EFFECT OF HIGH-VOLTAGE CAPACITOR DISCHARGE ON PERMEABILITY OF A CELL-MEMBRANE MODEL

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Experiments in which frog skin was used as a model of the cell membrane are described. The discharge from a defibrillator changed the permeability of the skin sharply so that the absorption of Ca^{45}, K^{42}, and Na^{24} ions and the transport of Na^{24} ions were increased; transport of K^{42} and Ca^{45} ions began to appear and develop. The effect depended on the voltage, polarity, and number of the discharges.

The authors have shown by experiments on frog skin as a model of the cell membrane that an electric pulse changes its resting potential [1]. Changes in the volt-ampere characteristics observed under analogous conditions indirectly confirmed the view that the effect is based on increased permeability of the cell membranes [2].

To obtain direct evidence in support of this hypothesis the action of a defibrillator discharge on the permeability of frog skin (membrane model) to radioactive isotopes Na^{24}, K^{42}, and Ca^{45} was studied.

EXPERIMENTAL METHOD

A cell consisting of two compartments separated by skin (A and B) was used. Compartment A was filled with a solution of a salt of one of the isotopes. The solvent used for Na^{24} and K^{42} was Ringer's solution or a solution of the corresponding salt (NaCl or KCl) with Na or K concentration of 350 mg %. The concentration of the element in $CaCl_2$ solution containing Ca^{45} was 350 mg %. Ringer's solution or distilled water was poured in compartment B. A discharge from the ID-1-VÉI defibrillator was applied across the skin. If the electrode in compartment A was positive, the polarity was direct, and vice versa. The radioactivity was measured in the skin on the surface facing compartment B.

EXPERIMENTAL RESULTS AND DISCUSSION

The high-voltage discharge activated the absorption of Na^{24}, K^{42}, and Ca^{45} by the skin and increased the permeability of the skin for those ions. The degree of the increase in absorption and permeability depended on the voltage of the pulse (Table 1).

If a series of discharges of increasing voltage was applied to the skin, the changes in permeability were found to depend on the pulse voltage (Table 2).

Comparison of the results in Tables 1 and 2 shows that the state of increased permeability continued after the discharge for some time, and if several discharges were applied the changes in the skin were cumulative. This was shown by the appearance of permeability to K^{42} with a voltage of 1 kV (after the second discharge) and the increased passage of the isotope after application of a pulse of 3 kV, and by the transport of Ca^{45} with a discharge of 3 kV (the 4th pulse). Several discharges led to considerably greater accumulation of the isotopes in the skin.

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TABLE 1. Effect of Discharge Voltage on Absorption and Transport of Na^{24}, K^{42}, and Ca^{45} Ions through Frog's Skin (polarity direct; outer surface of skin facing compartment A of the cell)

Voltage of discharge	Ringer–Ringer		$K_{350}-H_2O$		$Ca_{350}-H_2O$	
	Na^{24} (in %)		K^{42} (in %)		Ca^{45} (in %)	
	passed through	absorbed	passed through	absorbed	passed through	absorbed
Control	0,32	0,05	0	0,13	0	0,33
Discharge						
0,2 kV	—	—	0	0,18	0	0,69
0,5 kV	0,44	0,15	—	—	—	—
1,0 kV	—	—	0	0,44	0	0,81
3,0 kV	0,59	0,36	0,13	0,49	0	0,95

TABLE 2. Effect of High-Voltage Discharges on Accumulation of K^{42} and Ca^{45} Ions in the Skin and Their Transport through It (polarity direct; outer surface of skin facing compartment A of the cell)

Solutions	Ions	Control		Discharge (in kV)				
		passed through	absorbed (in %)	0,5	1,0	2,0	3,0	absorbed (in %)
				passed through (in %)				
Ringer–Ringer	K^{42}	0,11	0,25	0,04	0,18	0,34	0,52	0,47
$K_{350} - H_2O$	K^{42}	0	0,13	0	0,08	0,30	0,43	1,05
$Ca_{350} - H_2O$	Ca^{45}	0	0,33	0	0	0	0,23	2,46

The next step was to determine the effect of the polarity of the discharge on skin permeability. With a discharge of direct polarity there was a greater accumulation of K^{42} and Ca^{45} in the frog skin if the outer surface was in contact with the solution of the isotope. Transport of Ca^{45} also was found after a pulse of 3 kV. If the inner surface of the skin faced the A compartment of the cell, a discharge of direct polarity led to a much greater transfer of Ca^{45}.

LITERATURE CITED

1. I. P. Arleevskii and V. K. Bezuglov, Kardiologiya, No. 2, 138 (1972).
2. I. P. Arleevskii and V. K. Bezuglov, Byull. Éksperim. Biol. i Med., No. 12, 9 (1972).