

CFM Abstracts

(Cerebral Function Monitor)

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Neurological Assessment

Role of cerebral function monitoring in the newborn. de Vries, LS, Hellström-Westas L. Arch Dis Child Fetal Neonatal Ed 2005; 90(3):F201-F207.

OBJECTIVE: For many years, newborn infants admitted to neonatal intensive care units have had routine electrocardiography and been monitored for heart rate, oxygen saturation, and blood pressure. Only recently has it also been considered important to monitor brain function use continuous electroencephalography. The role of cerebral function monitoring in sick full term and preterm infants is reviewed.

An Atlas of Amplitude-Integrated EEGs in the Newborn, First Edition. Hellström-Westas L, de Vries LS, Rosén I. Parthenon Publishing, 2002.

ABSTRACT: An Atlas of Amplitude-Integrated EEGs in the Newborn is the first clinical atlas-textbook on interpreting Cerebral Function Monitor (CFM) tracings, a simplified method of continuous amplitude-integrated EEG (aEEG) monitoring increasingly used in neonatal units. The authors are pioneers on the aEEG method and have shown that severely ill newborn infants may suffer from repeated subclinical seizures that can only be diagnosed with continuous EEG monitoring. These experts have received worldwide attention for their demonstrations of the accurate prognostic ability of very early aEEG (CFM) recordings in newborn infants. Using illustrations of aEEG tracings, the atlas shows

and discusses the difference between aEEG tracings in the healthy and at risk neonate, including developmental changes from the premature to the full-term period. The chapters illustrate tracings in normal infants, effects of medications, seizures, birth asphyxia, intracranial hemorrhages including intraventricular hemorrhages and periventricular leukomalacia, metabolic diseases, congenital malformations and other conditions. This large-format atlas provides you with a collection of mainly previously unpublished aEEG tracings by leading specialists in the field, bibliographic references, and an index. These features combined with its expert instruction on the technical aspects of continuous aEEG monitoring in premature as well as full-term infants make An Atlas of Amplitude-Integrated EEGs in the Newborn an essential clinical reference for all neonatal units.

Evaluation of the Cerebral Function Monitor as a tool for neurophysiological surveillance in neonatal intensive care patients. Klebermass K, Kuhle S, Kohlhauser-Vollmuth C, Pollak A, Weninger M. Childs Nerv Syst 2001; 17(9):544-550.

BACKGROUND: Cerebral function in critically ill infants is difficult to assess and would certainly require continuous monitoring. Therefore, this study was performed to evaluate the Cerebral Function Monitor (CFM) as a tool for continuous neurophysiological surveillance in the Neonatal Intensive Care Unit (NICU). PATIENTS: A total of 40 neurological risk neonates were included in the study. They were classified on the basis of their primary diagnoses as infants with clinically manifest seizures, suspected seizure activity, intracranial hemorrhage (ICH) and hypoxic-ischemic encephalopathy (HIE). A group of 20 neurologically normal (preterm and full-term) infants served as controls. RESULTS AND CONCLUSION: All patients with seizures showed pathologic patterns in both the CFM and the conventional EEG tracings. The patients with ICH showed depressed amplitudes, an increase in discontinuous activity, and a high incidence of seizure activity. The patients with HIE were characterized by depressed activities correlating with the severity of the pathology. Our results indicate that the CFM is a very helpful tool for neurophysiological surveillance in high-risk neonates.



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The studies shown here were all performed using CFM

The difference between a CFM and other aEEGs

Not every amplitude-integrated EEG (aEEG) is a CFM. Only an aEEG that uses the original proprietary, single-channel algorithm developed by Maynard and Prior in the UK in the late 60s is an authentic CFM, supported by the extensive literature base.

The CFM technology was licensed in the 1980s to a British firm, Lectromed, which incorporated the algorithm in their Lectromed (4640 and 5330) brain monitors. Over the past 25 years, more than 50 CFM studies have been published based on data collected with these instruments. Today any CFM tracing can be interpreted by following the principles described in these papers.

The Olympic CFM 6000 was developed in collaboration with Lectromed as a digital replacement for their original analog CFM, and it uses the original Maynard-Prior algorithm, which was validated by independent and experienced CFM users who compared tracings recorded simultaneously from infants on both the Olympic and Lectromed devices.

The Olympic CFM 6000 provides continuity with the extensive CFM literature base – which includes studies demonstrating its clinical value in predicting and treating seizures, improving the accuracy of newborn neurological exams, showing response to medication, and screening for hypoxic-ischemic encephalopathy. Much of the published literature base uses the terms CFM and aEEG interchangeably. It is important to recognize that references to “aEEG” or “amplitude-integrated EEG” in some of the newer brain monitors does not provide assurance that their data is traceable to the established literature base. Today, only the Olympic CFM can claim full traceability to the source literature.

For further information on the traceability of the Olympic CFM 6000 to published papers, please consult your Olympic Medical representative or call 800-426-0353.

The importance of using the cerebral function monitor (CFM) in the neurological prognosis of neonates in intensive care. Romeo MG, Tina LG, Cilauro S, Morano C, Virzi G, Rodono A, Betta P, Saporito A, Distefano G. *Pediatr Med Chir* 1998; 20(3):197-199.

ABSTRACT: Cerebral function monitor (CFM), unlike traditional EEG, allows a long-term evaluation of electric brain activity, without interfering with the nursing of the newborn in the intensive care unit. Our aim was to evaluate the prognostic value of CFM for neurological outcome. We studied 102 newborns (gestational age 34.5 +/-4.36 weeks; weight 1980 +/-720 grams) by Multitrace CFM (Lectromed) 5 hours daily in the first week following admission. The patients also underwent cerebral echography, EEG and neurological follow-up to the 24th month. CFM was found to correlate well with the EEG recorded 3 months later. The persistence for at least one week of an I.C. tracing or the normalization of initial tracing have a good prognostic value (positive predictive value 95.23%), a persistently pathologic registration has a negative prognostic value (negative predictive value 85.18%), that even increases if cerebral echographic alterations are demonstrated (98.57%). The association of CFM and ultrasound abnormalities determines a relative risk for neurological motor impairment of 69.14, whereas CFM alone gives a relative risk of 6.4. [The full article is in Italian.]

Cerebral function monitor in the neonate. I: Normal patterns. Verma UL, Archbald F, Tejani NA, Handwerker SM. *Dev Med Child Neurol* 1984; 26(2):154-161.

The cerebral function monitor (CFM) is a monitoring device which records integrated encephalograms (EEGs on slow-running paper, allowing continuous observations of cerebral activity for prolonged periods. The CFM was assessed in 49 normal neonates of different gestational ages and was found to reflect EEG activity accurately. Gestational age and sleep-wake states could be differentiated and normal patterns were defined. The establishment of normal patterns will allow further assessment of the CFM as a screening tool for the neonate at risk for cerebral hypoxic ischemic injury.

Comparison between simultaneously recorded amplitude integrated electroencephalogram (cerebral function monitor) and standard electroencephalogram in neonates. Toet MC, van der Meij W, de Vries LS; Uiterwaal CS, van Huffelen KC. *Pediatrics* 2002; 109(5):772-779.

OBJECTIVE: To assess the value and the limitations of amplitude integrated electroencephalogram (EEG) using the cerebral function monitor (CFM) in comparison with standard EEG in neonates who have hypoxic ischemic encephalopathy or were suspected of having convulsions. **CONCLUSION:** CFM is a reliable tool for monitoring both background patterns (especially normal and severely abnormal) and ictal activity. Certain focal, low amplitude, and very short periods of seizure

discharges can be missed. We recommend using CFM as a monitoring device and performing intermittent standard EEG whenever there is any doubt about the classification of the CFM (ie, DNV pattern or suspected epileptiform activity).

Cerebroelectric depression following surfactant treatment in preterm neonates. Hellström-Westas L, Bell AH, Skov L, Griesen G, Svenningsen NW. *Pediatrics* 1992; 89(4):643-647.

ABSTRACT: During surfactant treatment of respiratory distress syndrome, 23 premature newborns were investigated with continuous amplitude-integrated electroencephalography (cerebral function monitors). Simultaneously, arterial blood pressure and transcutaneous blood gas values were recorded. A short (less than 10 minutes) but significant decrease in cerebral activity was seen in almost all neonates immediately after the surfactant instillation, in spite of an improved pulmonary function. In 21 of 23 neonates, a transient fall in mean arterial blood pressure of 9.3 mm Hg (mean) occurred coincidentally with the cerebral reaction. Neonates in whom intraventricular hemorrhage developed tended to have lower presurfactant mean arterial blood pressure (P greater than .05), but they had a significantly lower mean arterial blood pressure after surfactant instillation (P less than .05). No other differences were found between neonates in whom intraventricular hemorrhage developed and those without intraventricular hemorrhage. The present findings demonstrate that an acute cerebral dysfunction may occur after surfactant instillation. In some vulnerable neonates with arterial hypotension and severe pulmonary immaturity, the fall in mean arterial blood pressure may increase the risk of cerebral complications and could be related to an unchanged rate of intraventricular hemorrhage after surfactant treatment.

Comparison between tape-recorded and amplitude-integrated EEG monitoring in sick newborn infants. Hellström-Westas L. *Acta Paediatr* 1992; 81(10):812-819.

ABSTRACT: In 15 ill newborn infants a comparison between long-term multichannel and single-channel recordings of simultaneously tape-recorded (Medilog system) and amplitude-integrated EEG (Cerebral Function Monitor) was made. There was good agreement between the main type of background activity diagnosed with the tape-recorded and the amplitude-integrated EEG for all recordings. Two infants had repetitive subclinical and subtle seizure activity, lasting for several hours, which was detected by both techniques. Short, single seizures were diagnosed in the recordings of nine infants. When a single electrographic seizure appeared in an otherwise stable recording, it was identified by both the tape-recorded and the amplitude-integrated EEG. Very short (5-30 s) seizure patterns, which were diagnosed with the tape-recorded EEG, were not identified in the cerebral function monitor recordings. In the

single-channel recordings of both the EEG and the cerebral function monitor there were, on some occasions, difficulties in distinguishing single seizures from interference due to external artefacts. In the multichannel recordings the diagnosis of seizure patterns was facilitated by comparison with the other channels. Both the Medilog EEG and the cerebral function monitor are feasible techniques for following cerebral electrical activity in sick neonates, although neither technique is specifically constructed for this purpose. For clinical use in the neonatal intensive care unit the advantage with the cerebral function monitor is the immediately available recording. The tape-recorded EEG offers possibilities of more channels and a higher reliability when diagnosing short subclinical seizures, however, only after offline analysis.

Amplitude-integrated electroencephalogram in newborn infants for clinical and research purposes. Hellström-Westas L, Rosén I. *Acta Paediatr* 2002; 91(10):1028–1030.

ABSTRACT: No abstract available; this is a commentary article in the the publication.

HIE / Asphyxia

Assessment of neonatal encephalopathy by amplitude-integrated electroencephalography. al Naqeeb N, Edwards AD, Cowan FM, Azzopardi D. *Pediatrics* 1999 Jun; 103(6 Pt 1): 1263–1271.

OBJECTIVE: To define normal and abnormal patterns, test interobserver variability, and the prognostic accuracy of amplitude-integrated electroencephalography (aEEG) soon after the onset of neonatal encephalopathy. CONCLUSION: The aEEG is a simple but accurate and reproducible clinical tool that could be useful in the assessment of infants with encephalopathy.

Amplitude-integrated electroencephalography coupled with an early neurologic examination enhances prediction of term infants at risk for persistent encephalopathy. Shalak LF, Laptook AR, Velaphi SC, Perlman JM. *Pediatrics* 2003; 111(2):351–357.

OBJECTIVES: The objectives of this study were to determine, first, whether an early neurologic examination could predict a persistent abnormal neonatal neurologic state comparable to the amplitude-integrated electroencephalography (a-EEG) and, second, whether a combination of the 2 methods would further enhance early identification of high-risk infants. CONCLUSION: The combination of the a-EEG and the neurologic examination shortly after birth enhances the ability to identify high-risk infants and limits the number of infants who would be falsely identified compared with either evaluation alone.

Prognostic significance of amplitude-integrated EEG during the first 72 hours after birth in severely asphyxiated neonates. ter Horst HJ, Sommer C, Bergman KA, Fock JM, van Weerden TW, Bos AF. *Pediatr Res* 2004; 55(6):1026–33.

Amplitude-integrated EEG (aEEG) is used to select patients for neuroprotective therapy after perinatal asphyxia because of its prognostic accuracy within several hours after birth. We aimed to determine the natural course of aEEG patterns during the first 72 h of life, in relation to neurologic outcome, in a group of severely asphyxiated term infants. Our findings indicate that the course of aEEG patterns adds to the prognostic value of aEEG monitoring in asphyxiated infants. Spontaneous recovery of severely abnormal aEEG patterns is not uncommon.

Selection of babies for intervention after birth asphyxia. Groendaal F, de Vries LS. *Sem Neonatol* 2000; Feb; 5(1):17–32.

ABSTRACT: Based on animal experiments, the therapeutic window for neonates with signs of perinatal hypoxia-ischaemia is probably less than 6 h, and early selection of patients is of utmost importance. In term neonates, fetal heart rate and blood flow patterns, the Apgar score, and other clinical scoring systems are insufficient to select patients for intervention, whereas umbilical artery pH<7.0 combined with umbilical arteriovenous differences in PCO₂, lactate/pyruvate ratios in cord blood, and CSF interleukin-1beta have a better predictive value. At present, neurophysiological methods such as (amplitude-integrated) EEG and evoked potentials have the best predictive value. In preterm neonates, lactate/pyruvate and uric acid measurements in cord blood, as well as neurophysiology appear to be helpful to predict brain injury, and might be used to select patients for intervention.

Cerebral function monitoring: a method of predicting outcome in term neonates after severe perinatal asphyxia. Thornberg EEkstrom-Jodal B. *Acta Paediatr* 1994; 83(6):596–601.

ABSTRACT: The cerebral function monitor (CFM), a simplified one-channel EEG monitor, was evaluated in predicting outcome after severe perinatal asphyxia in 38 term infants. Survivors were followed until 1.5–2.5 years of age. All those 17 infants who survived without major neurological handicap showed continuous activity on the CFM trace during the first and/or second day of life. Twenty of the 21 infants who either died or developed severe neurological damage had burst suppression or paroxysmal activity on the first or second day of life. Thus cerebral function monitoring can be a valuable tool in predicting prognosis for infants with severe perinatal asphyxia.

Amplitude integrated EEG at 3 and 6 hours after birth in full-term neonates with hypoxic ischemic encephalopathy. Toet MC, Hellström-Westas L, Groenendaal F, Eken P, de Vries LS. *Arch Dis Child Fetal Neonatal Ed* 1999; 81(1):F19–F23.

OBJECTIVE: To assess the prognostic value of amplitude integrated EEG (aEEG) 3 and 6 hours after birth. CONCLUSION: aEEG could be very useful for selecting those infants who might benefit from intervention after birth asphyxia.

Predictive value of early continuous amplitude-integrated EEG recordings on outcome after severe birth asphyxia in full term infants. Hellström-Westas L, Rosén I, Svenningsen NW. *Arch Dis Child Fetal Neonatal Ed* 1995; 72(1):F34–F38.

ABSTRACT: The background pattern in single channel amplitude integrated EEG recordings (aEEG) was recorded in 47 infants within the first six hours after birth to see if this could predict outcome after birth asphyxia. The aEEG background pattern during the first six hours of life was continuous and of normal voltage in 26 infants. All these infants survived; 25 were healthy, one had delayed psychomotor development. A continuous but extremely low voltage pattern was present in two infants, both of whom survived with severe handicap. Five infants had flat (mainly isoelectric) tracings during the first six hours of life; four died in the neonatal period, and one survived with severe neurological handicap. Burst-suppression pattern was identified in 14 infants, of whom five died, six survived with severe handicap, and three were healthy at follow up. The type of background pattern recorded within the first six postnatal hours in the aEEG tracings predicted outcome correctly in 43 of 47 (91.5%) infants. Use of aEEG monitoring can predict outcome, with a high degree of accuracy, after birth asphyxia, within the first six hours after birth. The predictive value of a suppression-burst pattern was, however, somewhat lower than the other background patterns. The aEEG seems to be a feasible technique for identifying infants at high risk of subsequent brain damage who might benefit from interventionist treatment after asphyxia.

Predictive value of early neuroimaging, pulsed Doppler and neurophysiology in full term infants with hypoxic-ischaemic encephalopathy. Eken P, Toet MC, Groenendaal F, de Vries LS. *Arch Dis Child Fetal Neonatal Ed* 1995; 73(2):F75–F80.

ABSTRACT: To evaluate their prognostic value, five different non-invasive techniques were used on 34 full term infants with hypoxic-ischaemic encephalopathy (HIE) within six hours of delivery. Cranial ultrasonography, the resistance index (RI) of the middle cerebral artery

obtained with Doppler ultrasonography, somatosensory evoked potentials (SEPs), visual evoked potentials (VEPs) and the cerebral function monitor (CFM) were used. According to the criteria of Sarnat, 11 infants developed mild, seven moderate, and 16 severe encephalopathy. The CFM had the highest positive (PPV 84.2%) and negative predictive value (NPV 91.7%). All but one of the infants with a continuous pattern had a good outcome. The CFM of 11 cases with a suppression-burst pattern changed to a continuous pattern over 24 to 48 hours in four infants, and was associated with a normal outcome in three. All five cases with an isoelectric CFM died. The SEPs also provided useful information (PPV 81.8%; NPV 91.7%). VEPs were often delayed during the first hours or life and did not carry a poor prognosis in five of 14 cases (PPV 77.3%). Both ultrasonography and Doppler RI were of little value, as they were almost always normal at this early stage. In 34 full term infants with HIE, studied within 6 hours of life, the CFM and SEPs provided the most useful information about the expected course of encephalopathy and subsequent neurodevelopmental outcome.

Sleep-wake cycling on amplitude-integrated electroencephalography in term newborns with hypoxic-ischemic encephalopathy. Osredkar D, Toet MC, van Rooij LG, van Huffelen AC, Groenendaal F, de Vries LS. *Pediatrics* 2005; 115(2):327–32.

OBJECTIVE: The objective of this amplitude-integrated electroencephalography (aEEG) study was to evaluate the influence of perinatal hypoxia-ischemia on sleep-wake cycling (SWC) in term newborns and assess whether characteristics of SWC are of predictive value for neurodevelopmental outcome. CONCLUSIONS: The presence, time of onset, and quality of SWC reflected the severity of the hypoxic-ischemic insult to which newborns were exposed. The time of onset of SWC has a predictive value for neurodevelopmental outcome.

Cerebral glucose metabolism and early EEG/aEEG in term newborn infants with hypoxic-ischemic encephalopathy. Thorngren-Jerneck K, Hellström-Westas L, Ryding E, Rosén I. *Pediatr Res* 2003; 54(6):854–60.

The objective was to investigate how early electrocortical background pattern, as recorded with amplitude integrated EEG (aEEG), correlates with global and regional cerebral glucose metabolism (CMRgl) measured by positron emission tomography during the subacute phase after birth asphyxia. Early electrocortical background patterns, early presence of sleep-wake cycling, and delayed seizure activity were highly correlated with global CMRgl measured during the subacute phase after asphyxia, but did not correlate with any specific pattern of regional uptake.

Recovery of amplitude integrated electroencephalographic background patterns within 24 hours of perinatal asphyxia. van Rooij LG, Toet MC, Osredkar D, van Huffelen AC, Groenendaal F, de Vries LS. *Arch Dis Child Fetal Neonatal Ed* 2005 May; 90(3):F245–51.

OBJECTIVE: To assess the time course of recovery of severely abnormal initial amplitude integrated electroencephalographic (aEEG) patterns (flat trace (FT), continuous low voltage (CLV), or burst suppression (BS)) in full term asphyxiated neonates, in relation to other neurophysiological and neuroimaging findings and neurodevelopmental outcome. CONCLUSION: In this study there was a small group of infants who presented with a severely abnormal aEEG background pattern within six hours of birth, but who achieved recovery to a continuous normal background pattern within the first 24 hours. Sixty one percent of these infants survived without, or with a mild, disability.

Cerebral function monitor in the neonate. II: Birth asphyxia. Archbald F, Verma UL, Tejani NA, Handwerker SM. *Dev Med Child Neurol* 1984; 26(2):162–168.

OBJECTIVE: The cerebral function monitor (CFM) records an integrated electroencephalogram on slow-running paper, and therefore is suited to long-term, continuous monitoring. CONCLUSION: It is concluded that the CFM can be of advantage in predicting outcome for asphyxiated neonates.

Seizures / Anticonvulsant Therapy

Amplitude-integrated electroencephalography: a tool for monitoring silent seizures in neonates. Shany E, Khvatskin S, Golan A, Karplus M. *Pediatr Neurol*. 2006 Mar;34(3):194-9.

The clinic use of amplitude-integrated electroencephalography in the diagnosis of seizures in high-risk newborn infants with suspected central nervous system insult is evaluated with emphasis on silent seizures. Recordings from 93 infants with suspected central nervous system insults over a period of 7 years were retrospectively analyzed for the presence of electrical seizures and for their correlation with clinical events.

Electroencephalographic seizures are common in sick newborn infants. Amplitude-integrated electroencephalography can provide important information concerning their neurologic status and help to confirm or refute the presence of seizures in clinically suspected cases and detect infants with silent seizures.

Silent seizures in sick infants in early life. Diagnosis by continuous cerebral function monitoring. Hellström-Westas L, Rosén I, Swenningesen NW. *Acta Paediatr Scand* 1985; 74(5):741–748.

ABSTRACT: Cerebral electric activity was surveilled with a Cerebral Function Monitor (CFM) technique in 87 newborn infants under neonatal intensive care. A total of 26 infants had electrographical signs of repeated seizure activity. Among these infants 14 had periods of one hour or more of silent seizures activity. Among these

infants 14 had periods of one hour or more of silent seizures, i.e. typical pattern of ictal epileptic activity on CFM without clinical symptoms or signs of convulsions. The occurrence of silent seizures and their pattern in relation to the clinical condition and management was unpredictable in most cases. Besides general limpness or flaccidity in an outward quiet baby these infants showed no clinical fits or clonic convulsions. The findings indicate that anticonvulsive therapy in small infants may be insufficient and need re-evaluation, since the long-term effect of silent seizures on cerebral function and activity is still uncertain.

Lidocaine for treatment of severe seizures in newborn infants. I. Clinical effects and cerebral electrical activity monitoring. Hellström-Westas L, Westgren U, Rosén I, Svenningsen NW. *Acta Paediatr Scand* 1988; 77(1):79–84.

ABSTRACT: The anticonvulsive effect of lidocaine was evaluated in 46 newborn infants with severe, recurrent seizures. Before the lidocaine all infants were being given phenobarbital, and 22 infants were also treated with diazepam. Different dosages of lidocaine were tested. A loading dose of 2 mg/kg followed by i.v. infusion of 6 mg/kg/hour was the most effective dosage and had an immediate anticonvulsive effect in 18 of 25 infants; within 30 min the same effect was attained in another five of the infants, with an overall seizure control in 92% of the sample population. During the lidocaine treatment cerebral electrical activity was followed continuously with a cerebral function monitor (CFM), which also enabled evaluation of the treatment. No serious side effects on blood-pressure, heart-rate or cerebral electrical activity were registered. For newborn infants with severe recurrent seizures not responding to other drugs, lidocaine is an effective additional mode of treatment.

Burst suppression on amplitude-integrated electroencephalogram may be induced by midazolam: a report on three cases. ter Horst HJ, Brouwer OF, Bos AF. *Acta Paediatr* 2004; 93(4):559–63.

ABSTRACT: Continuous amplitude-integrated electroencephalogram (aEEG) recording with a cerebral function monitor is a useful tool to evaluate prognoses following perinatal asphyxia in term infants. Drugs may change the pattern of the conventional EEG. This report presents three infants treated with midazolam for status epilepticus and repetitive seizures who proved resistant to other anticonvulsants (phenobarbitone, lidocaine). The infants developed burst suppression patterns on aEEG concurrent with high serum levels of midazolam (900-7093 microg l(-1)). Following discontinuation of midazolam treatment, serum levels normalized and background patterns returned to normal voltage traces. CONCLUSION: These findings indicated that midazolam can cause burst suppression on aEEG. Therefore, the prognostic value of aEEG is limited in case of high serum levels of midazolam. Serum levels of midazolam should be measured in infants who have burst suppression patterns on aEEG during midazolam treatment.

Lidocaine for treatment of severe seizures in newborn infants. II. Blood concentrations of lidocaine and metabolites during intravenous infusion. Hellström-Westas L, Svenningsen NW, Westgren U, Rosén I, Lagerstrom PO. *Acta Paediatr* 1992; 81(1):35–39.

ABSTRACT: The blood concentrations of lidocaine and its main active metabolites, methylethylglycinexylidide (MEGX) and glycinexylidide (GX), were measured in 24 newborn infants during anticonvulsive treatment with an iv infusion of lidocaine. After a bolus dose of 1.5–2.2 mg/kg and continuous infusion of lidocaine (4.7–6.3 mg/kg/h) there was accumulation of the drug and MEGX within 24 h. After termination of the iv infusion, both lidocaine and the metabolites were eliminated within 24–48 h. The anticonvulsive effectiveness—estimated by clinical observation and continuous amplitude integrated EEG monitoring (cerebral function monitor)—was immediate in 15 infants (nine term and six preterm). There was no correlation between blood concentrations of lidocaine and metabolites, and anticonvulsive effect (i.e. good, intermediate or no response). No differences in blood concentrations were found between full-term and preterm babies, or between infants with or without birth asphyxia. In combination with a fast withdrawal of the drug, few adverse reactions were seen with the dosages used, even though blood concentrations were high. Routine measurements of lidocaine concentrations during anticonvulsive treatment in neonates seem to be of little clinical value. For evaluation of the anticonvulsive effect and for early detection of seizure activity during lidocaine withdrawal, continuous EEG monitoring is preferable.

Amplitude-integrated encephalography in pyridoxine-dependent seizures and pyridoxine-responsive seizures. Helström-Westas L, Blennow G, Rosén I. *Acta Paediatr* 2002; 91(8):977–980.

Pyridoxine-dependant seizures are rare in newborn infants, although recent data suggests that the prevalence probably is underestimated. In all newborn infants with recurrent epileptic seizures the general recommendation is to administer pyridoxine and simultaneously record an electroencephalogram (EEG). **CONCLUSION:** One infant with pyridoxine-responsive seizures and another with pyridoxine-dependent seizures had different electroclinical responses on amplitude-integrated EEG monitoring (aEEG) when pyridoxine was administered.

Preterm Infants

Cerebral function monitoring: a new scoring system for the evaluation of brain maturation in neonates. Burdjalov VF, Baumgart S, Spitzer, AR. *Pediatrics*. 2003;112(4):855–861.

OBJECTIVE: Cerebral function monitoring (CFM), using compressed single channel amplitude-integrated electroencephalogram recorded from 2 biparietal electrodes, as been shown previously to be a simple bedside tool

for monitoring neonatal central nervous system (CNS) status. As the pattern of the CFM changes with gestational age, the technique can be used to assess brain maturation in premature infants. We have developed a new scoring system for the interpretation of neonatal CFM recordings. The objective of this study was to evaluate DFM tracing at increasing gestational and postnatal ages to develop a scoring system to quantify CFM pattern changes. **CONCLUSION:** Our proposed scoring system may be a valuable tool to quantify changes during CFM more objectively, reflecting variations in CNS activity in newborn infants and allowing for better statistical comparisons between amplitude-integrated electroencephalogram tracings from different patients as well as from the same patient at different points of time.

Intra- and extrauterine maturation of amplitude-integrated electroencephalographic activity in preterm infants younger than 30 weeks of gestation. Klebermass K, Kuhle S, Olischar M, Rucklinger E, Pollak A, Weninger M. *Biol Neonate*. 2006; 89(2)120–5. Epub 2005 Oct 11.

OBJECTIVE: To prospectively investigate the longitudinal changes of amplitude-integrated electroencephalographic (aEEG) activity in preterm infants < 30 weeks gestational age (GA). **CONCLUSION:** Maturation of aEEG activity in preterm infants is influenced by both GA and PNA.

Sleep-wake cycles in preterm infants below 30 weeks of gestational age. Preliminary results of a prospective amplitude-integrated EEG study. Kuhle S, Klebermass K, Olischar M, Hulek M, Prusa AR, Kohlhauser C, Birnbacher R, Weninger M. *Wein Klin Wochenschr*. 2001 Apr 17;113(7–8):219–23.

In the newborn, presence of sleep-wake cycles indicates integrity and maturity of the central nervous system. By spectral EEG analysis and polygraphic recordings subtle variation of EEG background activity and behavioural patterns corresponding to early sleep-wake cycles have been found in preterm infants as young as 27 weeks of gestation. The emergence of sleep-wake cycles at early gestational ages may have a positive predictive value for long-term neurological outcome. Amplitude-integrated EEG may thus serve as a useful noninvasive test for brain function in preterm infants.

Progressive posthemorrhagic hydrocephalus leads to changes of amplitude-integrated EEG activity in preterm infants. Olischar M, Klebermass K, Kuhle S, Hulek M, Messerschmidt A, Weninger M. *Childs Nerv Syst* 2004; Jan; 20(1):41–45. Epub 2003 Oct 11.

CONCLUSION. Continuous neurophysiological monitoring by aEEG may be of value in the diagnostic and therapeutic management of preterm infants with progressive PHH.

Reference values for amplitude-integrated electroencephalographic activity in preterm infants younger than 30 weeks' gestational age. Olischar M, Klebermass K, Kuhle S, Hulek M, Kohlhauser C, Rucklinger E, Pollak A, Weninger M. *Pediatrics* 2004 Jan; 113(1 Pt 1):e61-6.

OBJECTIVE: To prospectively investigate the development of amplitude-integrated electroencephalographic (aEEG) activity during the first 2 weeks of life in neurologically normal and clinically stable preterm infants <30 weeks' gestational age (GA). CONCLUSION: Normal values for aEEG background activity were determined in preterm infants <30 weeks' GA. Clinically stable and neurologically normal preterm infants exhibit at least 2 different patterns of aEEG activity. There is a correlation between the GA and the relative duration of continuous aEEG activity.

Amplitude-integrated EEG in preterm infants: maturation of background pattern and amplitude voltage with postmenstrual age and gestational age. Sisman J, Campbell DE, Brion LP. *J Perinatol* 2005 June; 25(6): 391-6.

OBJECTIVE: Amplitude-integrated electroencephalogram (aEEG) is a single channel EEG recorded from two parietal electrodes. The objective of this study was to test the hypothesis that aEEG maturation follows postmenstrual age (PMA) irrespective of gestational age (GA). CONCLUSIONS: In preterm infants aEEG matures predominantly with PMA. Our data suggest that some aspects of aEEG maturation are enhanced, rather than inhibited by extremely preterm birth. These data suggest that aEEG in preterm infants may need to be analyzed by comparing results with standards of similar PMA and GA.

Normal pattern of the cerebral function monitor trace in term and preterm neonates. Thornberg E, Thiringer K. *Acta Paediatr Scand* 1990; 79(1):20-25.

ABSTRACT: Cerebral Function Monitor (CFM) recordings were performed on 10 term and 19 preterm healthy infants. Term infants were monitored once, while preterm infants were followed serially. Forty-six recordings were made on 7, 14, 16 and 9 occasions in the age groups 30-31, 32-33, 34-35 and 36-37 weeks. All infants were examined clinically at 18 months of age and found healthy. By drawing weighted lines derived from the lower and upper limits of the CFM traces, mean values of minimum and maximum cerebral activity were calculated for the different age groups. In the term infants different CFM traces were identified corresponding to quiet sleep and active sleep. In the preterm infants a similar cyclic variability of the CFM trace was noted. A gradual increase in the minimum cerebral activity was found with increasing gestational age, resulting in a gradual narrowing of the trace.

Early prediction of outcome with aEEG in preterm infants with large intraventricular hemorrhages. Hellström-Westas L, Klette H, Thorngren-Jerneck K, Rosén I. *Neuropediatrics* 2001; 32(6):319-324.

OBJECTIVE: To investigate if early prediction of outcome is possible from aEEG in preterm infants with large IVH. CONCLUSIONS: This study shows that outcome may be predicted with aEEG already during the first days of life in preterm infants with large IVH. The findings should be confirmed in prospective studies since they may have clinical implications if specific medical interventions become available.

Lack of influence of mild hypothermia on amplitude integrated-electroencephalography in neonates receiving extracorporeal membrane oxygenation. Horan M, Azzopardi D, Edwards AD, Firmin RK, Field D. *Early Hum Dev.* 2006 Jun 28; [Epub ahead of print]

OBJECTIVE: To observe amplitude integrated electroencephalography (aEEG) in neonates receiving ECMO and to determine whether mild hypothermia influenced the aEEG recording. METHODS: Twenty-six consecutive neonates enrolled in a pilot study of mild hypothermia during ECMO were studied. The first group (N=6) was maintained at 37° C throughout the study period. Subsequent groups were cooled to 36° C (N=4), 35° C (N=5), and finally 34° C (N=6) respectively for 24 h and the final group (N=5) to 34° C for 48 h before being rewarmed to 37 °C. The aEEG was recorded continuously during the first 5 days of ECMO. The aEEG was classified as normal, moderately or severely suppressed and examined for the occurrence of seizures. To assess the effect of temperature, the aEEG was compared over 12 h during the final 6 h of cooling and during the first 6 h once infants were rewarmed. RESULTS: No change in aEEG amplitude was noted over the temperature range studied. Of the 26 traces obtained, 16 (62%) were normal throughout, 6 (23%) were intermittently moderately abnormal and 1 (14%) was severely abnormal. Three (11%) traces had periods of frequent seizure activity and these were not associated with clinical manifestations in two neonates. In one infant who suffered a cerebral haemorrhage, the aEEG became abnormal before cranial ultrasound abnormalities were apparent. CONCLUSIONS: Continuous cerebral monitoring with aEEG is feasible during ECMO and may add information to clinical examination. Mild hypothermia to 34° C for up to 48 h does not influence the aEEG suggesting that cerebral monitoring with aEEG is possible during mild hypothermia.