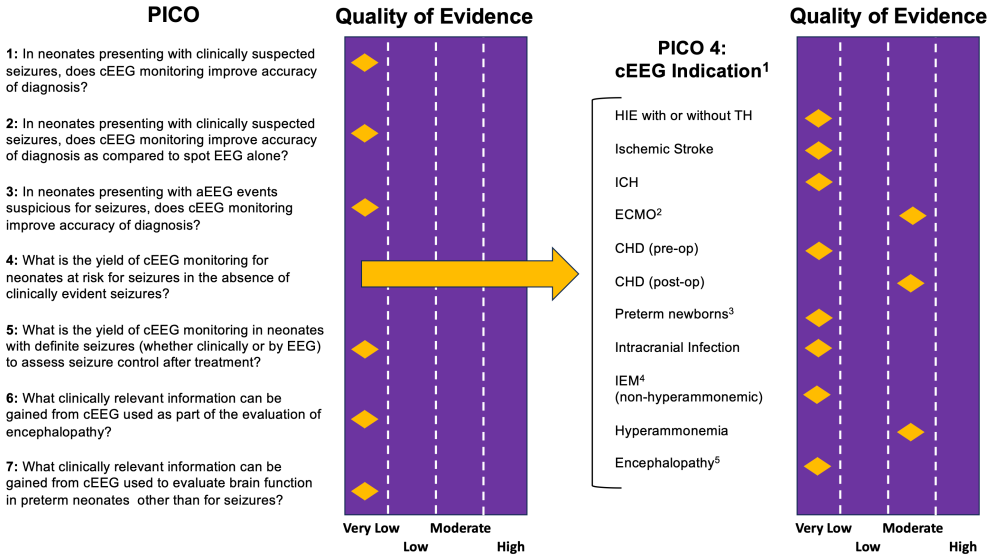

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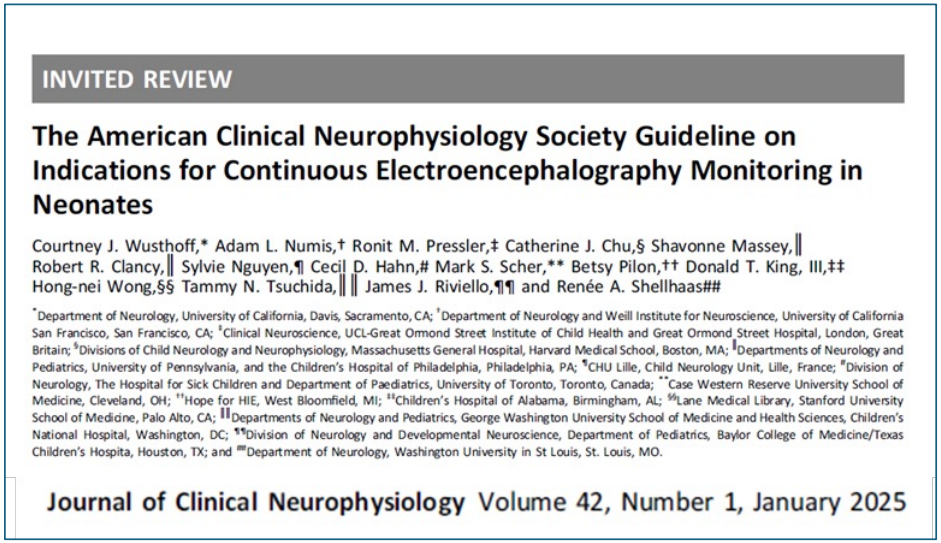

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ACNS GUIDELINE: Indications for cEEG

We suggest cEEG be used

- To improve accuracy of seizure diagnosis in neonates with clinically suspected seizures, as compared to observation alone, aEEG alone, or routine EEG. (Conditional)
- To confirm diagnosis of aEEG events suspected to be seizures. (Conditional)
- For monitoring neonates at risk for seizures without clinically events. (Conditional)
- In neonates with definite seizures to assess for seizure control after treatment and to confirm resolution of seizures. (Conditional)
- There was insufficient evidence to make a recommendation for or against cEEG monitoring after weaning or discontinuing anti-seizure medications.
- among neonates with encephalopathy and preterm neonates for assessment of interictal background to prediction risk of seizures, death or outcome (Conditional)

BSCN / ANS Neonatal EEG Standards & Guidelines

- Consensus based Standards and Guidelines based on
  - Findings of Neonatal audit
  - Current literature (Tsuchida et al 2013, Kane et al 2017, Bourel-Ponchel et al 2021, Pressler et al 2021, Dilena et al 2021, Malfilâtre et al 2021, Wusthoff et al 2025)
- Consists of
  - INDICATIONS – Ronit Pressler
  - RECORDING STANDARDS – Bryony Carr
  - REPORTING STANDARDS – Ronit Pressler

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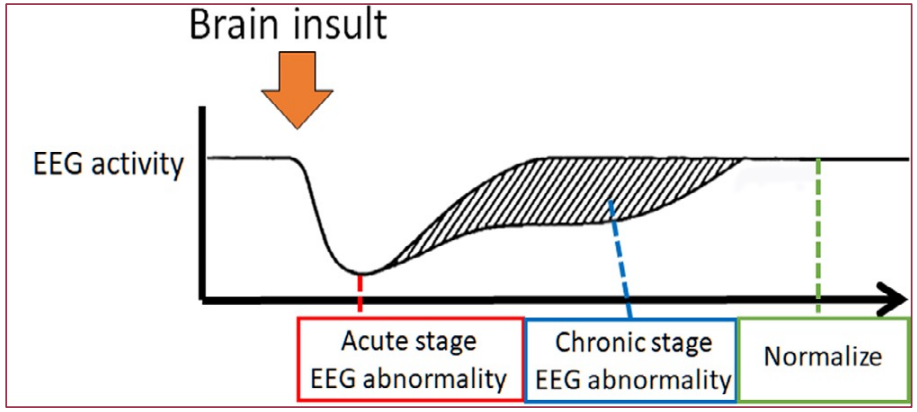
Indications for Neonatal EEG

- To determine whether or not reported clinical events are seizures.
- To confirm diagnosis of aEEG events suspected to be seizures.
- To classify seizure type +/- aid in the diagnosis of specific syndromes.
- For monitoring neonates at risk for seizures in the absence of clinically evident seizures.
  - neonates with HIE with/without therapeutic hypothermia
  - vascular events including ischemic stroke, intracranial haemorrhage
  - preterm <32w CGA with additional risk factors
  - clinical encephalopathy (other than HIE)
  - post operative newborn heart surgery for congenital heart disease and babies on ECMO
  - intracranial infection
  - inborn errors of metabolism
- To assess for seizure control after treatment and to confirm resolution of seizures.
- For the assessment of interictal background patterns as part of risk stratification for evolving brain injury and prediction of acute seizures and for neurological prognosis

Neonatal EEG for prognosticating outcome

- EEG may indicate prognosis for neurodevelopmental outcome after
  - HIE and other hypoxic brain injury
  - Acute symptomatic seizures
  - Preterm brain injury
- Ideal timing in HIE day 2-3
  - Good outcome if normal < 8 hr
  - Poor outcome if
    - No sleep wake cycling >48 hr
    - Severe background abnormality >24 hr (@48hrs when cooled)
    - Mild background abnormality > 3 weeks
  - No predictive value if normal or mildly abnormal day 5-21
- In preterm brain injury serial EEG has best predictive value at 30, 32 & 35weeks



References: Takeuchi et al 1989, Pressler et al 2001, Murray et al 2009, Bourel-Ponchel et al 2023, Wusthoff et al 2025

Standard 1 - Before starting testing the patient is identified, and the clinical information from the referral verified.

Guideline 1.1 – Appropriate (video) consent should be taken if data is to be used for teaching or training.

RECORDING STANDARDS

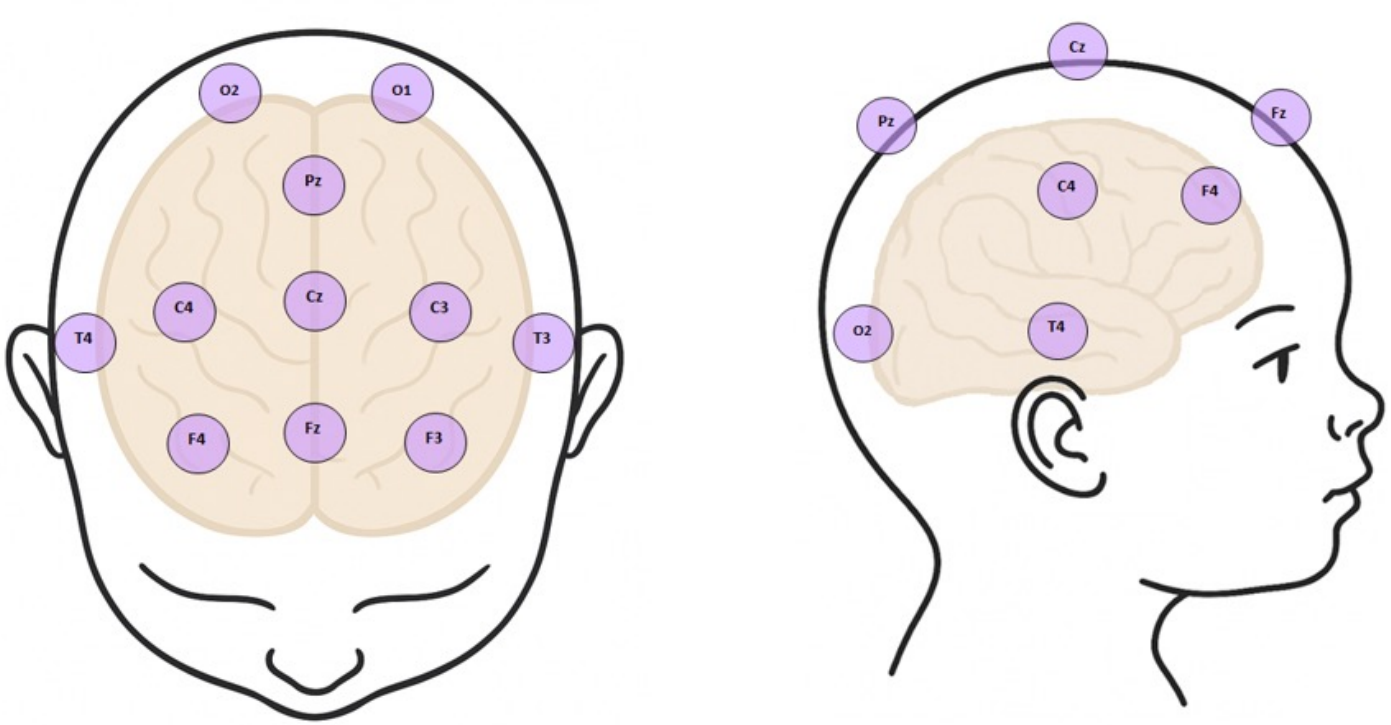
Standard 2 **– Disposable cup electrodes should be applied, dependant on scalp access, with electrode impedances <10kΩ and where possible, balanced across the scalp. Electrode impedance should be checked and recorded at the beginning and end of the recording (Lloyd *et al*, 2014; Tsuchida *et al*, 2013, Malfilâtre *et al*, 2020).**

Guideline 2.1 – A minimum of 13 (11 active; ground and ref) electrodes is recommended for patients >35w CGA on the NICU/PICU. This can be increased to a full 10-20 montage

Guideline 2.2 - A minimum of 11 (9 active; ground and reference) electrodes is recommended where scalp access is limited due to prematurity (<35w CGA) or other factors.

Option 2.1 – *S*upport from the clinical team providing direct care (e.g. bedside nurse, neonatologist) can be enlisted to move the patient carefully during electrode application.

Appendix: Suggested neonatal montage



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Standard 3 – Polygraphy should be included for the duration of the recording (Tsuchida et al, 2013; Malfilâtre *et al 2021*).

As a minimum this should include:

- **Bilateral deltoid EMG**
- **ECG**
- **Respiratory monitoring**

Guideline 3.1 – Additional EMG channels should be considered, with positioning tailored to the clinical history (Tsuchida *et al*, 2013, André *et al*, 2010).

Option 3.1 – Consider integration of vital signs monitors.

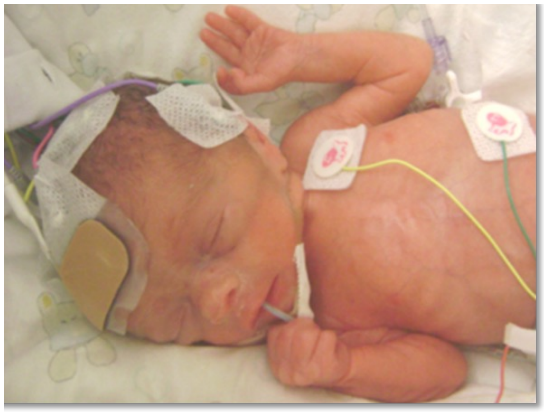
Option 3.2 – Consider oxygen saturation monitoring (Tsuchida *et al*, 2013, Malfilâtre *et al*, 2020).

		Electrode modality					
		EEG	**ECG**	**EMG**	**Respiratory**	**EOG**	**SaO_2**
Settings	Electrode type	Disposable surface	Disposable surface	Disposable surface	Band or transducer	Disposable surface	Transducers
	LFF (Hz)	0.5	1.6	5	0.15	0.5	Parallel DC recording channel
	HFF (Hz)	70	30	300	15	30	
	Sensitivity (uV/cm)	Adjustable	Adjustable	Adjustable	Adjustable	Adjustable	

Standard 4 – Skin integrity is vulnerable in this age-group, particularly in pre-term infants

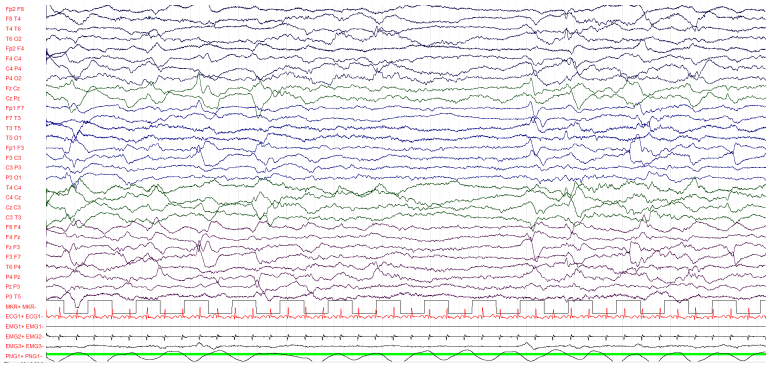
(ASET Position Statement on Skin Safety During EEG Procedures – A Guideline to Improving Outcome, 2016; El Ters *et al*, 2018; Ness, Davis, & Carey, 2013)

- Skin must be prepared using a gentle cleansing gel.
- Electrodes should be attached as per standard 2 using water-soluble adhesives and not using collodion adhesive.
- Electrodes should be removed using water; any skin irritation or sores should be highlighted to the bedside nursing team.

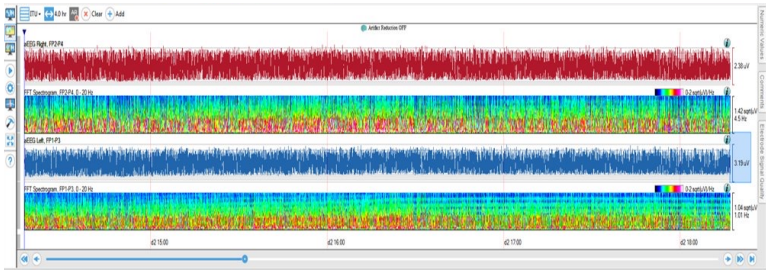


Standard 5 - Recording duration should be a minimum of 60 mins, incorporating wake and sleep states (Shellhaas et al, 2011; Malfilâtre et al, 2020).

Guideline 5.1 – Consider prolonging recordings for event capture for clinically suspected seizures. For long recordings over 24 hr, observation of the scalp integrity should be noted, recorded & neonatal staff notified if damage is identified



Option 5.1 - If the EEG is inactive/isoelectric, recording can be limited to 30 mins, ensuring adequate reactivity testing is performed in this time.



Option 5.2 - Consider timing, increasing duration and repeat recordings for assessment of electrographic seizures and neurological prognosis according to the indication.

Option 5.3 – Quantitative EEG may be used as an **adjunct** to assess seizure burden, effects of medication and subtle changes in background state, particularly in the muscle relaxed patient.

Standard 6 – Time-locked video should be recorded with full visibility of the patient (Shellhaas *et al*, 2011; Malfilâtre *et al*, 2020)

Guidelines 6.1 – Remove blankets for a clear view throughout the recording.

Option 6.1 - A marker button or diary sheet may be used to allow accurate marking of clinical events (Shellhaas *et al*, 2011). Bedside staff and parents/carers should be encouraged to identify and describe events of concern.

Option 6.2 – Where vital signs information cannot be integrated into the recording, incorporating vital signs monitors into the video capture frame may be useful.

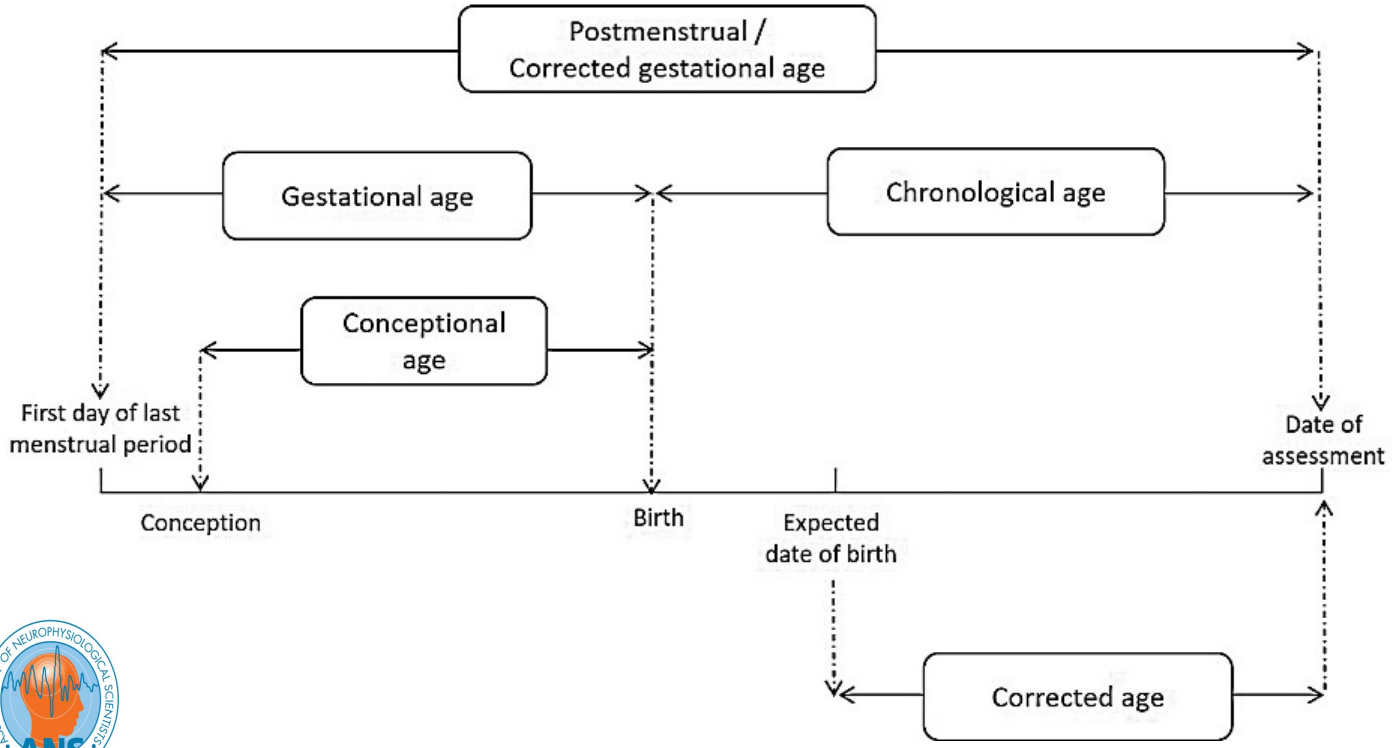
Standard 7 – Tactile stimulation

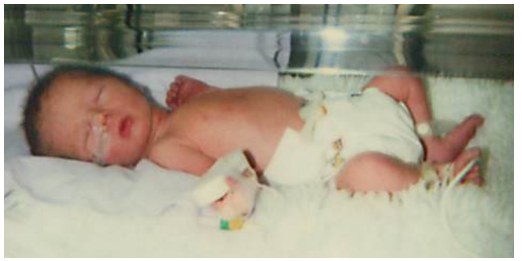
- In neonates of >32w CGA, tactile stimulation should be performed to assess reactivity unless this is contraindicated.
- Stimulation should be repeated, where possible, to confirm reproducibility and this should be accurately documented in the recording (André *et al*, 2010). Repeat stimulation should be performed at an interval of 30 seconds OR when the EEG baseline returns if reactivity is observed, whichever is longer.
- A graded approach should be used Auditory -> tactile-> +/- suction (Hwang J et al 2022, ACNS and European guideline)

Guideline 7.1 – Units/ departments should agree standardised local protocols to assess reactivity in conjunction with the neonatal team to ensure adherence to developmental care (see appendices for example stimulation protocol).

Standard 1 – A concise and relevant clinical history should be documented, including:

- CGA/PMA, GA





Born at GA 34+2 weeks

At 4 weeks of age (chronologic age)
CGA or PMA 38+2 weeks

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Standard 1 – A concise and relevant clinical history should be documented, including:

- CGA/PMA, GA
- Medication (anti-seizure medications, sedation (loading or maintenance)
- Indication for test
- History: Pregnancy, birth complications, APGAR score, cord pH, blood gas results
- Family history including genetic abnormalities and consanguinity
- Cooling – core temperature at time of EEG and timeframe to rewarming
- Event description including event frequency and time of last event
- Imaging results and previous EEG/aEEG/CFAM results if from

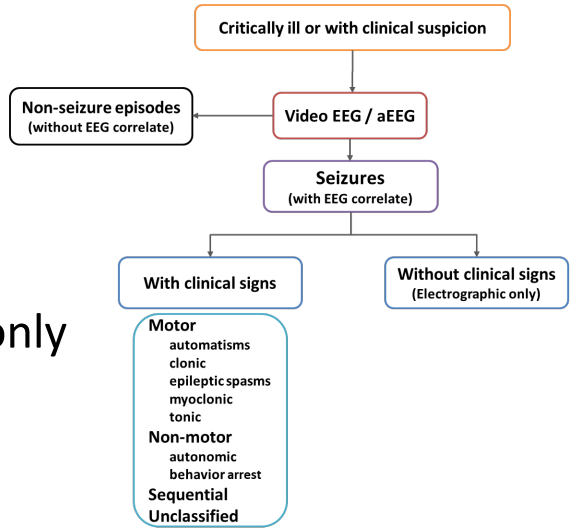
Guideline 1.1 – Consider including results of other investigations.

Standard 2 – A factual report should include:

- Electrode array including polygraphy
- Technical factors including artefacts or changes in recording duration
- Presence/absence of sleep-wake cycling
- Background EEG description including:
  - Continuity – duration of continuity/discontinuity
  - Synchrony/symmetry in each patient state
  - Normal/abnormal graphical elements
- Description of events captured; habitual/ non-habitual and associated EEG changes
- Description of stimulation and reproducibility
- Any medical interventions performed during the recording
- Autonomic changes recorded

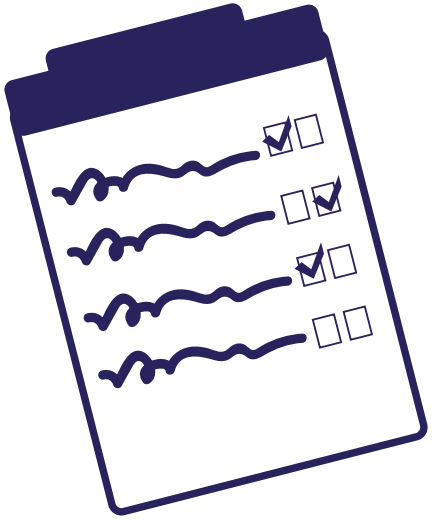
Standard 3 – A clinical interpretation should include:

- A statement of whether the background is appropriate for GA, CGA / PMA
- Wake and sleep
- Effect of anaesthesia/ cooling etc
- A statement on normality or abnormality in the recording
- Presence/ absence of background abnormalities incl. location
- A summary of captured clinical, electroclinical and electrographic-only events with EEG correlates including duration, frequency, location, evolution and propagation
- Classification of electro-clinical seizures (Pressler et al, 2021)
- Comment on the interpretation and significance of the observed findings in the context of the clinical presentation. This may include reference to and/or recommendation for adjunct investigations
- A comparison with previous EEG records should be made where these are available



Standard 4 – Signing off

- The professional status of the practitioners performing the investigation and providing the report are stated
- The report is signed by the practitioner taking medico-legal responsibility for it.



Standard 5 – Timing of reporting:

- A written or verbal report should be disseminated to the requesting clinical team in a timely manner.
- For in-patients, this should be on the same day as test requested (Shellhaas *et al*, 2011).

Standard 6 – Storage of data :

- Clinical and electrographic data should be stored in accordance with local guidelines.

Thank you to Neonatal audit team

- Bryony Carr
- Daniela P. Quayle
- Emma Dean
- Gareth Payne
- Kelly Bill
- Khazina Waraich
- Matthew Sparkes
- Rachel Thornton
- Ronit Pressler
- Sushma Goyal
- Tatyana Yermakova

(In alphabetical order)