Neonatal cerebral function monitoring — understanding the amplitude integrated EEG

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Abstract

Amplitude integrated electroencephalography (aEEG) is produced by cerebral function monitors (CFM), and is increasingly used in neonates following research into hypothermia for hypoxic ischaemic encephalopathy in term infants. Formal training packages in aEEG in term infants are limited. aEEG is used less often in clinical practice in preterm infants, and requires an understanding of the normal changes seen with increasing gestational age. A number of classifications for aEEG interpretation exist; some purely for term neonates born, and others encompassing both preterm and term neonates. This article reviews the basics of aEEG, its indications and limitations. We also discuss its role in prognostication in term and preterm infants.

Keywords cerebral function monitoring; electroencephalography; neurology; newborn; seizure

Introduction

Amplitude integrated EEG (aEEG) is becoming a standard of care in the UK for term neonates with hypoxic ischaemic encephalopathy (HIE). aEEG and the raw EEG, which the aEEG is derived from, can:

- determine the severity and prognosis of HIE
- assess improvement in encephalopathy with time
- detect some epileptic seizures.

In our experience, aEEG is also being used increasingly in term neonates without HIE, such as those with seizures from different aetiologies, and in late-preterm infants with HIE. However, interpretation can be difficult, especially in infants who are preterm. This article discusses:

- what aEEG is
- the indications for aEEG
- the advantages and disadvantages of aEEG
- the proposed classifications of preterm and term aEEG
- the prognostic abilities of aEEG.

For more details on neonatal electroencephalograpy (EEG), please refer to our companion article.

What is amplitude integrated EEG?

aEEG is a simplified, compressed trace derived from EEG. Electrical signals are recorded from scalp electrodes attached to the head using adhesive pads, silver cups glued to the scalp, or subcutaneous needles. Whilst standard EEG uses many different leads to record signals from a wide area, aEEG uses fewer leads: often only one pair of electrodes crossing the midline over either the parietal or central regions (Figure 1). These positions were originally chosen because they covered the vascular watershed areas and avoided muscle artefact. Another electrode, called the ground, is also placed, usually about an inch anterior to the vertex. This aids suppression of any interfering signals recorded. Increasingly, modern monitors may use additional leads and display aEEG from two regions of the brain: either anterior and posterior, or the left and right hemispheres (Figure 1).

The EEG leads record the spontaneous extracellular electrical activity of the brain. The monitor rectifies the signal, meaning biphasic waveforms are converted to a monophasic waves, and filters it to remove activity less than 2 Hz and more than 15 Hz. This helps reduce the effect of artefacts from, for example, handling the baby or mains-powered electrical equipment. The signal is compressed in time. The amplitude of the recorded activity is displayed on a partly logarithmic y-axis: up to 10 μV amplitudes are plotted in linear fashion, 10—100 μV is shown logarithmically. The x-axis represents time, and is compressed to around 6 cm/hour. The results are visualised as a thick band: the lower margin represents the minimum amplitudes recorded and the upper margin shows the maximum.

Electrode impedance is also displayed and reflects the opposition to flow of the electrical current. It is used as a measure of the quality of electrode contact with the skin.

The terminology is used interchangeably and incorrectly: aEEG is the trace itself and CFM is the monitor. Modern CFM also show raw, real time EEG and are digital, allowing for easy review of the aEEG over time, and correlation between abnormalities and the time-locked EEG trace. CFAM is the name of an earlier monitor that displayed the relative amounts of electrical activity in certain frequency bands (alpha, beta, delta, theta) in addition to aEEG. More modern machines do not display this extra information and are not CFAM.

Indications for aEEG

The main use of aEEG is to monitor trends in the electrical activity of the brain over time, and helps assess encephalopathy severity and recovery. aEEG can also provide useful prognostic information, and may help determine whether abnormal movements are seizures, or whether electrographic seizures without clinical features are occurring.

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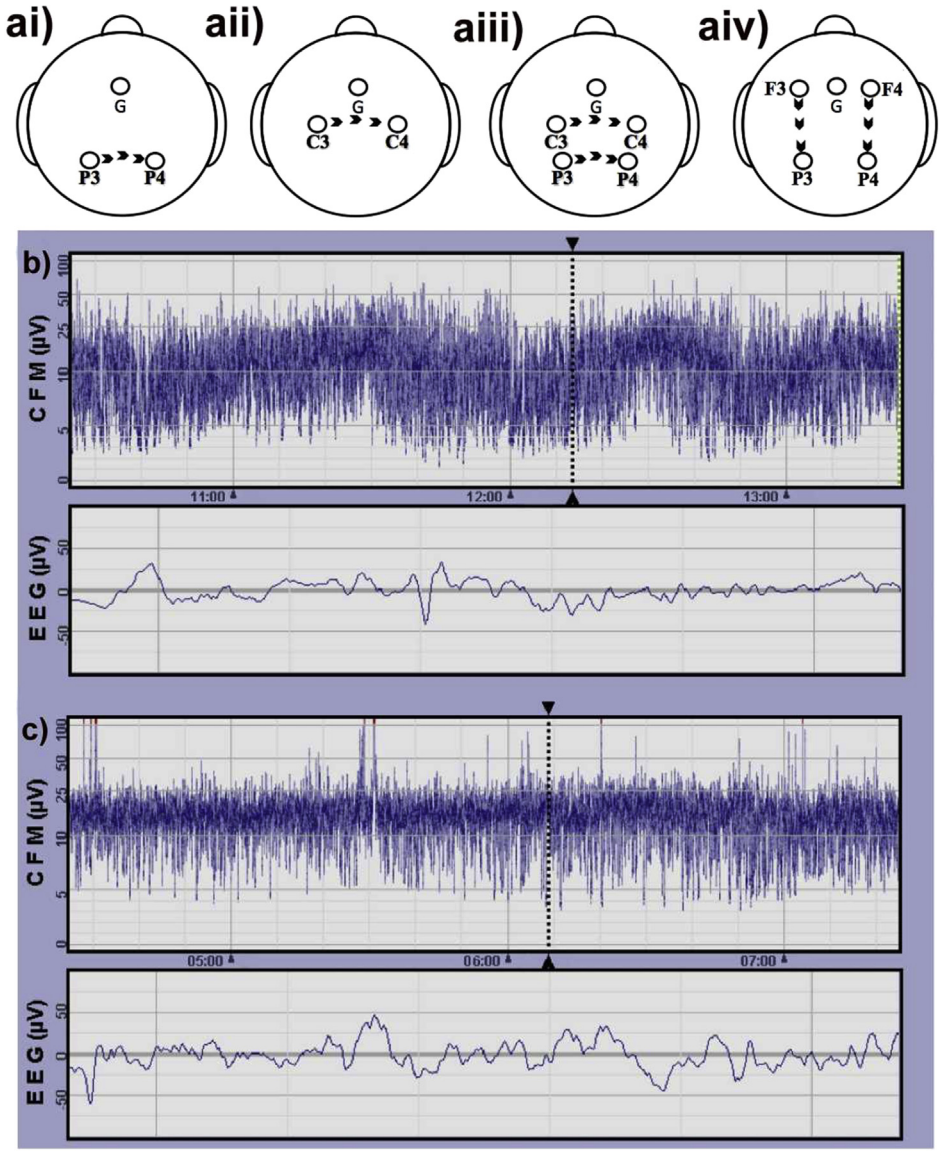

Figure 1 (**a i**–**iv**), Schematics of possible aEEG electrode placement. The most common electrode configurations and shown in (**i**) and (**ii**). Some new machines use four electrodes which could look across (**iii**) or along (**iv**) hemispheres. (**b**) upper panel – continuous normal voltage aEEG with evidence of SWC; lower panel – a few seconds of normal raw EEG at time point marked with the dotted line. (**c**) upper panel – continuous normal voltage aEEG but with no SWC and no seizures. The classification described by Al Naqeeb et al. would describe this as normal, but the absence of sleep wake cycling means it is not; lower panel – a few seconds of normal raw EEG at time point marked with the dotted line.

Limitations of aEEG

- Standardised training in aEEG interpretation for nurses and trainees is limited
- Standard EEG is needed for more detailed evaluation of background activity
- Gestational age (GA) needs to be taken into account during interpretation of aEEG, so clinicians need an understanding of its normal maturation
- The raw EEG trace on some CFM monitors is difficult to interpret
- Artefacts can also be misdiagnosed as seizures
- Short lasting seizures (less than 30 seconds), those with low amplitude or distant from the electrodes can be missed
- aEEG has a poor sensitivity for recognising seizures compared to standard EEG. Studies comparing the two demonstrate that aEEG identifies 1/3 of single seizures and 2/3 of repetitive seizures, although this is clearly superior to clinical observation. Attempts to improve seizure detection on aEEG include the use of two channels (four electrodes) and automatic seizure detection algorithms, which are not used in routine clinical practice in all UK neonatal units.

The evolution of the normal aEEG from preterm to term

The EEG and aEEG change from preterm towards term age. As discussed in our companion article, the normal preterm EEG is