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Origin and Recording of Bioelectric Signals

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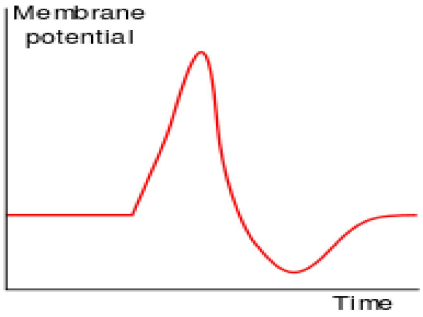
Abstract: *Bioelectric signals are generated as a result of migration of ions in the cell membrane. Muscles and neurons are the main source for the generation of that signals by contraction and relaxation. These bio electric signals can be recorded with the help of electrodes by placing it over the surface of the skin. Bioelectric signals are in very small amplitude and they require amplification for analyzing and for further studies. The signals which obtained are the primary source for diagnosis the malfunction of the tissues or organs. The most common types of bioelectric signals are ECG (Electrocardiogram), EEG (Electroencephalogram) and EMG (Electromyogram). Here we explained the origin and recording of these bioelectric signals in a detailed manner.*

Keywords: Bioelectric signals, ECG, EEG, EMG, Diagnosis

I. INTRODUCTION

Human body is composed of various types of living tissues. They generate multiple electric signals. The main sources for the bioelectric signals are muscles and nerve cells. These bioelectric signals are used to extract information of a biological system which is under investigation. The signals may be pulse on the wrist or from the internal tissue which are extracted by non-invasive methods. The most common type of bioelectric signals are ECG (Electrocardiogram), EEG (Electroencephalogram) and EMG (Electromyogram).

The bioelectric signals are produced by the contraction of muscle which makes the ions to migrate among the cell membrane. These migrations of ions result in the potential difference of the cell membrane. This potential difference in the cell which is polarized is called as resting potential and the decrease of this resting potential is called as depolarization. A rapid rise and fall in the potential across the cell membrane with a characterized pattern is called as Action potential.



The bioelectric signals can be measured and recorded with the help of electrodes by placing on the surface skin of the body along with reference electrode. These measurements are much helpful for diagnosis and therapy.

II. ELECTROCARDIOGRAM (ECG)

The bioelectric signal which is a recording of electrical activity of the heart is known as Electrocardiogram (ECG) through the instrument called Electrocardiograph. The electrical signal of heart is produced by the action of contraction of heart muscles. The contraction is initiated by the Sino- Atrial node (SA node) at the right atrium of the heart. SA node is 25 to 30 mm in length and 2 to 5 mm in thick. The SA node is generated and conducted by Heart's own system through a ionic concentration across the cell membrane. The wave passes through the right and left atrium of heart at

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velocity 1m/s. the impulse created by SA node spreads to the Atrio – Ventricular node (AV node). The AV node is located at the end of two atriums. The impulse then spread to the fibres in the bundle called purkinje fibres. The velocity of the purkinje fibre is about 1.5 to 2.5 m/s. This makes the ventricles to contract.

The frequency range of ECG signal is 0.05 to 120 Hz and signal amplitude is 0.1 to 5µV. The types of electrodes which is used to extract the ECG signal are,

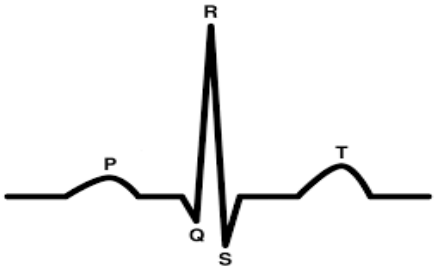
1. Limb Electrodes
2. Floating Electrodes
3. Pregelled Disposable Electrodes
4. Pasteless Electrodes

2.1 Placement of Electrodes

In 12-Lead ECG system, the first electrode is placed at 4th intercostals space, Right margin of the sternum. The second electrode is placed at 4th intercostal space along the left margin of the sternum. The third electrode is placed between second and fourth electrodes. The fourth electrode is placed at 5th intercostal space, mid-clavicular line. The fifth electrode is placed at the same to fourth electrode in anterior axillary line and the sixth electrode is placed at mid-axillary line as same as fifth electrode in the same level as fourth electrode.

2.2 ECG Signal Analysis

The signal contains P, Q, R, S, T and U waves. P-wave is a result of atria contraction which is stimulated by SA node. PR interval lies between 0.12 to 0.2s. The QRS interval is the result of ventricular contraction and it varies from 0.05 to 0.10s. Amplitude of QRS interval is about 1mV. The T wave represents the relaxation or depolarization of ventricles. U wave is a small deflection about 0.5mm.



III. ELECTROENCEPHALOGRAM (EEG)

Electroencephalogram (EEG) is an electro physical monitoring to record the electrical activity on the scalp that has been shown to represent the macroscopic activity of the surface layer of the brain underneath. It is typically non-invasive; with the help of electrodes placed along the scalp the bioelectric signals are extracted. The amplitude that can be picked up from the scalp is normally 100µ or less. The frequency varies from 0.5 to 50Hz. The waves can be classified based on the frequency as follows:

Delta (δ)	0.5 – 4 Hz
Theta (θ)	4 – 8 Hz
Alpha (α)	8 – 13 Hz
Beta (β)	13 – 22 Hz

3.1 Placement of Electrodes

Most commonly Chloride Silver discs having 6-8mm diameters are used in EEG. In 10 – 20 systems the letters F, T, C, P and O stands for Frontal, Temporal, Central, Parietal, and Occipital .Even numbers(2,4,6,8) refers to right hemisphere whereas odd numbers(1,3,5,7) refers the left hemisphere. Z refers the electrode which is in midline.

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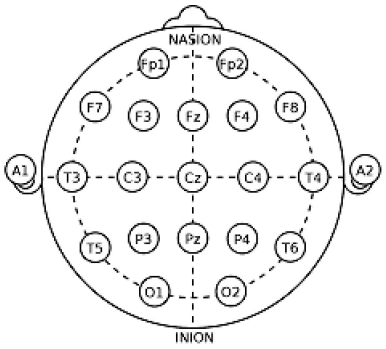


Placement of electrodes on the scalp in 10-20 system.

3.3 EEG Wave Analysis

As we previously said, EEG signals classified into Delta, Theta, Alpha, and Beta. Delta (0.5-4Hz) is seen in deep sleep. Theta (4-7Hz) arises in the starting stage of sleep. Alpha (8-13Hz) is seen when the attention is reduced. When we awake from sleep, which result in the Beta wave (13-22Hz). High frequency oscillations, that greater than 30 Hz are called as Gamma waves (γ) which attributed to sensory perception in different area.

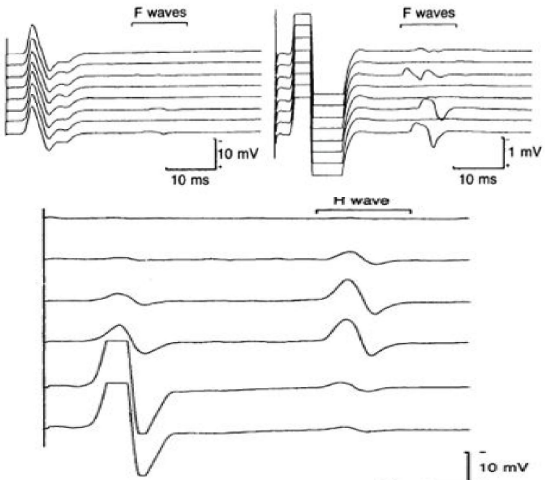
IV. ELECTROMYOGRAM (EMG)

Electromyogram is the measure of electrical activity by responding the nerve's simulation of muscle. During this process one or more electrodes are inserted to muscles by the use of needles. The activity is almost similar to the cardiac muscles but the re-polarization take place faster and the action potential is just occurred for few milliseconds. The potential created from the concentration of skeletal muscle ranges from 50μV to 5mV and it takes 2 to 15ms. Apart from the surface electrode here we use needle electrode for the better diagnostic details. The tip of the needle electrodes contains bare and insulated wire in cannula. Needle electrodes are majorly used to detect "Motor unit action potential" during low force contraction. types of electrodes used in EMG are,

1. Pad electrodes
2. Needle electrodes
3. Fine wire electrodes

4.1 Placement of Electrodes:

Electrodes for EMG are placed at a skin in the bipolar configuration. In between the motor unit and tedious insertion the surface electrode is placed. The distance between the center of electrode and the detection surface is 1-2cm only. For better result, the detecting surface must be belly and must have a higher fiber density.



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4.2 EMG Wave Analysis

We can classify the wave into H-reflex and F wave. H-reflex is the monosynaptic stretch reflex and normally obtained in few muscles only. The short duration acquires for less than 1 pulse/second and the long duration acquire for 0.5 – 1ms. It typically has amplitude between 0.5 to 5 mV. F wave is a long action potential simulation on a nerve. It ranges between 0.2 to 0.5mv.

V. CONCLUSION

The advancement in the technology and healthcare increase the accuracy in diagnosis and therapy. The implement of Artificial intelligence in healthcare technology provide much support in measuring and recording the bioelectric signals, apart from that it act as a life supporting tool. For example, the Smart watches have the sensor to measure the heart beat. Increasing tele-health technology helps in transferring signals from rural area to the diagnostic centre in short period of time and provides immediate doctor consultation.

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