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Battery Dependence of the Brain on Electric Charging of the Heart

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Abstract

Nowadays, it is difficult to do without various gadgets (smartphone, laptop, etc.) and for each of them, you need to have an electric charger. In this regard, the heart is a unique organ, it produces about 100 thousand electrical impulses per day, for itself and for charging the brain. Since ancient times, the electrical system of our body was unwisely divided into two parts: nervous and cardiac. We believe that there should be only one source of electrical energy in one organism and we will provide sufficient arguments for this.

Keywords: Electrical system of the organism; heart; brain; electric generator; battery; astrocyte.

Introduction

It is difficult to understand why, at the dawn of medical science, they decided to divide the electrical system of our body, because logic should have prevailed over the desire to divide diseases. And to this day, if you ask a neurologist - where is electricity generated in the heart, and ask a cardiologist the opposite question, they will find it difficult to answer.

Where in the nervous system is electricity generated? Neurologists have long been looking for and are still looking for the source of electricity generation. Here are notes from publications:

"Scientists from the University of California have discovered that little-studied branched processes of neurons in the brain - dendrites - are the predominant source of its electrical activity, writes The International Business Times 2017. Previously, scientists believed that the centers of nerve cells in the brain are the focus of electrical activity in the nervous system. However, as it turned out, the centers of cells account for only a small share of the total brain activity. According to the results of a new study published in the journal Science (Moore et al., 2017), dendrites produce about 90% of the brain's electrical activity";

"Every neuron is capable of generating electrical energy. The cell membrane is a thin, flexible layer that surrounds the neuron and separates its internal environment from the external environment. The cell membrane consists of a lipid bilayer, which is made up of two layers of phospholipids. Built into the cell membrane are ion channels, which are proteins that penetrate the membrane and allow ions to pass through. Ions are charged particles that play an important role in generating electrical impulses in neurons. The two most important ions involved in generating electrical impulses are sodium (Na^+) and potassium (K^+)" (Ye & Steiger, 2015).

We are cardiologists and we know where the electrical impulses of the heart are generated: the main pacemaker is the sinoatrial (SA) node; auxiliary generating nodes are the atrioventricular (AV) and other ectopic ones. The generating nodes consist of a conglomerate of specialized pacemaker P-cells.

Indeed, it is now believed that every neuron is capable of generating electrical energy. Alan Lloyd Hodgkin and Andrew Huxley proposed the possibility of inserting a thin capillary electrode into a nerve fiber to record the potential difference across the membrane. The idea was an immediate success and provided the first recording of an intracellular action potential. Hodgkin and Huxley quickly published their remarkable result in the journal Nature on October 21, 1939. In 1952, Alan Lloyd Hodgkin and Andrew Huxley created a mathematical model to describe the electrical mechanisms that cause the generation and transmission of a nerve signal in the giant axon of a squid. "To our surprise, it was found that the action potential was often significantly larger than the resting potential," Hodgkin reported after creating the mathematical model. For this, the authors received the Nobel Prize in Physiology or Medicine in 1963 (Brown, 2022). Please note that we have underlined that they recorded the action potential, we will return to this later.

It is hypothetically believed that a neuron can generate due to external chemical or electrical influence. In the scientific world of neurologists, there have been debates for a long time about whether a neuron is chemically or electrically stimulated (Jabeen & Thirumalai, 2018).

Cardiomyocytes, the Purkinje fibers of the heart, like neurons, have a cell membrane with built-in ion channels, but they can only be excited by an electrical impulse passing through them, but not generate!

Only living cells have tissue excitability, the presence of a positive charge on the surface of the muscle and a negative charge inside was discovered back in 1838 by K. Matteuchi. Subsequently, this phenomenon was discovered in most animal cells, these include nervous tissue, muscles (smooth, skeletal, myocardium) and glandular cells (Hughes, 2024).

By this we mean that not all cells that are excited in our body have the ability to generate electricity.

Scientists' Misconception

In 1902, Julius Bernstein conducted an experiment on rats, piercing a nerve with a thin metal electrode and detecting a "negative oscillation" of the resting potential. He hypothesized that ion gradients disappear, the resting potential difference quickly equalizes, and the resting potential decreases to zero. Subsequent restoration of the initial ion permeability leads to the return of the membrane potential to the resting potential level. Thus, according to Bernstein's theory, the action potential cannot be greater than the resting potential (Carmeliet, 2019). Bernstein's theory regarding the resting potential was confirmed by Kenneth Stewart Cole.

Bernstein's statement regarding the action potential was refuted by Alan Lloyd Hodgkin and Andrew Huxley in 1939. We have already written about the experiment they conducted on a large squid. Plus, if Bernstein wrote only about the potassium pump, then Hodgkin and Huxley added sodium and introduced the concept of the "sodium-potassium pump". But, let's return to the experiment of Hodgkin and Huxley, in particular, the study revealed a large action potential, exceeding the apparent zero potential. When the action potential arose, instead of the expected potential difference of +60 millivolts (mV), Hodgkin and Huxley recorded a potential difference of +90 mV and more, which indicated the temporary appearance of a greater positive charge on the inner surface of the axonal membrane in relation to the outer one (Schwiening, 2012). They recorded the action potential several times, here is the graph of that recording, but where is the resting potential (Fig. 1)?

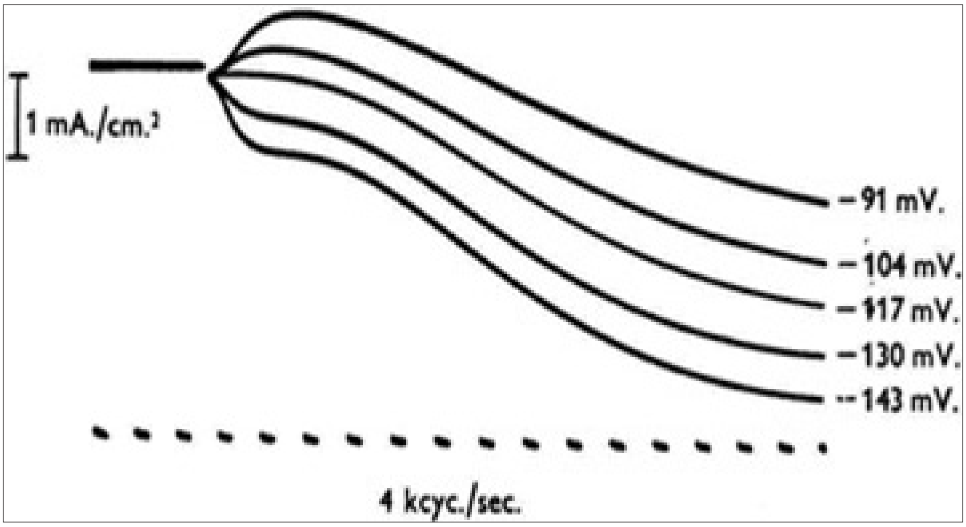

Figure 1: A family of currents acquired using large depolarizations under voltage-clamp control

Accordingly, the resting potential appeared mathematically. Scientists did not understand that in the nerve conduction path, they registered a constantly variable flow of electricity, there is no resting potential there! And the conjectures and calculation algorithms of scientists led to the cellular theory of the transmembrane action potential and rest.

Apparently, everyone was mistaken: researchers, reviewers, the society of neurologists and the Nobel Committee.

Let us put everything in its place. As a result of the two experiments, we have Bernstein's action potential close to 0 millivolts (mV) and Hodgkin and Huxley's action potential +90 mV, as well as, separate from the experiments, an algebraic transmembrane resting potential of -90 and an action potential of +30-60 mV.

Did Hodgkin and Huxley have the right to calculate the resting potential if they did not record it in the experiment? Definitely not! Hodgkin and Huxley knew that there is an action and resting potential in the heart, the goal of their work was to prove that an impulse passes through the nerve pathways and restoration (repolarization) occurs. You can't look for the proverbial black cat in a dark room where it never was! But Hodgkin and Huxley were obsessed, because all their work was pointless, no one was going to give them the Nobel Prize, without a resting potential.

In both cases, the experiments were carried out on nerve pathways, then what kind of cellular transmembrane potential are we talking about? They revealed an electrically conductive potential of constant action and an alternating (jumpy) current potential, without a resting potential. This means that the cellular

transmembrane resting potential of -90 and the action potential of +30-60 mV can be thrown into the trash until the true values appear! The cellular transmembrane potential cannot appear in the nervous system, there are no foci of electrical generation in it, and the multi-billion composition of neurons does not allow determining the cellular transmembrane potential of one neuron. This experiment can be carried out on the heart, for this it is necessary to recount all the pacemaker P-cells of the SA node (which no one has done yet), measure the action and resting potential, and divide the resulting action potential by the number of P-cells and that's it!
Conclusion on the research work of scientists Hodgkin and Huxley.

Scientists tried by all means to adopt the model of the SA node and the conduction pathways of the heart to the nerve conduction pathways! To do this, they used a mathematical way to solve the problem, calculating the missing resting potential during the experiment. But they did not take into account one thing, that in cardiac electrophysiology the state of the SA node and the conduction pathways of the heart is judged by myocardial changes, our myocardium contracts and relaxes every second. Accordingly, if we proceed from the work carried out by scientists, the innervation of all our peripheral muscles should lead to contraction and relaxation every second. But this is not so, our peripheral muscles do not twitch every second, there are certain diseases for this (nervous tic, tremor, Tourette syndrome, etc.)! Even before conducting the study, scientists needed to look at healthy people and notice that our peripheral muscles are in a state of muscle tone (direct current of electricity), which does not leave us even during sleep.

Pay attention to Figure 2, where there is left-sided facial nerve paralysis, there is no muscle tone. And when we want to smile or chew food, at this time the brain sends an additional, more powerful (than constant) electrical stimulus and we spasm certain muscles of the face and jaw! With the work of the vegetative (autonomous) nervous system, everything is different; there is also a constant current of electricity, but the rhythmic electrical stimulus, controlled by the hypothalamus and vegetative nuclei located in the spinal cord and brain, prevails.

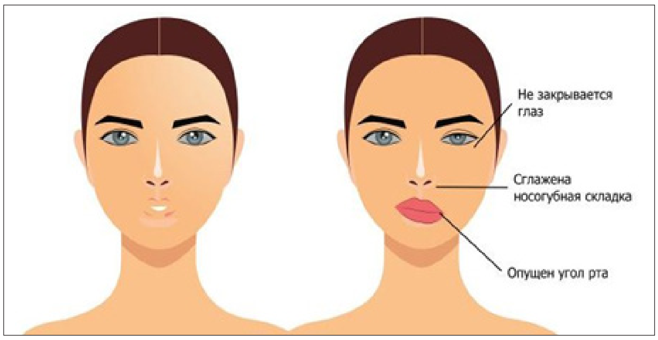

Figure 2: Left-sided facial nerve paralysis

For the information of neurologists, based on the obtained data of the experiments of Bernstein and Hodgkin with Huxley. We believe that in the conducting nerve pathways there is no full resting potential, it is only relative, due to the fact that a constant current flows in these pathways, and when transmitting information from the brain, it is abruptly amplified - this is the action potential. Let's go back to the experiments: Bernstein registered 0 action potential in the nerve pathway of a rat, whose brain weighs approximately 1.5 to 2.0 grams, and Hodgkin and Huxley registered +90 and more action potential in the nerve pathway of a squid, the weight of its brain is 100 grams, we will assume that it is approximately 50 times more. Accordingly, if we proceed from these indicators, the human brain weighs 1 kg. 360 grams, which is approximately 13 times more than a squid. If the weight of the brain is compared to a battery, and this is exactly how we think, then our conductive potential of constant action in the nerves can be approximately equal to +650 mV, but this is a rough calculation.

In addition, emergency situations occur in the heart - arrhythmia. Imagine, if we consider that each neuron can generate electricity, and there are more than 100 billion of them in a person, what will happen if they disrupt the rhythm of the nervous system.

Now we will try to answer the question of who generates electricity for the brain, which is distributed in the nervous system.

Magical Disappearance of Electric Impulse

We look at atrioventricular block of 2-3 degrees and do not notice that magic is happening - the electrical impulse disappears (Fig. 3)!

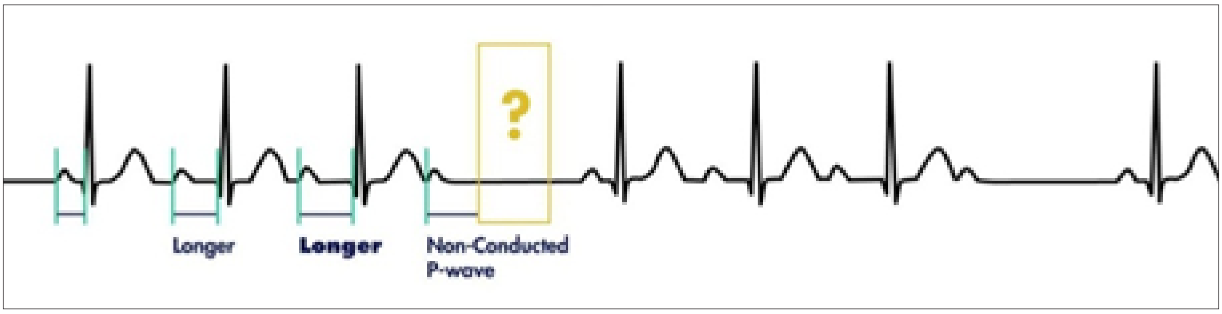

Figure 3: Second-degree atrioventricular block

An electrical impulse comes out of the SA node, excites both atria, then enters the AV node and the opposing node, it disappears (Fig. 4). For example, with blockades in the ventricular legs, an electrical impulse gets into the block of one of the legs and bypasses it along the unblocked one, and here it is blocked and disappears.

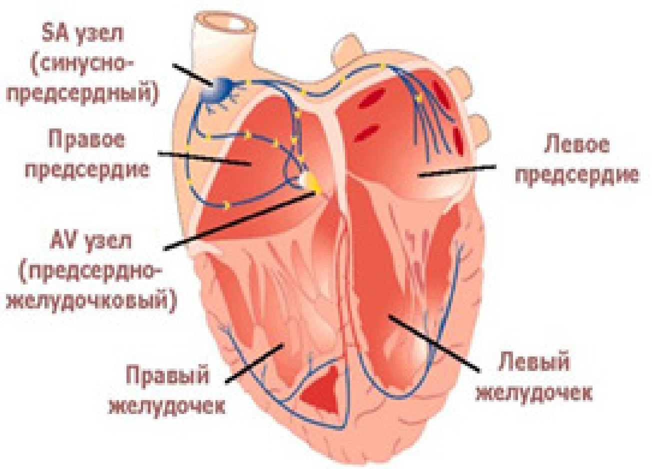

Figure. 4: Electrically conducting pathways of the heart

Accordingly, the disappearance of the electrical impulse during the blockade of the AV node led us to the understanding that the heart produces electricity both for itself and for the brain! Many foreign authors note that the AV node works as a “relay station” (Ivanaga et al., 2023; Gheorghe et al., 2017). A relay station is a switching device that, when exposed to external physical phenomena, abruptly takes on a finite number of output values. The purpose of the relay is to automate the closing or opening of an electrical circuit.

Considering the above, it became obvious to us that the brain affects the operation of the AV node and can switch the relay from the cardiac pathways of the electrical impulse to the neural (afferent) ones. Thus, part of the electricity blocked in the AV node goes to the brain.

How much electricity the heart produces in mV and how much is needed for the needs of the nervous system, no one has asked these questions, we can only indirectly judge the current strength in the myocardium, by the voltage of the cardiac complexes.

Electrically Isolated myocardium?

Have you ever wondered how electrical waves enter the myocardium during cardiac defibrillation (CD)?

At the moment, it is believed that during electrical CD, the processes of hyperpolarization and depolarization of cardiomyocyte membranes are consistently realized (Gudkova & Kozlov, 2016). That is, it is theoretically believed that electrical waves directly enter the myocardium. Let’s figure this out.

The myocardium is covered from the outside and from the inside with a connective tissue membrane, the epicardium and endocardium (Anke et al., 2018). And the connective tissue membrane does not conduct electrical impulses through itself. Accordingly, the myocardium is electrically isolated, it does not let in or let out electrical impulses from itself.

Yes, someone may say that electricity can enter the myocardium through small arterial and venous vessels, but this is not true. As soon as external electrical impulses begin to enter the myocardium through the blood flow of the coronary vessels, an instant spasm of all small arterioles and venules will occur. In addition, our body is not so stupid as to waste electricity in vain, everything in it is thought out to the smallest detail. In this regard, we believe that with DS, an electrical discharge enters the heart through the nerves, namely, through the receptors of the SA, AV and other nodes. In this case, the SA node takes on the function of the pacemaker, but there may be other options. Accordingly, after the excitation of the ventricular myocardium, electricity cannot leave the myocardium except through the afferent nerve pathways. We will confirm this theory below.

Facts in Favor of Our Theory

In the embryonic period, the heart begins to work on the 22nd day, and the electrical activity of the brain from the 5-6th week. The normal heart rate (HR) of the fetus is on average 120-180 beats per minute and the HR is normalized only by 8-10 years, up to 60-90 beats per minute. Such frequent work of the heart occurs because the cells of the embryo and the child divide more actively, they need several times more oxygen and nutrition (Serov, 2014).

We believe that this is not the only reason, the fact is that the brain is actively growing, and if you consider that it is a tiny battery, then its capacity is small and a high HR is needed for a rapidly growing brain. This high HR is set by the brain itself, it requires more electricity from the heart!

Neurons are unique in their ability to receive and transmit information, efferent neurons (motor or descending) send nerve impulses from the central nervous system (CNS) to peripheral tissues and organs, instructing them how to act. Afferent neurons (sensory or ascending) conduct impulses from peripheral tissues and organs to the CNS (Chow et al., 2022). Many of you know that the wires in our homes and electrical appliances have a two-wire cable, one of them is the active phase, which carries electricity, the other is the zero phase (grounding), their correct operation closes the electrical circuit (Fig. 5).

Figure 5: Phase 0 and phase active, closed electrical circuit

So, in our house there is such a wiring diagram, and in the nervous system it is like this (afferent and efferent path), and in the heart there is only one active phase, where is phase 0? Where does the current go after the excitation of the ventricles of the heart, we need a 0 phase of grounding! Afferent nerve pathways are just the 0 phase of the myocardium, they must remove excess and residual electrical energy from the myocardium so that the next impulse can excite the heart again. Thus, if electrical energy did not leave the myocardium into the nervous system (phase 0), then this would be called an "open electrical circuit", when there is a break in any circuit, it becomes an open circuit, preventing the flow of current (Fig. 6). Simply put, if a person, like a bird, sits on only one high-voltage wire, then he will not be electrocuted. Accordingly, if the heart were electrically isolated, it would not be able to become excited and contract.

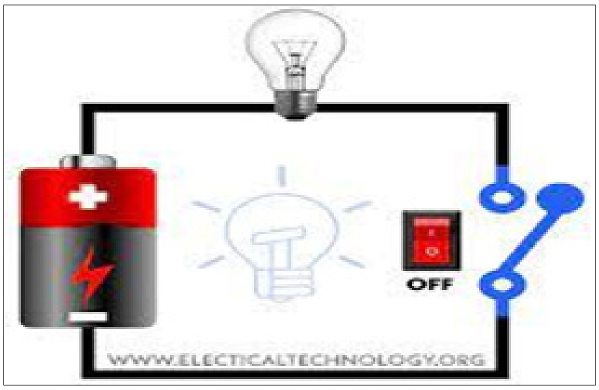

Figure 6: Phase 0 and phase active, open electrical circuit

Brain Storage Capacity

Our brain is more like a car battery, they are 70-80% electrolyte water. A car battery consists of 4 important parts: a plastic box to hold water and electricity; electrolyte water; lead plates and incoming electricity from an electric generator. Thus, an electrochemical reaction of lead oxidation and generation of additional electricity occurs.

The human brain has: an outer shell of connective tissue and fat, they hold fluid and do not allow electricity to leave the brain; electrolyte water and incoming electricity from the heart; but there are no lead plates, maybe glycolysis will do here?

When activated, the brain temporarily drives glucose through astrocytes (Fig. 7), where glycolysis occurs, and then oxidizes lactate in neurons using oxygen. During glycolysis, 2 ATP molecules are consumed to activate one glucose molecule. At the same time, during the metabolic conversion of each C3 fragment, 2 ATP molecules are formed. As a result, the energy gain is 2 moles of ATP per mole of glucose. Glycolysis consists of a chain of successive enzymatic reactions and is accompanied by the storage of energy in the form of ATP and NADP (Morita et al., 2019).

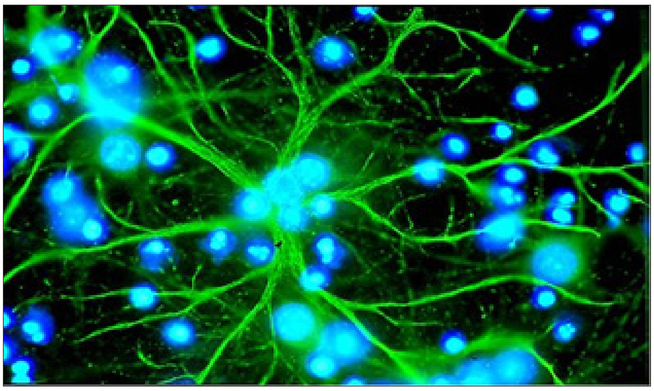

Figure 7: Astrocyte

However, neurologists themselves can establish the accumulative function of the brain, it is not so difficult. For example, a team of scientists from Italy, Switzerland and Israel led by Alessandro Morelli in their new study Morelli et al. (2025) concluded that perhaps the brain needs sleep to "charge the battery". This "battery" is nothing more than the myelin sheath surrounding the nerve fibers. For many years, myelin was considered a passive insulation of nerve fibers, similar to the plastic coating of electrical wires, necessary for signals to travel faster along neurons. Researchers have suggested that myelin works as an energy accumulator, or more precisely, as a proton capacitor. This means that during sleep it accumulates protons - positively charged particles that participate in the synthesis of ATP, a universal source of energy for cells.

Example from A Disease in Neurology and a Car

In connection with the above, we will give an example from a disease in neurology and a car:

1. Multiple sclerosis is a disease Prokaeva et al. (2024) that causes the destruction of the protective myelin coating of nerve axons (Fig. 8). This disrupts the connection between the brain and the rest of the body.

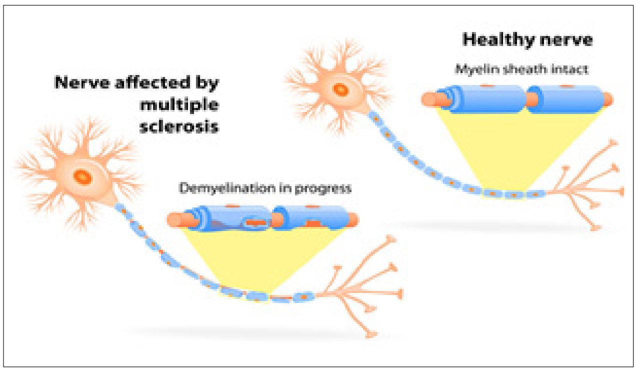

Figure 8: Damage to the protective myelin sheath of the nerve

Symptoms of multiple sclerosis may include:

- vision problems;
- gait or balance problems;
- impaired clarity of thought;
- numbness or weakness, especially in the legs and arms;
- depression;
- sexual or urinary problems;
- extreme fatigue.

It seems to us that such symptoms may be associated with a leak of electricity from the brain to the body. As a result, the brain's accumulative electrical energy decreases. Here is an example from a car disease.

2. Over time, the insulation of the car wires wears out, which leads to electricity leaking from the battery to the car body. You can detect the leak yourself, without resorting to the services of a service. To do this, you will need a special tool - a multimeter. You need to carefully touch the indicator probe to the car body, if the LED lights up, then there is a leak. If there is a current leak, the multimeter shows a resistance above 20 megohms.

We understand that somewhere, it is funny.

Conclusion

At first, we thought that in patients with AV block of 2-3 degrees it is enough to make an electroencephalogram and catch the disappearing electrical impulse of the heart, which goes to the brain. But we realized that the brain has its own structures and you can't catch anything there!

Then we thought that during a heart transplant, the brain is electrically inactive, because electricity does not reach it from the heart. But we were wrong, during a heart transplant, the brain remains active, although the patient is under anesthesia. In addition, the heart is not completely transplanted, part of the atria and the SA node are preserved, respectively, they can generate and transmit electricity to the brain (Nour El Hadi et al., 2025). And in some cases, two SA nodes are preserved: the donor's and the recipient's. The same thing happens with the transplantation of an "artificial heart", although they talk about a complete heart transplant, but only two or one ventricle is transplanted, and the upper atria with the SA node remain in place. The artificial ventricles themselves operate from an external power source (Senage et al., 2020). Accordingly, the brain is not left without a flow of electricity from the heart.

Thus, our brain receives electricity from the afferent neurons of the heart, accumulates and uses it, but only due to the uninterrupted flow of electricity from the heart. Our brain is similar to a car battery, which is recharged when the engine and generator are running. How long the brain will work without the electrical work of the heart, but with artificial blood circulation, is difficult to say.

This article can lead to new research in neurology and cardiology, open new horizons for science.

Author Contributions

All authors meet the ICMJE criteria for authorship. Author contributions (according to the Credit system): Khabchabov R.G. – article concept, source search, manuscript creation and editing, approval of the final version of the article; Makhmudova E.R. – article concept, source search, manuscript creation and editing, approval of the final version of the article.

Conflict of Interest

The authors declare no obvious or potential conflicts of interest or personal relationships related to the publication of this article. The authors did not declare any other conflicts of interest.

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