Theoretical substantiation of the measuring current value for electropunctural diagnostics

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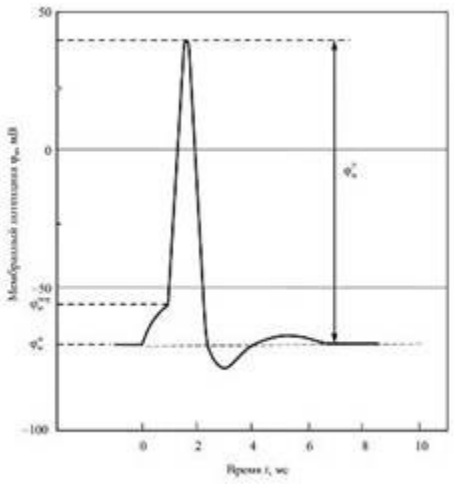
The action potential of neurons is the electrical component of a nerve impulse. First investigated in the works of A. Hodgkin, E. Huxley and D. Eccles, today it is described in detail not only in the scientific, but already in the educational literature [1, 2]. In fig. 1 as an example, an idealized diagram of the action potential of a neuron is presented.



Rice. 1. An idealized scheme of the action potential of a neuron

The duration of the spike of the action potential of neurons is ~ 1–2 ms.
The amplitude of the action potential of neurons φ_{dm} ~ (110-130) mV.

It is known that electric current is a universal irritant of nerve cells. If the cells located in the BAP area are acted upon by a microcurrent, the receptor potential depolarizes the cell membrane, and upon reaching the threshold value φ_{m} since the membrane potential of the cell sharply
grows, changes sign and reaches the maximum (amplitude) value $\varphi_{d\,m}$ ... After reaching the amplitude of the action potential, the membrane potential rapidly decreases to the resting potential $\varphi_{m.NS}$

The cell membrane is an electrical double layer. Knowing the potential difference between the inner and outer surfaces of the membrane, in the approximation of a uniform field, it is easy to calculate the strength E of the membrane's electric field. In an unexcited state, the strength of the electric field of the membrane

$$E_{nn} = \varphi_{mn} / d, \quad (1)$$

where φ_{mns} - the membrane potential of the rest of the cell;
d is the thickness of the cell membrane.

When the cell is excited, the membrane potential increases sharply, changes its

sign and becomes positive. The electric field strength also increases sharply. Change in the strength of the electric field in the membrane at change in membrane potential from resting potential φ_{NS} to amplitude values φ_{dm}

$$\Delta E_{nd} = \varphi_m / d. \quad (2)$$

The change in the strength of the electric field can be described using the concept of displacement current. The concept of "displacement current" in physics was first introduced by Maxwell in the theory of the electromagnetic field. Numerical value of the bias current density j_{cm} in the environment is calculated by the formula:

$$j_{cm} = dD / d, \quad (3)$$

where D is electrical displacement.

Electrical displacement D is related to the electric field strength E by a simple relationship: $D = \varepsilon_o \varepsilon E$, (4)

εo - electrical constant (εo = 8.85 x 10-12 F / m); ε is the dielectric constant of the medium. (The dielectric constant of the membrane is ε = 4–6).

In a homogeneous medium (ε = const), the displacement current density

$$j_{cm} = dD / dt = d(\varepsilon_o \varepsilon E) / dt = \varepsilon_o \varepsilon (dE / dt). \quad (5)$$

The duration of the action potential in neurons is ~ 1–2 ms. According to some estimates, the membrane potential increases from the resting potential φ_{NS} before amplitude value φ_{dm} in time Δt ~ (0.4-0.8) ms, according to others - it reaches the amplitude value for the time Δt ~ (0.2–0.5) ms.

The amplitude of the action potential of neurons φ_{dm} ~ (110-130) mV. Thickness neuronal membranes d ~ (7-11) nm.

Based on formulas (5) and (2), based on the available thickness values d, permittivity ε, amplitude φ_{dm} and the duration of the depolarization phase Δt of the membrane action potential, it is possible to estimate the average value of the bias current density $\langle j_{cm} \rangle$ that occurs when a neuron is excited:

$$\langle j_{cm} \rangle \approx \varepsilon_o \varepsilon (\Delta E_{nd} / \Delta t) = \varepsilon_o \varepsilon (\varphi_{dm} / d\Delta t). \quad (6)$$

Calculated by formula (6) from the average values ε = 4, φ_{dm} = 110 mV, Δt = 0.5 ms, d = 9 nm bias current density $\langle j_{cm} \rangle \approx 0.865$ A / m2...

The above calculations of the bias current density are presented by us in order to compare the values of $\langle j_{cm} \rangle$ with a diagnostic current density $\langle j_d \rangle$ flowing through the BAP during electropuncture measurements according to the method of R. Voll.

For a healthy organ (~ 55 conventional units of Ts), the diagnostic current of R. Voll's device is ~ 5.9 μA. The stylus tip has a diameter of ~ 3 mm. The same linear dimensions are typical for biologically active points. Diagnostic current density I_d flowing through the BAP with a radius r,

$$j_d = I_d / \pi r^2 \ldots \quad (7)$$

Diagnostic current density calculated by formula (7) I_d = 5.9 μA flowing through a BAP with a diameter of ~ 3 mm is $\langle j_d \rangle \approx 0.835$ A / m2...

The calculations performed give an amazing result: the bias current density $\langle j_{cm} \rangle \approx 0.865$ A / m2 arising during the excitation of a neuron, and the density

diagnostic current flowing through the BAP, <j_d> ≈ 0.835 A / m_2, practically coincide.

The parameters of neurons and, accordingly, the duration of their action potentials may differ insignificantly from those used in the above calculations of the bias current density <j_{cm}>, as well as the size of BAP and the values of the diagnostic current, on the basis of which the density of the diagnostic current was calculated <j_d>.

However, even taking into account all these differences, it is obvious that the bias current density <j_{cm}> upon excitation of neurons and the density of the diagnostic current flowing through the BAP, <j_d> are quantities of the same order.

For other excitable cells, for example, muscle cells, the duration of the action potential is tens and hundreds of times longer than the duration of the action potential of the neuron. In skeletal muscles, the duration of the action potential is ~ 5-10 ms, in the heart muscle ~ 300 ms. Obviously, the bias current density <j_{cm}> in muscle cells will significantly exceed the density of the diagnostic current<j_d>.

How much US known choice magnitudes diagnostic current was carried out by R. Voll experimentally, based on the results of a large, statistically significant, number of electropuncture measurements. As follows from the above calculations, the value of the diagnostic current of R. Voll's device is physically justified.

It is generally accepted that the change in the readings of R. Voll's device during electropuncture is due to a change in skin resistance in the BAP area.

Our calculations of the bias current density unambiguously indicate the electromagnetic nature of electropuncture diagnostics according to R. Voll. The impact of a microcurrent on BAP leads to the body's response in the form of the appearance of an action potential of neurons (nerve impulse) and the emergence of a displacement current in the body. R. Voll's diagnostics is based not on registering changes in skin resistance, but on comparing the measuring microcurrent of the device and the bioelectric current flowing through the BAP.

Literature

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