Cerebral Function Monitor

Overview

The Cerebral Function Monitor (CFM), or amplitude-integrated EEG (aEEG), is a device for monitoring background neurological activity. It uses a single, bipolar or bitemporal lead (three wires) to obtain an EEG signal. The output is no longer a regular EEG but is, rather, a representation of the overall activity. A low value indicates low activity.

Because of its simplicity and ease of training there is increasing use of the CFM in the NICU. The CFM allows clinical personnel without in-depth knowledge of EEG to quickly determine global neurological status and monitor this status long-term. This is similar to the use of pulse oximetry and EKG to evaluate oxygenation and cardiac status.

Future

The next generation CFM will allow digital recording of the CFM signal with additional software analysis tools, making it even easier to use. In addition, it will have the ability to simultaneously display the raw EEG for any portion of the CFM trace to aid in positive identification of seizure activity.

Analysis

A clinician can quickly learn to read CFM tracings. Initially it is easiest to use the systematized approach introduced by Naqueeb et al., from the Imperial College of London. It is based on noting the upper and lower margins and mean of the main band of activity, as seen in the accompanying examples. As a result of this processing, the output is no longer a regular EEG signal but is, rather, a representation of the overall electrocorticographic background activity of the brain. A high reading on the chart indicates a high level of activity. A low value indicates low activity.

Applications

The CFM was first developed in the late 1980s for use in monitoring adults undergoing surgery, suffering head trauma, or in a coma. In the mid 1980s research groups in Sweden and the Netherlands began investigating its use in neonates. Since that time there have been a number of studies of the CFM in neonates both in Europe and the United States. They have shown that the CFM has a high sensitivity, specificity, and predictive value for long-term severity of hypoxic-ischemic encephalopathy if recordings are taken within 6–12 hours of a perinatal asphyxial event. More recently, the CFM has been shown to be useful in the detection of seizures in neonates when compared to regular EEG. A number of studies are being conducted in Europe and the United States, investigating its use in pre-mature infants and other intensive care applications.

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Examples

The following examples show the types of traces that might be obtained from normal infants and those that have suffered varying degrees of neurologic insult. With a basic understanding of the nature of the traces presented here, a clinician can immediately begin to use the CFM to evaluate infants. The traces are provided courtesy of Dr. Denis Azzopardi, Imperial College London, School of Science, Technology, and Medicine, U.K.

For more examples and a self-training exercise, contact Olympic Medical and request a copy of the Olympic CFM Model 6000 Clinical Guide.

Normal Trace

Note the variation in the amplitude indicating sleep/wake cycling. The upper margin of the main band of activity is above 10 µVolts. The lower margin is above 5 µVolts. The mean is around 25 µVolts.

Moderately Abnormal with Seizure

In an infant with mild to moderate asphyxia, the trace flattens with the loss of sleep/wake cycling. The upper margin is slightly depressed but is still above 10 µVolts. The lower margin has dropped below 5 µVolts. The mean is less than 10 µVolts. Note the seizure pattern in which the difference between the upper and lower bands decreases and the mean increases sharply.

Severely Abnormal

This trace is from an infant that suffered a severe asphyxial insult. Note the very narrow, suppressed band of activity with occasional spikes indicating burst suppression.

Examples, continued

Severely Suppressed with Seizures

This is an example of a severely asphyxiated infant with suppressed background and frequent seizures.

Figure 1. Normal Trace

Figure 2. Moderately Abnormal with Seizure

Figure 3. Severely Abnormal

Figure 4. Severely Suppressed with Seizures

Figure 5. Moderately Abnormal with Seizures and Administration of Phenobarbital

Figure 6. Severely Abnormal with Frequent Seizures

Moderately Abnormal with Seizures and Administration of Phenobarbital

This trace shows a moderately suppressed background. There is no indication of sleep/wake cycling, but the lower margin is generally above 5 µVolts. There is evidence of occasional seizures. Note the expected decrease in the mean and lower margin after administration of phenobarbital.

Severely Abnormal with Frequent Seizures and Administration of Phenobarbital

An example of a severely suppressed background with frequent seizures. Note the decrease in the frequency of the seizure after an increase in the dose of phenobarbital. Due to the already severely suppressed background there is no noticeable effect on the amplitude.

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Note the variation in the amplitude indicating sleep/wake cycling. The upper margin of the main band of activity is above 10 µVolts. The lower margin is above 5 µVolts. The mean is around 25 µVolts.

Moderately Abnormal with Seizure
In an infant with mild to moderate asphyxia, the trace flattens with the loss of sleep/wake cycling. The upper margin is slightly depressed but is still above 10 µVolts. The lower margin has dropped below 5 µVolts. The mean is less than 10 µVolts. Note the seizure pattern in which the difference between the upper and lower bands decreases and the mean increases sharply.

Severely Abnormal
This trace is from an infant that suffered a severe asphyxial insult. Note the very narrow, suppressed band of activity with occasional spikes indicating burst suppression.

Severely Suppressed with Seizures
This is an example of a severely asphyxiated infant with suppressed background and frequent seizures.

Moderately Abnormal with Seizures and Administration of Phenobarbital
This trace shows a moderately suppressed background. There is no indication of sleep/wake cycling, but the lower margin is generally above 5 µVolts. There is evidence of occasional seizures. Note the expected decrease in the mean and lower margin after administration of phenobarbital.

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An example of a severely suppressed background with frequent seizures. Note the decrease in the frequency of the seizure after an increase in the dose of phenobarbital. Due to the already severely suppressed background there is no noticeable effect on the amplitude.
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Overview

The Cerebral Function Monitor (CFM), or amplitude-integrated EEG (aEEG), is a device for monitoring background neurological activity. It uses a single, bipolar, or bitemporal lead (three wires) to obtain an EEG signal. This signal is filtered, semi-logarithmically compressed, and rectified. The output is displayed at a very slow chart speed, 1 mm/minute, giving a trace as seen in the accompanying examples. As a result of this processing, the output is no longer a regular EEG signal but is, rather, a representation of the overall electrocorticographic background activity of the brain. A high reading on the chart indicates a high level of activity. A low value indicates low activity.

Applications

The CFM was first developed in the late 1960s for use in monitoring adults undergoing surgery, suffering head trauma, or in a coma. In the mid-1980s research groups in Sweden and the Netherlands began investigating its use in neonates. Since that time there have been a number of studies of the CFM in neonates both in Europe and the United States. They have shown that the CFM has a high sensitivity, specificity, and predictive value for long-term severity of hypoxic-ischemic encephalopathy if recordings are taken within 6–12 hours of a perinatal asphyxial event. More recently, the CFM has been shown to be useful in the detection of seizures in neonates when compared to regular EEG. A number of studies are being conducted in Europe and the United States, investigating its use in pre-mature infants and other intensive care applications.

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Analysis

A clinician can quickly learn to read CFM tracings. Initially it is easiest to use the systematized approach introduced by Naqeeb et al., from the Imperial College of London. It is based on noting the upper and lower margins and mean of the main band of activity of the CFM trace. Using these measurements a clinician can predict the severity of outcome for infants at risk for Hypoxic-Ischemic Encephalopathy (HIE) as well as learn to detect seizures. With more practice and experience, the clinician will begin to recognize various patterns as shown in the Atlas of Amplitude-Integrated EEG in the Newborn, recently published by Hellström-Westas, de Vries, and Rösen, from Sweden and the Netherlands.