Electroencephalographic Response during Procedural Pain in Neonates

Thesis

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Laila Taher Bassiouni

List of Contents

Title	Page No.

List of Tables

List of Tables (Cont...)

List of Figures

List of Figures (Cont...)

List of Abbreviations

Abb.	Full term
aEEG	*Amplitude Integrated Electroencephalography*
AS	*Active sleep*
C	*Continuous activity*
Cps	*Cycles / sec.*
D	*Discontinuous activity*
EEG	*Electroencephalogram*
EMG	*Electromusclogram*
EOG	*Electrooculogram*
FFT	*Fast Fourier Transformation*
NICU	*Neonatal Intensive Care Unit*
NIPS	*Neonatal / infant pain scale*
NMDA	*N-methyl-D-aspartate*
NNS	*Non-nutritive suckling*
NR	*Nonreactive*
NREM	*Non-rapid eye movement*
PCA	*Postconceptional age*
QEEG	*Quantitative EEG*
QS	*Quiet sleep*
R	*Reactive*
REM	*Rapid eye movement*
SEF	*Spectral edge frequency*
SWC	*Sleep-wake cycling*
TF	*Time frequency*
V	*Vertex*

INTRODUCTION

Newborn infants undergoing intensive care may become exposed to a considerable number of painful experiences ***(Barker et al., 1995 and Annad et al., 2006).*** Identification and assessment of pain in newborn infants is challenging because the infant's ability to communicate pain is limited. Pain assessment instruments for clinical use have mainly been constructed for evaluation of acute procedure-related pain responses ***(Stevens et al., 2000).*** There is a growing international request to produce valid instruments for assessing both continuous and procedure-related pain in newborns ***(Hummel et al., 2006 and Annad, 2007).***

Although the somatic sensation of painful stimuli undoubtedly takes place within hundreds of milliseconds after the stimulus, several studies have demonstrated that painful stimuli also produce more long-lasting behavioral and physiologic responses. Resulted in a change in EEG activity and this change was attenuated by oral sucrose given before the noxious stimulus ***(Fernandez et al., 2003).***

Sucrose is a naturally occurring sweetener with analgesic effects in newborns .oral sucrose is frequently given to relieve procedural pain in neonates on the basis of its effect on behavioural and physiological pain scores. Sucrose administration reduces pain – specific brain and spinal cord activity after an acute noxious procedure in newborn ***(Annad et al., 2006)***.

AIM OF THE WORK

The aim of this study is to asses

1- Effect of pain on neonatal vital data and spectral EEG analysis.

2- Whether sucrose administration reduces pain during acute painful procedures in neonates.

Chapter 1
ELECTROENCEPHALOGRAPHY (EEG)

The electroencephalogram (EEG) is the depiction of the electrical activity occurring at the surface of the brain. This activity appears on the screen of the EEG machine as waveforms of varying frequency and amplitude measured in voltage (specifically microvoltages). EEG waveforms are generally classified according to their frequency, amplitude, and shape, as well as the sites on the scalp at which they are recorded. The most familiar classification uses EEG waveform frequency (eg, alpha, beta, theta, and delta) ***(Niedermeyer and Lopes da Silva, 1993; Blume and Kaibara, 1999; Fisch and Spehlmann, 1999)***.

Information about waveform frequency and shape is combined with the age of the patient, state of alertness or sleep, and location on the scalp to determine significance.

Normal EEG waveforms, like many kinds of waveforms, are defined and described by their frequency, amplitude, and location ***(Stern and Engel, 2004).***

- Frequency (Hertz, Hz) is a key characteristic used to define normal or abnormal EEG rhythms.
- Most waves of 8 Hz and higher frequencies are normal findings in the EEG of an awake adult. Waves with a frequency of 7 Hz or less often are classified as abnormal in

awake adults, although they normally can be seen in children or in adults who are asleep. In certain situations, EEG waveforms of an appropriate frequency for age and state of alertness are considered abnormal because they occur at an inappropriate scalp location or demonstrate irregularities in rhythmicity or amplitude ***(Ioannides et al., 2004)***.

- Some waves are recognized by their shape, scalp location or distribution, and symmetry. Certain patterns are normal at specific ages or states of alertness and sleep.
- The morphology of a wave may resemble specific shapes, such as vertex (V) waves seen over the vertex of the scalp in stage 2 sleep or triphasic waves that occur in the setting of various encephalopathies.

Frequency:

The frequencies most brain waves range from are 0.5-500 Hz. However, the following categories of frequencies are the most clinically relevant:

- Alpha waves - 8-13 Hz
- Beta waves - Greater than 13 Hz
- Theta waves - 3.5-7.5 Hz
- Delta waves - 3 Hz or less.

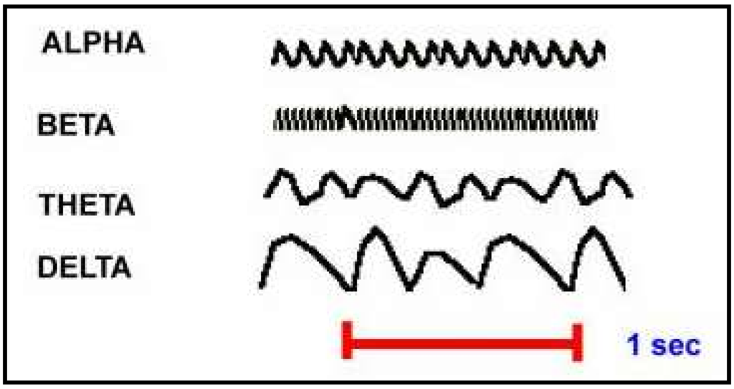

Figure (1): Examples of alpha, beta, theta and delta electroencephalography frequencies

Alpha waves - 8-13 Hz

- Alpha waves generally are seen in all age groups but are most common in adults. They occur rhythmically on both sides of the head but are often slightly higher in amplitude on the nondominant side, especially in right-handed individuals. A normal alpha variant is noted when a harmonic of alpha frequency occurs in the posterior head regions. They tend to be present posteriorly more than anteriorly and are especially prominent with closed eyes and with relaxation.
- Alpha activity disappears normally with attention (eg, mental arithmetic, stress, opening eyes). In most instances, it is regarded as a normal waveform.
- An abnormal exception is alpha coma, most often caused by hypoxic-ischemic encephalopathy of destructive processes in the pons (eg, intracerebral hemorrhage). In alpha coma, alpha waves are distributed uniformly both anteriorly and posteriorly in patients who are unresponsive to stimuli.

Beta waves - Greater than 13 Hz

- Beta waves are observed in all age groups.
- They tend to be small in amplitude and usually are symmetric and more evident anteriorly.
- Drugs, such as barbiturates and benzodiazepines, augment beta waves.

Theta waves - 3.5-7.5 Hz

- Theta waves normally are seen in sleep at any age. In awake adults, these waves are abnormal if they occur in excess.
- Theta and delta waves are known collectively as slow waves.

Delta waves - 3 Hz or less

- These slow waves have a frequency of 3 Hz or less.
- They normally are seen in deep sleep in adults as well as in infants and children.
- Delta waves are abnormal in the awake adult.
- Often, they have the largest amplitude of all waves.
- Delta waves can be focal (local pathology) or diffuse (generalized dysfunction).

Source of EEG activity:

Neurons, or nerve cells, are electrically active cells that are primarily responsible for carrying out the brain's functions. Neurons create action potentials, which are discrete electrical signals that travel down axons and cause the release of chemical neurotransmitters at the synapse, which is an area of near contact between two neurons. This neurotransmitter then activates a receptor in the dendrite or body of the neuron that is on the other side of the synapse, the post-synaptic neuron. The neurotransmitter, when combined with the receptor, typically causes an electrical current within the dendrite or body of the post-synaptic neuron. Thousands of post-synaptic currents from a single neuron's dendrites and body then sum up to cause the neuron to generate an action potential. This neuron then synapses on other neurons, and so on ***(Nunez and Srinivasan, 1981).***

EEG reflects correlated synaptic activity caused by post-synaptic potentials of cortical neurons. The ionic currents involved in the generation of fast action potentials may not contribute greatly to the averaged field potentials representing the EEG. More specifically, the scalp electrical potentials that produce EEG are generally thought to be caused by the extracellular ionic currents caused by dendritic electrical activity, whereas the fields producing magnetoencephalo-graphic signals are associated with intracellular ionic currents ***(Buzsaki, 2006).***