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# Acquisition of EEG Seizure during ECT

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*Abstract*

*Acquisition is a process of obtaining the data from a source. Electroconvulsive therapy (ECT) in which electrical current is used to induce seizures, is an effective treatment in psychiatry. The procedure of ECT essentially involves application of a low frequency electrical stimulus across two electrodes applied over the scalp to induce a generalized seizure for therapeutic purposes. Seizure is the first sign of neurological disease or dysfunction in the newborn. An Electroencephalogram (EEG) is a commonly used non-invasive technique for studying brain activities. EEG is used to study the relationship between the changes in electric potentials in different area of cortex and sub cortical structures.*

*Keywords-Electroconvulsive therapy, Seizure, Sampling, Electroencephalography, Stimulus*

## 1. INTRODUCTION

Man is a Bio-electric generator, some of the organs like brain, heart, muscles and eye can produce

electric potentials. Such potentials are called as bio-electric potentials. These potentials can be picked up by using suitable electrodes and leads. Human brain cells create particular-shaped regular electric potentials and these are referred to as brainwaves. In 1929, for the first time in the world, German psychiatrist Hansberger inserted two platinum electrodes into the skin beneath the skull of a patient with head injuries and recorded brainwaves, which were referred to as EEG.

The process of recording electrical discharges of the brain by placing suitable electrodes on the surface of the skull is called electroencephalography (EEG). The EEG is used as basic non-invasive diagnostic tool for neurological disorders and sleep disorders [1]. The common neurological disorders in which the EEG pattern is altered are epilepsy, disorders of mid brain and subdural hematoma, brain tumour, amnesia etc.

The EEG signals are recorded from the scalp by placing electrodes on the intact skull. The fig.1 shows the international standard 10-20 electrodes placement system proposed by Jasper (1958). The positions of the electrodes are based on intervals of 10 and 20% of the distances between specified points on the scalp. Reference points used are the root of the nose and ossification centre on the occipital bone, which can usually felt. From these points the skull perimeters are measured in the transverse and median planes and these perimeters are divided in to 10 and 20% intervals to determine the electrode locations. The electrodes are held in place with elastic bands and electrode paste is applied between the electrode and skin. In the case of unconscious and some conscious patients, needle electrodes inserted in the scalp are also used [1].

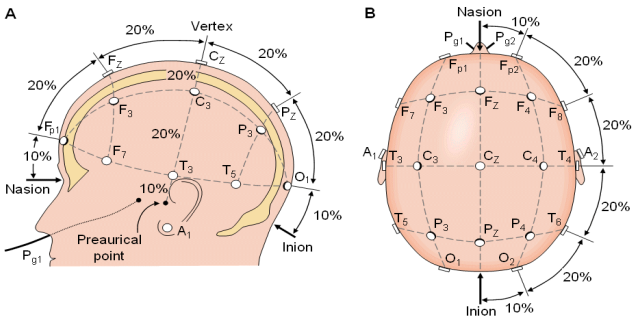


Fig. 1 10-20 Electrode system

The EEG can be recorded by bipolar or monopolar techniques. In the bipolar technique the difference in potential between two adjacent electrodes is measured, where as in the monopolar technique the potentials of each electrode is measured with respect to an indifferent electrode is located on the mastoid or earlobes. These two techniques give EEG's containing essentially the same information, but they are used together for practical reasons to help locating pathological changes.

The peak to peak amplitude of the waves that can be picked up from the scalp is normally 100µv or less. The frequency varies greatly with different behavioural states. The normal EEG frequency content ranges from 0.5 to 40Hz [1]. The nature of the wave varies over the different parts of the scalp. The waves of EEG are classified into alpha (α), beta (β), delta (δ) and theta (θ) respectively [2]. Some of the responses from the brain are shown in Fig.2.

Table.1 Waves of EEG

| Wave Type | Frequency | Amplitude | Region & Situation |
|---|---|---|---|
| Alpha | 8-12 Hz | 50 µv | Found in Occipital region of scalp, during Drowsiness or light sleep |
| Beta | 13-22Hz | 5-10 µv | In Parietal & frontal region, during Intense activation of CNS |
| Delta | Below 5Hz | 20-200 µv | Appears during deep sleep, Depression, tumor, epilepsy etc |
| Theta | 4-7.5Hz | 10 µv | In children below 5 years of age |

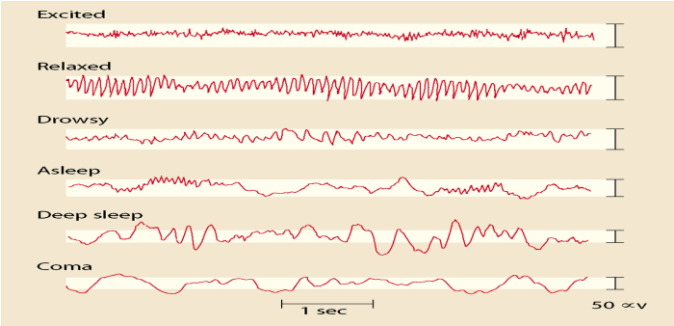


Fig. 2 Response of the Brain at different situations

A seizure is defined to occur when there is an excessive synchronous discharge of neurons with in the central nervous system (CNS). Its manifestation in the EEG known as the electrographic seizure consists of paroxysmal events which are best described as stereotyped repetitive waveforms that evolve in amplitude and frequency before eventually decaying.

### 1.1 ELECTROCONVULSIVE THERAPY

ECT is an important modality of treatment in psychiatry. The introduction of modified ECT, brief pulse stimulation, alternative methods of electrode placement and use of EEG monitoring have decreased the adverse effects and increased the acceptability of treatment. The objective of ECT is to electrically induce a generalized seizure, which is an essential but not sufficient ingredient for therapeutic effect [3].

The most common principal diagnostic indicators for ECT are Major Depression, Bipolar Disorder, Schizophrenia, catatonia, mania and Other Psychotic Disorders. Schizophrenia is characterized

by a broad range of cognitive, emotional and behavioural problems, which are in general classified into positive and negative symptoms. Individuals with delusions or hallucinations are described as psychotic. Catatonia is a syndrome that is associated with both schizophrenia and affective (mood) disorders. It is characterized by marked changes in muscle tone or activity that may alternate between the extremes of a deficit of movement (catatonic stupor) and excessive movement.

Mania is characterized by elated, euphoric or irritable mood and increased energy. The term may refer to a mental disorder or to a mood state or symptom, and mania is associated with bipolar disorders. In severe manic episodes, individuals are psychotic and require continual supervision to prevent physical harm to themselves or others.

ECT is an electromotive force generated from the ECT device, which drives a flow of electrons. The current across the two electrodes applied on the patient's scalp. The intensity of this current is inversely dependent on the electrical impedance offered in the circuit between the two electrodes. The total stimulus energy is a function of electromotive force (V), current (I) in the circuit and time (T). This is expressed in joules [4].

The ECT devices employed to generate a range of user selectable electromotive forces from 90 to 160V. This voltage is derived from stepping down the mains AC voltage using a transformer. The current conducted in the circuit through the brain structures between the electrodes is governed by the inter-electrode impedance is variable both across individual and within individuals across ECT sessions. The current yields the charge traversing the brain tissue in units of coulombs(C) from the formula C=IT. The method of arriving at the stimulus dose in units of coulombs is referred as coulometry [4].

The conventional sine wave stimulus is crude and slow rising and trailing edges of the sine wave do not produce efficient cerebral stimulation. This unnecessarily continues stimulation even while the neuronal tissue is in a post depolarization refractory period. The sine wave was hence modified to eliminate the rising and trailing edges retaining only the peaks in the form of square wave pulses. The pulses are brief(1-2 m-sec) with no stimulus in between the pulses intermittent stimulation using pulses is more efficient as it allows the tissue to recover from post depolarization refractory period. Hence the preference is given for brief pulse stimulus. The stimulus sources available today evaluate the inter-electrode impedance and dynamically adjust the voltage to ensure a constant current throughout the stimulus application. In the sine wave stimulus, the amplitude of current or voltage gradually rises and trails in each cycle [4].

Table.2 Some of specifications of ECT device

| Signal | V | I | Frequency | Width | Duration | Z | Joule | Charge (mC) |
|---|---|---|---|---|---|---|---|---|
| Pulse | 160V | 0.8A | 100PPS | 1ms | 1S | 200 | 12.8 | 80 |
| Sine | 180V | 0.6A | 50Hz | --- | 0.5S | 200 | 36 | 300 |

Frequency refers to number of cycles per second, in the transformer based sine wave stimuli, and the line frequency is about 50Hz. In the pulse stimulus, on the other hand, the operator varies the frequency but some devices keep this factor constant. It is a better convention to use the term pulses per second (PPS) in this form of stimulus.

Pulse width is a measure relevant to only pulse wave stimuli. Stimulus duration is the total period for which the stimulus train is applied. Charge is the total amount of electrons traversing the inter-electrode tissue including the brain is the product current and actual duration of stimulus, and it is measured in milli-coulombs.

In modified ECT, anaesthesia, muscle relaxant and the seizure eliciting electrical stimulus are administered in the same order [4]. Use of a muscle relaxant prevents musculoskeletal injuries resulting from peripheral seizures. The anaesthetic agent induces sleep and prevents anxiety associated with the cessation of breathing due to a muscle relaxation. Short acting barbiturates are commonly used as induction agents. Methohexitane (0.5mg/kg body weight) is recommended as it has been shown to have minimal effect on seizure threshold, while ensuring quick induction and recovery [5]. Thiopentane (3-5mg/kg) is also commonly used but may be associated with shorter seizure duration and increased hemo dynamic changes [6]. Succinylcholine (1mg/kg) is more effective in modifying the peripheral convolution [7]. This dose can be used in the first ECT session. For subsequent seizures the dose may be altered depending on the response for optimal motor seizure modification [7], [9].

The seizure causes activation of neurons throughout the brain and changes in many of the chemicals in a person's brain. It is thought that these actions then result in a decrease in the symptoms of mental illness. Usually ECT is unilateral in that a seizure is started only on one side of the brain. Some times when people are not responding to this treatment alone. ECT is done bilaterally and seizures are started on both sides of the brain. Depending up on their illness most people will have between four and six treatments before their symptoms show significant improvement. Most patients will continue to have regular treatment until their symptoms are significantly decreased. Some patients will then continue to have 'maintenance ECT' on a less frequent schedule (ex: once per week, once every other week, once per month).

Treatment with ECT is highly effective and works rapidly when compared with other psychiatric treatments for the right conditions. While some antidepressants may take between two to three

months to have a complete effect. ECT is specifically valuable in the treatment of severe depression and depression with psychosis. In some patients who do not improve with multiple medication treatments ECT may be the only treatment that effectively controls their symptoms.

Requirements for an ECT & Medications:

1) Stretcher or bed with a firm mattress, side rails, and the capacity to elevate both the head and the feet.
2) Automatic blood pressure monitoring device or manual sphygmomanometer.
3) Stethoscope, Pulse oximeter, Suction apparatus, Reflex hammer.
4) ECT treatment device with EEG monitoring capability.
5) ECG monitoring equipment, Oxygen delivery system capable of providing intermittent positive pressure oxygen by mask or endotracheal tube.
6) Intubation set and equipment for managing difficult airways [4].

Specific medications that should be present include

1) A primary anesthetic agent (methohexital sodium) .
2) A primary muscle relaxant (succinylcholine).
3) An anticholinergic agent (glycopyrrolate and/or atropine sulfate).
4) β-adrenergic blocking agents such as labetalol and esmolol.
5) α-adrenergic blocking agents such as prazocin and clonidine [4].
6)

**1.2 Methodology**

**a. Calibration of EEG signal**

Calibration is so important to know the performance of EEG amplifier**.** A known signal of 10 Hz with a trough to peak voltage of 100 µv is applied before the recording of an EEG signal.

Removing baseline drift means making zero mean correction. It is often observed during EEG recording that the signal obtained begins to stay away from the baseline which is the is the isoelectric line. Removing baseline drift involves calculating the mean of the signal and then replotting every point of the signal.

**b. Data collection**

EEG signals from volunteer were recorded with EEG amplifiers. The four channels of Unipolar are placed on Right frontal, Right temporal and Left frontal, Left temporal regions. The EEG signals were obtained for duration of 160 seconds. The subject was instructed to close his eyes for some time during the data acquisition period. The signals were digitized (using 12 bit ADC) 256 samples/second per channel. Built in EEG amplifier in ECT machine has the following settings gain 1000-2000. To remove artefacts and noise low pass filter as well as high pass filters with frequencies 40Hz and 0.5 to 2Hz respectively were employed. 50 Hz notch filter is used to remove power line artefact.

**c. Filtering of EEG signal**

Raw EEG signals were filtered by using Finite impulse response (FIR) low pass filter because FIR filters provide linear phase and always stable. The

design method are generally linear, the filter start-up transients have finite duration. The order required for FIR filter is higher [10]. An FIR filter of length M is described by the difference equation.

$y(n) = b_0x(n)+b_1x(n-1)+b_2x(n-2)+----------b_{m-1}x(n-m+1)$

$y(n) = \sum b_k\, x(n-k)$ between the limits k=0 to m-1

Where $b_k$ is the set of filter co-efficients from the above equation the response of the FIR filter depends only on present and past input samples. Linear characteristics within pass band are achieved by FIR filter.

**Design procedure:** Initialization of order and cut off frequency: Filter order = 40, Wc=32rad/sec ;

$\tau = (M-1)/2$ (Phase delay)

The transfer function is $h(n) = \sin\{Wc(n-\tau)\}/\pi(n-\tau)$

Where n = 0 to M-1.

Convolving h(n) with the input signal x(n) to get the filtered out put as y(n)

$$y(n) = x(n)*h(n)$$

$y(n) = \sum x(k)h(n-k)$ between the limits k=0 to m-1

where n- input signal length

## 2. RESULTS

The EEG Seizure was recorded using four channels during electroconvulsive therapy. The samples from precisely defined stimulus are shown in fig.3. Each segment contains 1536 samples of EEG data (6 seconds) are shown in fig.4. The entire EEG time series data is displayed for the user to analyse the series are shown in fig.5.

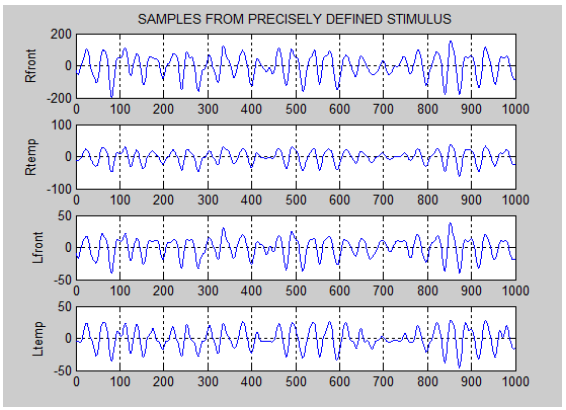


Fig. 3 EEG seizure from precisely defined stimulus

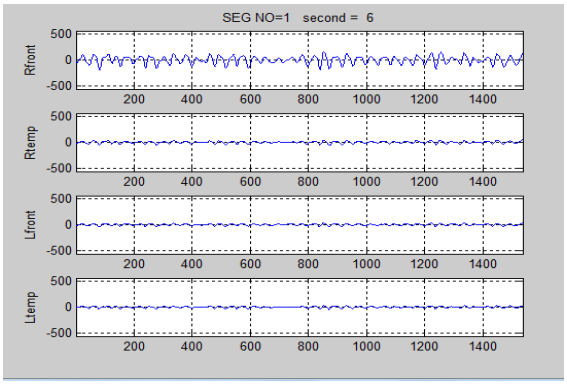


Fig. 4 EEG signal data for 6-Seconds (256samples/sec)

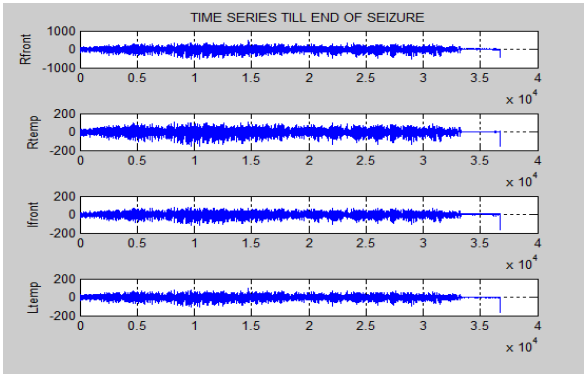


Fig. 5 EEG Time series data (37000 samples)

**3. CONCLUSION**:

The ECT stimulus of known intensity has been applied to the patient and a series of EEG seizure data were recorded. ECT is an effective treatment when the medications are not so effective on patient during the treatment. ECT is an useful treatment for severe mental depression and many psychiatric disorders.

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