Burst Suppression in Neurovascular Surgery

An essay submitted for the partial fulfillment of the master degree in anesthesiology

Submitted By

Ehab Saeed Bakry

M.B. B.Ch

Supervised By

Prof. Dr. Omar Wagih Abbas

Professor of Anesthesiology

Faculty of Medicine – Cairo University

A. Prof. Dr. Mohamed Walid Awad

Assistant Professor of Anesthesiology

Faculty of Medicine – Cairo University

Dr. Hesham Abd Elwahab Abo Eldahab

Lecturer of Anesthesiology

Faculty of Medicine – Cairo University

Faculty of Medicine

Cairo University

2009

Acknowledgments

First and for ever, thanks to **Allah**, the creator of the continuously developing human mind.

I would like to present my sincere gratitude and deepest appreciation to **Prof. Dr. Omar wagih Abbas,** Professor of Anesthesia, Faculty of Medicine, Cairo University for his generous assistance and help.

I am also grateful to **A. Prof. Dr. Mohamed Walid Awad,** Assistant Professor of Anesthesia, Faculty of Medicine, Cairo University for his continuous guidance and explanations.

I would like to extend my indebtedness and gratitude to **Dr. Hesham Abo Eldahab,** Lecturer of Anesthesia, Faculty of Medicine, Cairo University for his valuable and remarkable observations.

Finally I would like to thank all my family, especially my wife, for their continuous support.

Ehab Bakry
2008

CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

- ACT: Activated clotting time.
- ADP: Adinosine diphosphate.
- AMPA: Alpha methyl propionic acid.
- ATP: Adinosine triphosphate.
- AVM: Arterio-venous malformation.
- $BAEP_s$: Brainstem auditory evoked potentials.
- BETS: Benign epileptiform transients of sleep.
- BMI: Body mass index.
- BIS: Bispectral index scale.
- BSR: Burst suppression ratio.
- CBF: Cerebral blood flow.
- CBV: Cerebral blood volume.
- CEA: Carotid endarterectomy.
- CFAM: Cerebral function analyzing monitor.
- CFM: Cerebral function monitor.
- CMR: Cerebral metabolic rate.

- $CMRO_2$: Cerebral metabolic rate of oxygen consumption.
- CNS: Central nervous system.
- CPP: Cerebral perfusion pressure.
- CSA: Compressed spectral array.
- CSF: Cerebrospinal fluid.
- CVP: Central venous pressure.
- DHCA: Deep hypothermic circulatory arrest.
- DSA: Density spectral array.
- EAA: Excitatory aminoacids.
- ECT: Electro convulsive therapy.
- EEG: Electroencephalogram.
- FAR: Frontal arousal rhythm.
- FFA_s: Free faty acids.
- GABA: Gamma amino butyric acid.
- GCS: Glasgow coma scale.
- IBP: Invasive Blood Pressure.
- ICP: Intracranial pressure.
- ICU: Intensive care unit.
- IM: Intramuscular.
- IV: Intravenous.
- MAC: Minimum alveolar concentration.
- MAP: Mean arterial pressure.

- NMDA: N-methyl D-aspartate.
- NREM: Non-rapid eye movement.
- OR: Operating room.
- P_aCO_2: Partial pressure of arterial carbon dioxide.
- P_aO_2: Partial pressure of arterial oxygen.
- P Cr.: Phosphocreatinine
- PET: Positron emission tomography.
- PPED: Periodic patronized epileptiform discharge.
- REM: Rapid eye movement.
- RMTD: Rhythmic midtemporal discharge.
- SAH: Subarachnoid hemorrhage.
- SRCD: Subclinical rhythmic electrographic discharge.
- $SSEP_s$: Somatosensory evoked potentials.
- STA-MCA: Superficial temporal artery to middle cerebral artery.
- TCI: Target controlled infusion.

Abstract:

Induction of EEG burst suppression pattern in neurovascular surgery might avoid or decrease the development of brain ischemia.

Many drugs could be used for this purpose either intravenous like propofol and thiopental or inhalational like isoflurane and sevoflurane.

This could be monitored by the bispectral index.

Key words:

Burst suppression – Bispectral index – Brain ischemia.

Chapter I

Brain Electrical Activity

Brain Electrical Activity

- **<u>Origin Of Brain Waves:</u>**

The brain wave electrical potentials are generated mainly from cortical layers I and II, especially from the large matt of dendrites that extend into these surface areas from neuronal cells located deeper in the cortex ***(Gyton, Text Book of Medical Physiology, 1991)***. The potentials generated in the tissue fluids surrounding these dendrites can be either positive or negative, for the following reasons:

When the neuronal cells bodies in the deeper layers discharge, negative charges leak out of the cell bodies and cause negativity in the deeper cortical fluids; at the same time this loss of negative charges leaves the interior of the neuronal cell membranes positive. This positivity is conducted electronically upward through the dendrites to the surface layers of the brain and then transmitted by a capacitative effect across the dendrite membranes to the fluids surrounding these dendrites ***(Bindman L., 1981)***. Therefore, stimulation of neurons deep in the cerebral cortex usually causes initial positivity on the surface of the brain ***(Stern R.M., 1980)***. On the other hand, other cortical synapses lie not on the deep cell bodies but instead on the surface dendrites themselves, especially in cotrical layers II and III. When these synapses are excited, local depolarization occurs in the dendrites themselves, allowing negative charges to leak outward; then the electrical waves recorded from the surface of the scalp are negative. This difference between positivity and negativity is important because it sometimes allow one to distinguish the depth in the cortex of the neuronal discharges that produce specific types of waves ***(Gibbs and Gibbs, 1974)***.

- **Historic Perspective:**

The early evaluation of the central nervous system by physiologists in the late 1700s and early 1800s consisted of stimulating the brain electrically rather than measuring the electrical currents it generates. Not until the latter half of the nineteenth century did the British physiologist Richard Caton describe the electrical activity of the brain in experimental animals. Caton obtained cortical EEG recordings and he also noted that "Feeble currents of varying direction pass through the multiplier when the electrodes are placed on two points of the external surface of the skull ***(Bahmon – Dussan J.E. et al., 1989)***. Early in the twentieth century the Russian physiologist V.V. Pravdich - Neminsky used the term "electrocerebrogram" and he defined the predominant frequency bands of cerebral electrical activity in animals, labeling them alpha & beta. In 1929 Hans Berger published the initial findings on the EEG in humans, calling it the "Electronic encephalogram" ***(Bancaud J. et al., 1955)***. from which electroencephalogram has been derived. Previous investigators had noted the reactivity of the EEG in animals to peripheral somatic electrical stimulation. Berger showed that the human EEG is reactive to opening and closing of the eyes; such potential changes from the occipital region were later termed the Berger, or alpha rhythm ***(Adrian ED and Mathews BHC, 1934)***.

The application of EEG in a neuropathologic condition was initially described by Walter when he demonstrated focal EEG slowing in patients with brain tumours, which he called delta waves ***(Walter W.G., 1936)***.

- **Technical Aspects:**

The electrical activity of the brain has an amplitude in the microvolt range, typically ranging from 10 to 150 µv In a routine EEG, the brain's electrical activity is measured at the scalp using surface electrode. The electrical signal is then conducted by wire to the EEG machine, where it is amplified, filtered and displayed ***(Homan R.V. et al., 1987).***

Electrodes:

The most common electrode currently in use is a gold - plated disc 10 mm in diameter. Twenty-one electrode sites on the scalp are defined according to the international 10-20 system, which is based on skull land marks (inion, nasion, and left and right preauricular points) whose distances are then subdivided in a specified manner. A typical inter-electrode distance is 6 cm. Scalp electrodes are identified by a letter and a number. After marking the scalp according to the international 10-20 system, the technologist prepares each site by using a mild abrasive to lower and equalize the scalp impedance. An electrode is placed at each site using either a conductive paste or a colloid ion-soaked gauze patch through which conductive gel is injected into the disc ***(Jasper H.H, 1983)***.

EEG Machine:

The cerebral electrical activity is conducted by wires from the scalp to the Jack box of the EEG machine. The inputs to the Jack box are then used to compose a montage, which is a specific arrangement or array of electrodes that display the EEG. The EEG machines currently available use 16 , 18 or 21 channels. Each channel consists of a differential amplifier, which compares the input of two electrodes and amplifies the output to the pen - writing system or video display screen.

An upward pen deflection is defined as negative, and occurs when input 1 is negative with respect to input 2 or when input 2 is positive with respect to input 1.

A downward pen deflection is defined as positive, and occurs when input 1 is positive with respect to input 2 or when input 2 is negative with respect to input 1. This is shown in Fig.1.

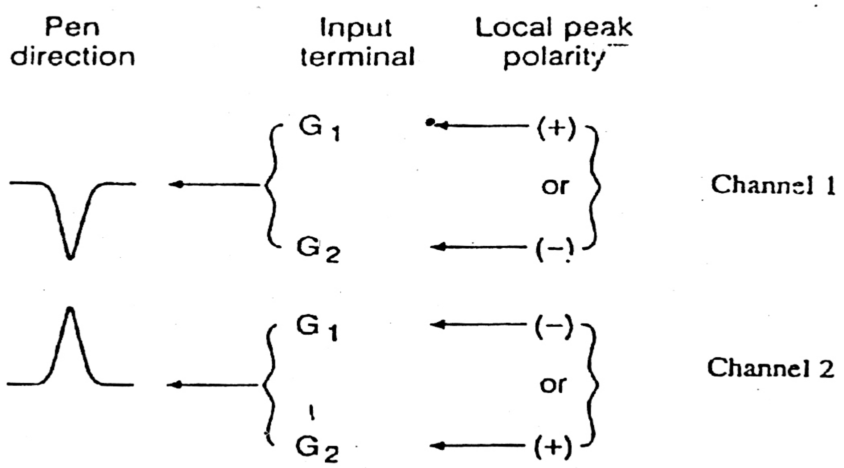

Fig.1 : Pen deflection based on inputs G1 and G2 into channels 1 and 2 ***(Daly DD and Pedley TA., 1990)***.

Before being displayed, the amplifier outputs are filtered, typically using a low frequency filter setting of 1 Hz and a high - frequency filter setting of 70 Hz. A 60-Hz " notch " filter may be used in a recording environment with excessive electrical interference, such as intensive care unit ***(Daly DD and Pedley TA., 1990)***.

Montages:

Montages are specific arrangements of electrodes. Each montage provides the electro-encephalographer with a different view, to delineate both normal and abnormal activity.

A bipolar montage is constructed by linking successive electrodes into sequential channels. In a referential montage, each electrode is "referred" to a reference electrode, such as the ipsilateral ear or the vertex. The most commonly used montages are the longitudinal (anterior to posterior, or AP) bipolar montage, the transverse (Left to right) bipolar montage, and the referential (to the ipsilateral ear) montage ***(Daly DD and Pedley TA., 1990)***.

- **EEG terminology:**

Frequency: Repetition rate or number of cycles per second (Hz) of a given wave form.

Amplitude: is the magnitude of EEG activity in microvolts (μv).

Polarity: is the sign of the EEG activity and may be negative, positive or isoelectrie (i.e., zero).

Morphology: refers to the shape of the EEG wave form.

The distribution: of EEG activity may be focal or generalized.

The EEG is rhythmic: when it has a sinusoidal pattern at a relatively constant frequency. Arrhythmic activity is a mix of frequencies and morphologies.

EEG activity: that occurs at the same time in different regions of the brain is called synchronous. Activity that occurs at the same time and same location on both sides of the scalp is bilaterally synchronous, or bisynchronous. Conversely, activity that occurs at different times is asynchronous.

Reactivity: refers to alteration in the EEG activity caused by stimulation of the patient.

A persistent activity is present in the region for at least 70 to 80% of the record, despite stimulation and state change.

EEG activity that is present in the region for less than 70% - 80% of the record is called intermittent ***(Daly DD and Pedley TA., 1990)***.

- **Normal EEG*:***

The age of the patient and the level of consciousness (i.e, awake or asleep) are critical parameters in describing the normal EEG, as both factors determine the frequency, amplitude, polarity, morphology, distribution, rhythmicity, synchrony, reactivity, and persistence of the activities that are recorded. The EEG of the neonate is significantly different form that of the infant of 3 months or older ***(Drazier MAB, 1960)***.