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It Looks Like Chicken Scratch to Me (or Making the Most of Today's Technology): A Practical Guide for the Bedside Nurse to Optimize Amplitude-Integrated EEG Monitoring☆,☆☆,★

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ABSTRACT

Neurological concerns in the neonate presenting as abnormal electrical activity in the brain can be difficult to identify, yet may have profound lifelong sequelae. Traditional video EEG is the gold standard for diagnosis, but is usually outside the scope of most neonatal providers to interpret. The development of amplitude-integrated electroencephalography (aEEG) gives neonatal providers a unique bedside opportunity to trend and interpret real-time neurologic activity to better care for the infants in the NICU. However, the interpretation is only as reliable as the information the monitor provides. It is critical for the nursing staff to correctly place aEEG monitor leads, assess for proper function, and troubleshoot potential concerns. Based on published information plus my own experiences working with aEEG monitors as well as teaching its use to almost 200 staff nurses in two Level III/IV NICUs, I will present a concise, approachable guide covering lead placement, troubleshooting, and basic interpretation.

Amplitude-integrated electroencephalography (aEEG) is a rising star in NICU technology. A variety of cerebral function monitors (CFM) are available today with which to provide aEEG monitoring. The traditional long-form EEG, usually with associated video, remains the gold standard for documentation and diagnosis of seizures via pediatric neurology consult. However, the development of aEEG gives neonatal providers a unique bedside opportunity to trend and interpret real-time neurologic activity to better care for the infants in the NICU.

The technology behind CFM was developed in the late 1960s for use with adults in intensive care, particularly while under anesthesia.[1] After a time it was further refined for use in neonates. An aEEG works by filtering and compressing brain signals into a form that is easier to read. Raw EEG data is first amplified, then passed through a filter which attenuates activity below 2 Hz and above 15 Hz. The purpose of this filtering is to minimize inherent artifact activity such as sweating, muscle movement, ECG and electrical interference.[1] The signal undergoes further filtering by amplitude and time compression, then is displayed on a monitor screen consisting of a semilogarithmic scale at a slow speed of 6 cm/hour.[2]

The particular position of the leads is important in order to minimize extraneous muscle movement and to maximize sensitivity to the most at-risk areas of the neonatal brain.[1] The most frequent use of aEEG monitoring is for the infant at risk for seizure activity due to hypoxic-ischemic encephalopathy (HIE). HIE in term infants is most commonly associated with some type of perinatal asphyxia event in the prenatal, perinatal or immediate neonatal period. With HIE, there is an interruption of cerebral blood flow and marked cerebral hypotension.[2] The areas of the brain most at risk for permanent injury are referred to as the watershed area. Watershed injuries are usually associated with term infants.[2]

The watershed area is best described as the outer reaches of the main cerebral arteries. Consider a few of the main cerebral arteries such as the anterior cerebral, middle cerebral, posterior cerebral and basilar arteries. As they course through the brain, they branch out into smaller arterioles before matching up with venuoles in the capillary bed. The brain tissue at the outer reaches of the small arterioles is referred to as the watershed area. This area is more susceptible to hypoperfusion injury when an infant has experienced HIE. The parietal-occipital region is more at risk for injury than the anterior region.[2] This fact informs lead placement.

This first CFM for neonatal use utilized a single-channel design and required two scalp leads plus the ground wire. With advancing technology, dual channel aEEG monitoring was developed with the idea that covering more areas of the brain would lead to a higher percentage of seizure activity identified via bedside monitoring. Studies have not strongly borne that out.[1] The most current monitor available is the digital aEEG. The digital advancement utilizes dual channel monitoring and also displays a simultaneous real-time EEG of each channel.[1–3] The

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digital aEEG/EEG displays allow the option to view separate left and right hemisphere tracings for a true dual channel experience, or to view a single combined waveform.[3]

The presence of the real-time EEG provides additional information which assists in the aEEG interpretation. It is especially helpful for advanced interpretation such as differentiating artifact from actual brain wave pattern, or determining if a subclinical aEEG wave suspicious for seizure in aEEG mode is a classical epileptiform spike in real-time.[1] This kind of advanced interpretation is very helpful as not all electrical discharges require pharmacological treatment, and not all clinical movements have associated electrical discharges. Being that real-time EEG interpretation is an advanced interpretation, it will not be covered in this article.

In order to obtain the best information for aEEG interpretation, the leads must be placed in a position to detect the majority of seizure activity in neonates. Infants with HIE are most at risk for injury in the posterior parietal-occipital region of the watershed area. Lead placement is based on the same mapping used for traditional EEGs. Dual channel aEEG monitors place leads in the C3/P3 and C4/P4 positions.[2,3] In EEG language, the number 3 refers to the left side of the scalp and the number 4 refers to the right side. The letter C refers to a spot located approximately over the coronal suture line. The letter P refers to a spot located over the posterior third of the parietal bone. All placements are relatively superiorly located on the scalp. These positions, especially P3/P4, relate well to the most vulnerable watershed areas of the underlying brain.[1,2] Careful measuring and lead placement is necessary to produce top quality aEEG signals for accurate interpretation.

Lead Placement

The information presented by a cerebral function monitor is only as good as the information which was gathered. The information going into the CFM is dependent upon the position and placement of the leads, proper set-up and function of the specific monitor, and ongoing assessment of the monitoring process. By far, the single most important factor in successful monitoring via aEEG apparatus is proper lead placement. Diligent upkeep with a keen eye toward troubleshooting potential problems will maximize the effectiveness of aEEG monitoring for infants in your NICU.

There are two types of leads — topical hydrogel pads and subdermal needles. Placement, maintenance, and troubleshooting for both options will be discussed, including pros and cons of each option. For the purpose of this guide, instructions will focus on utilizing dual-channel CFM monitoring with placement of five leads (C3/P3 and C4/P4 plus ground). Photos will depict the Olympic Brainz Monitor by Natus Medical Incorporated (San Carlos, CA). The determination of type of lead to use depends on key questions such as:

- What types of leads are available in your unit?
- What will be the length of CFM monitoring?
- How much hair is present on the scalp?

Regardless of the type of lead chosen, there are a few basic assistive devices that are required for lead placement. A specialized tape measure is used to pinpoint the C3/P3 and C4/P4 positions. This tape measure comes in two sizes, roughly a term and a preterm size, to accommodate a variety of cranium shapes and sizes. The tape has two sections with each section further divided by lettered hash marks. Each section is an approximate mirror image of the other. The most unique feature of this measuring tape is that each end is specifically labeled as either "Sagittal Suture" or "Ear Tragus". These labels indicate how to position the measuring tape against the side of the infant's head. In between the two sets of letters is a horizontal arrow. This arrow indicates the positions of the leads when the measuring tape is properly aligned. Always use the specialized measuring tape supplied by the manufacturer for determining aEEG lead placement.[3] A standard "length" type measuring tape cannot perform the same duty. The entire process of aEEG lead placement and set-up is best accomplished with two nurses.

(1) Place measuring tape on the side of infant's head assuring that the "Sagittal Suture" end is on top of the head, and the "Ear Tragus" end is over the ear.
(2) The anterior, or forward, edge of the tape should be just behind the tragus. When properly placed, the measuring tape should cover most of the ear (Fig. 1).
(3) Assure that the tape is parallel to the face, perpendicular to the shoulders; in line with the neck and not slanting across the side of the head.
(4) Palpate for the sagittal suture. The goal is to have the same letter at the sagittal suture and at the tragus at the same time. Move the tape vertically up or down until matching letters are achieved.
(5) If matching letters cannot be achieved despite multiple attempts at readjusting the measuring tape, then try the other size of tape (remember there are two sizes supplied by the manufacturer).
(6) When matching letters are achieved, hold the measuring tape in place, and use an approved medical skin marker to place dots on the scalp on both sides of the tape at the horizontal arrow.
(7) Proceed with skin preparation as dictated by type of lead chosen; repeat on the other side of the head.

Other supplies needed for both types of lead include one gel lead for the ground lead, material for head wrap (such as stockinet or wide gauze dressing), and 1 inch wide tape.

"The Last IV on Earth…"

Every PIV attempt has either failed, or has infiltrated as soon as it was flushed, and now, finally, after multiple needles sticks, something finally works. A successful PIV was placed in the scalp, and you now have a new order – for an aEEG monitor – ASAP. Great. Is there a work around? Yes, there is a way to alter lead placement to work around an IV that cannot be relocated due to difficulty in placement and/or lack of available sites for another IV placement.

Typically a scalp PIV is going to affect the C3/C4 positions because most are located on the anterior half of the scalp. With the aEEG lead measuring tape, perform a "dry run" measurement to determine if the IV site affects one side of the scalp more than the other. If it does, then mark the measurement dots on the most affected side first. With the affected spot, mark the dot as close to the desired location as possible. The key is that the corresponding spot on the other side of scalp should be in the same location.[3] For example, if a PIV on the left side of the head

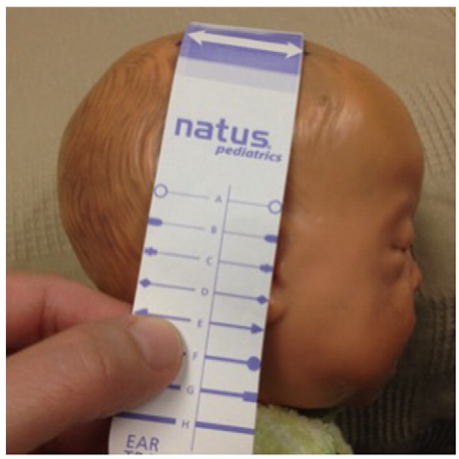

Fig. 1. Note that the specialized measure device is positioned vertically with the anterior edge just behind the tragus of the ear. In this case, the letter C matches at the ear and also at the sagittal suture. A skin marker is used to place dots on either side of the tape next to the locator arrow (photo by Sievert).