



Topic Expert Group: Medical care and clinical practice

Neurological monitoring of the high-risk infant: EEG and aEEG

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Target group

- Term and preterm infants at risk for brain injury:
 - Infants with hypoxic-ischaemic encephalopathy (HIE)
 - Infants with encephalopathy for other causes (e.g. metabolic)
 - Infants with suspected or verified seizures
 - Infants requiring intensive care and/or surgery
 - Infants with suspected/confirmed congenital central nervous system (CNS) anomalies
- Parents

User group

Healthcare professionals, neonatal units, hospitals, and health services

Statement of standard

In order to improve evaluation and outcomes of newborn infants at risk of brain injury, management includes neurological monitoring using a structured, age-appropriate neurological assessment and a range of devices to evaluate brain haemodynamics, oxygen transport, brain function, and imaging, as required.

Rationale

Newborn infants comprise a high-risk population for developing brain injury, during the first days after birth due to respiratory, haemodynamic, infectious, or metabolic instability. Full term and preterm infants with hypoxia-ischaemia, CNS infections, or congenital anomalies are at particular risk of brain injury. Early recognition of on-going disturbances of brain function or structural damage is important in implementing preventive or treatment strategies, and appropriate follow-up. Early detection of cerebral compromise, such as encephalopathy and seizures, is associated with better management of these conditions. High-risk infants should be identified as early as possible, the patient history together with a structured clinical examination and repeated clinical observations form the basis of the evaluation. The electroencephalogram (EEG) provides sensitive detection of abnormal brain function. (1,2) Continuous monitoring with a full montage EEG or the limited-channel amplitude-integrated EEG (aEEG) has been increasingly used in neonatal units and is excellent in the detection and grading of the severity of cerebral compromise in both term and preterm infants, and can be used for early evaluation before interventions such as therapeutic hypothermia. (3–11) Modern aEEG monitors also display the raw EEG (aEEG/EEG), which improves seizure detection. (12,13) The use of continuous EEG or aEEG/EEG monitoring is associated with earlier seizure diagnosis and better seizure management. (14,15) Studies in asphyxiated newborn infants have shown that aEEG combined with near-infrared spectroscopy is useful. (16,17)



Benefits

Short-term benefits

- Improved evaluation of clinical symptoms, including seizures, and early detection of cerebral compromise (2,6,14,18,19)
- Refined clinical management of neonatal seizures, including more efficient treatment and less use of antiepileptic drugs (14,15,18–20)
- Early prediction of outcome may assist medical decisions such as interventions and redirection of care (5,9,10,21)

Long-term benefits

- Improved long-term outcomes (22–25)
- Improved cost-effectiveness (26,27)
- Reduced exposure to antiepileptic drugs (15,20)

Components of the standard

Component	Grading of evidence	Indicator of meeting the standard
For parents and family		
1. Parents are informed by healthcare professionals about the role of EEG and aEEG/EEG monitoring.	B (High quality)	Patient information sheet
For healthcare professionals		
2. A unit guideline on neurological monitoring including EEG and aEEG/EEG monitoring is adhered to by all healthcare professionals, to include <ul style="list-style-type: none">• asphyxiated newborn infants, including undergoing therapeutic hypothermia (3–5,5,6,16,23,26)• infants at risk of and undergoing treatment for seizures. (6,12–15,18–20,22,23,28)	A (High quality) B (High quality)	Audit report, guideline
3. Specific training on the use of EEG and aEEG/EEG monitoring is attended by all responsible healthcare professionals. (5,11,14,27,29)	A (Moderate quality) B (High quality)	Training documentation
4. Teams with a focus of interest on EEG and aEEG/EEG monitoring (e.g. neonatologists, neurologists, neurophysiologists, nurses, radiologists, radiographers, and physicists) are established. (29,30)	A (High quality) B (High quality)	Guideline



For neonatal unit

5. A unit guideline on the implications of EEG and aEEG/EEG monitoring is available and regularly updated.	B (High quality)	Guideline
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For hospital

6. Training on the use of EEG and aEEG/EEG monitoring is ensured. (5,11,14,27,29)	A (Moderate quality) B (High quality)	Guideline
7. An interdisciplinary team for neurological evaluation (including EEG and aEEG/EEG) of high-risk infants in the NICU is supported. (14,15)	A (Moderate quality)	Audit report
8. Facilities for EEG and aEEG/EEG monitoring and interpretation are provided.	B (High quality)	Audit report

For health service

9. High-risk infants are transferred to NICUs with appropriate neuro-monitoring systems and expertise. (31)	A (High quality)	Audit report, guideline
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Where to go – further development of care

Further development	Grading of evidence
For parents and family N/A	
For healthcare professionals N/A	
For neonatal unit	
<ul style="list-style-type: none"> Develop a full neonatal neuro-critical care concept, including guidelines and close collaboration with neurologists. (13,19,24) 	A (Moderate quality)
For hospital	
<ul style="list-style-type: none"> Use monitoring systems that allow for expert evaluation of aEEG/EEG or EEG 24/7 also from outside the hospital. 	A (Low quality)
For health service	
<ul style="list-style-type: none"> Monitor incidence, treatment and long-term outcomes after neonatal seizures. (15,24,25) Develop multi-centre expertise by sharing EEG databases. 	A (High quality) B (Moderate quality)



Getting started

Initial steps

For parents and family

- Parents are verbally informed by healthcare professionals about the implications of EEG monitoring.

For healthcare professionals

- Attend training on the use of EEG and aEEG/EEG monitoring.
- Identify leading staff with a focus of interest on neonatal neurological evaluation and monitoring.

For neonatal unit

- Develop and implement a unit guideline on the use of EEG and aEEG/EEG monitoring.
- Develop parental information material about EEG and aEEG/EEG monitoring, also including parental perspectives.
- Provide resources for specific training on EEG and aEEG/EEG monitoring tools.

For hospital

- Support healthcare professionals to participate in training on the use of aEEG/EEG and EEG monitoring.
- Provide technology for EEG or aEEG/EEG monitoring.

For health service

- Create systems to effectively transfer high-risk infants to NICUs with appropriate neuromonitoring systems and expertise.

Description

Electroencephalography (EEG) and amplitude-integrated EEG (aEEG) for evaluation of brain function in high risk infants

A majority of adverse events affecting brain function in term and preterm infants occur during deliver or the first week after birth. Such events include perinatal asphyxia, cerebral haemorrhages, ischaemia, metabolic and infectious conditions. Cerebral symptoms may be vague or entirely absent but may also include encephalopathy and seizures. Evaluation of brain function with conventional EEG or continuous monitoring with the aEEG/EEG gives diagnostic and prognostic information in high-risk term and preterm infants. Continuous video-EEG monitoring can be considered to be the gold standard, but this method is not available in all neonatal intensive care units (NICU) and not feasible for routine monitoring of large numbers of high-risk infants. During the last two decades EEG and aEEG/EEG monitoring have been increasingly used worldwide in compromised newborn infants.

Newborn infants with compromised brain function or at risk for developing severe cerebral complications should be monitored closely by clinical observation and continuously with aEEG/EEG. Conventional EEG should be performed in newborn infants monitored by aEEG/EEG.

Regular knowledge updates and training of healthcare professionals in basic management and evaluation of aEEG/EEG and EEG is of utmost importance. Several studies have reported that insufficient training in aEEG/EEG is associated with poorer and unreliable performance of the monitoring. For this reason, aEEG/EEG monitoring should be conducted in collaboration with clinical



neurophysiologists or neurologists, and for most monitored newborn infants at least one standard EEG should be recorded. (13,28–30,32–35)

Several studies have demonstrated that the electrocortical activity is one of the most sensitive measures for early evaluation of brain function and early prediction of outcome in asphyxiated newborn infants. Consequently, it is recommended to record the aEEG/EEG for evaluation of asphyxiated newborn infants before hypothermia treatment. (5,21) In asphyxiated term infants, simultaneous monitoring with aEEG/EEG and NIRS is associated with more precise outcome prediction. (16,17)

Clinical identification of suspected seizures is not reliable since a majority of neonatal seizures have only subtle clinical symptoms or are entirely subclinical. Brain monitoring with aEEG/EEG and EEG in asphyxiated newborn infants allows earlier recognition of seizures in newborn infants with HIE, and with more precise treatment of seizures and the use of fewer antiepileptic drugs. (14,15,18,19,22–25,36)

The compressed aEEG trend alone is not sensitive enough for detection of seizures since especially brief seizures may be missed in the compressed trend. However, if both aEEG and raw-EEG is inspected around 80-90% of all seizures that can be identified in a standard EEG may be detected. (13,37) Development of efficient automated seizure detection alarms is urgently needed in the busy NICU setting.

Many studies have also shown that aEEG and EEG may be sensitive early predictors of outcome in preterm infants (1,7,9,10), but clinical experience of aEEG in very preterm infants is still limited. The early predictive accuracy of aEEG and EEG can be expected to be lower in preterm infants than in term infants since the long-term outcome of especially very preterm infants may be affected by later complications during the clinical course.

The neonatal neurocritical care concept is an emerging strategy which includes a care concept based on specially trained NICU healthcare professionals and interdisciplinary teams that include neurologists, guidelines and protocols for consistent management of newborn infants at risk of neurological injury, aEEG/EEG and EEG monitoring of high-risk infants, and long-term follow up. (31) The first reports from NICUs practicing neurocritical care show very promising results. (15,24,25,27)

Source

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Lifecycle

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