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Original Article

Membrane depolarization in stroke patients

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Abstract

Aim: This study was investigated to evaluate the level of membrane potential in stroke patients in Owerri.
Material and method: 60 stroke patients and 60 apparently healthy subjects between the ages of 60 to 80years admitted to General Hospital Owerri were selected in this study. Fasting venous blood was collected and was used for the determination of membrane potential.
Results: The results obtained revealed that the level of membrane potential was significantly decreased in stroke patients when compared with the control at $P<0.05$.
Conclusion: This could probably imply depolarization of cell membrane potential leading to reduced cell activity.

1. Introduction

Stroke is known as Cerebrovascular accident (CVA). In adults and mainly in the elderly individuals the cerebrovascular accidents are strongly associated with cardiovascular risk factors such as hypertension, hypercholesterolemia, diabetes, nicotine-abuse and obesity. It is when blood flow to a part of the brain is stopped either by a blockage or the rupture of a blood vessel [1].

A stroke is a brain attack. It's similar to a heart attack, but it happens to the brain. It is something that causes lack of blood flow to the brain. When certain parts of the brain do not receive the blood that they need, they do not receive the oxygen they need and it causes that temporary shut off and eventually death of the cell[2]. Hence, a stroke is basically just an exclusion of oxygen to the brain. Strokes occur due to problems with the blood supply to the brain: either a blood vessel within the brain ruptures or the blood supply is blocked, causing brain tissue to die [3].

Three different types of strokes are Hemorrhagic, Ischemic and transient ischemic attack (TIA) Stroke. Hemorrhagic Stroke is caused when a blood vessel in the brain ruptures, interrupting the blood supply to the brain and this whole area of the brain is not getting the blood supply that it needs and begins to bleed [4]. It simply occurs when a blood vessel ruptures, or hemorrhages, and then prevents blood from getting to part of the brain. The hemorrhage may occur in any blood vessel in the brain, or it may occur in the membrane surrounding the brain. This is more serious, when a vessel starts to bleed, it bleeds out and it interferes with the flow of blood, the flow of oxygen and part of the brain begins to suffer and eventually die [5]. The other type is referred as the Ischemic Stroke. Ischemic means deficiency of oxygen. What happens here is something stops the blood flow to the brain. A lot of times it could be a clot, and something that excludes the vein from bringing the oxygen up to the brain. Consequently, the blood is not able to flow to bring the oxygen and nutrients to the brain and this part of the brain startings to die[6].

In other words, an ischemic stroke is the most common and occurs when a blood clot blocks a blood vessel and prevents blood and oxygen from getting to a part of the brain. There are two ways that this can happen. One way is an embolic stroke, which occurs when a clot forms somewhere else in the body and gets lodged in a blood vessel in the brain. The other way is a thrombotic stroke, which is when the clot forms in a blood vessel within the brain.On the hand, If symptoms last less than one or two hours it is known as a transient ischemic attack (TIA) or mini-stroke [7]. A Stroke symptoms include difficulty walking, dizziness, loss of balance and coordination, difficulty speaking or understanding others who are speaking, numbness or paralysis in the face, leg, or arm, most likely on just one side of the body, blurred or darkened vision, a sudden headache, especially when accompanied by nausea, vomiting, or dizziness[8].

These symptoms of stroke can vary depending on the individual and where in the brain it has happened. Symptoms usually appear suddenly, even if they are not very severe, and they may become worse over time. The risk factors for having stroke, including high blood pressure, atrial fibrillation, and diabetes. The diagnosis of stroke is typically with medical imaging such as a CT scan or magnetic resonance imaging (MRI) scan, doppler ultrasound, and arteriography, along with a physical exam [9]. Other tests such as an electrocardiogram (ECG) and blood tests are done to determine risk factors and rule out other possible causes. However, the preventive measures for stroke are include Maintain normal blood pressure, Limit saturated fat and cholesterol intake, Refrain from smoking, and drink alcohol in moderation, Control diabetes, Maintain a healthy weight, Get regular exercise and Eat a diet rich in vegetables and fruits[10].

Furthermore, Stroke is the most frequent cause of death worldwide in Nigeria. Between 1990 and 2010 the number of strokes decreased by approximately 10% in the developed world and increased by 10% in the developing world. Generally, two-thirds of strokes occurred in those over 65 years old [11].

Stroke is a public health problem linked with membrane depolarization which is reduction of the normal voltage difference between the inside and the outside of a cell. It is caused by the influx of cations, such as sodium and calcium, through ion channels in the membrane [12]. In many neurons and muscle cells, depolarization may lead to an electric impulse and reduction of cell activity. After a cell has

established a resting potential, that cell has the capacity to undergo depolarization. During depolarization, the charge within the cell rapidly shifts from negative to positive. For this rapid change to take place within the interior of the cell, several events must occur along the plasma membrane of the cell as well. While the sodium potassium pump continues to work, the voltage gated ion channels that had been closed while the cell was at resting potential have been opened by an electrical stimulus. As the sodium rushes back into the cell the positive sodium ions raise the charge inside the cell from negative to positive. Once the interior of the cell becomes positively charged, depolarization of the cell is complete.

The process of depolarization is entirely dependent upon the intrinsic electrical nature of most cells. When a cell is at rest, the cell maintains what is known as a resting potential. The resting potential generated by nearly all cells results in the interior of the cell having a negative charge compared to the exterior of the cell. To maintain this electrical imbalance, microscopic positively and negatively charged particles called ions are transported across the cell's plasma membrane. The transport of the ions across the plasma membrane is accomplished through several different types of transmembrane proteins embedded in the cell's plasma membrane that function as pathways for ions both into and out of the cell, such as ion channels, sodium potassium pumps, and voltage gated ion channels[13,14].

In this study, the level of membrane potential in stroke patients was determined to provide information on their status in Owerri Imo State, Nigeria.

2. Materials and method

2.1 Subjects:

60confirmed stroke patients admitted to the General Hospital Owerri were selected, while 60 apparently healthy individuals were used as control. They are between the ages of 60 and 80 years. Patients with past history of a hypertension, diabetes, renal disease were excluded from the study. Their consent was obtained as well as ethical approval from the ethical committee of the hospital. The extracellular cation concentrations were determined from serum samples while intracellular calcium concentrations were determined from lysed erythrocytes.

2.2 Blood Collection

In all subjects 4ml of fasting veinous blood was collected into plain and EDTA bottle. The serum was separated by centrifuging the whole blood in westerfuge (model 684) centrifuge at 5,000g for 10 minutes.

2.3 Biochemical Assay

The serum calcium was estimated using Randox Kit. While membrane potential was determined by calculation using Nerst Equation.

2.4 Statistical Analysis

The values were expressed as mean ± standard deviation. The student t-test was used to calculate the significant differences at $P<0.05$.

3. Results

Table 1: Membrane potential instroke patients and healthy control

Parameters	Control	Stroke
Red Cell Calcium(mmol/L)	0.67±0.08	1.03±0.19*
Serum Calcium(mmol/L)	2.77±0.04	1.69±0.15*
Membrane potential(J)	248.06±30.00	98.45±47.37*

*Significantly different from control at P<0.05

The levels of membrane potential was decreased in stroke patients when compared with the control at $p<0.05$.

4. Discussion

A stroke is a brain attack. It can happen to anyone at any time. It occurs when blood flow to an area of brain is cut off. When this happens, brain cells are deprived of oxygen and begin to die[15]. When brain cells die during a stroke, abilities controlled by that area of the brain such as memory and muscle control are lost[16].

In this study, the membrane potential was significantly reduced in stroke patients when compared with the control. The change in charge typically occurs due to an influx of sodium ions into a cell, although it can be mediated by an influx of any kind of cation or efflux of any kind of anion. This is consistent with the work of [13]. This means that there is reduction in cell activity in stroke patients. This could be associated with high blood pressure. Due to cell depolarization, free radicals could play an important role in brain ischemia and reperfusion injury while the generated reactive oxygen species impair the cell[17,18].The over-generation of reactive oxygen species (ROS) and lipid peroxidation play an important role in the pathogenesis of neuronal damage induced by ischemia-reperfusion. The presence of increased levels of polyunsaturated fatty acids in the membrane lipids of the brain is associated with lipid peroxidation reactions [19,20].

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