The Role of the Lymphatic System in the Changes of Electrolyte Balance in the Febrile Reaction

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The shifts of the electrolyte level in the lymph and blood are of the same direction, namely, increased. The content of potassium, sodium, and calcium changes only after prolonged fever, while that of magnesium changes after just a single administration of pyrogenal. The lymph level of calcium and magnesium rises more significantly as compared to the blood.

Key Words: *febrile reaction; lymph; electrolytes*

Depending on its nature and duration, the febrile reaction (FR) is accompanied by marked alterations in the electrolyte balance which manifest themselves in a change of the electrolyte level in the peripheral blood [4]. The lymphatic system, in its turn, plays an significant role in the maintenance of homeostasis by transporting electrolytes from the intracellular and interstitial compartments [3].

In view of the above, we performed a comparative assay of the content of Na, K, Ca, and Mg in the lymph and blood in the time course of an FR of various duration.

MATERIALS AND METHODS

Experiments were carried out on 63 Chinchilla rabbits weighing 2.5-4.2 kg. The FR was simulated by the administration of pyrogenal according to a method described previously [5]. The animals treated with apyrogenic physiological saline were the control. The content of electrolytes was determinated by flame photometry in lymph taken from the thoracic duct, postnodal part of the hepatic lymphatic duct, and the intestinal lymphatic trunk, as well as in blood sampled from the femoral vein. Euthanasia of animals was performed by administration of a lethal dose of a narcotic.

RESULTS

As is shown in Table 1, the concentration of Na, K, and Ca was the same in all biological fluids. Contrary to this, the content of Mg in the lymph was 2.5-3-fold lower than in the blood. Shifts of the level of electrolytes studied in the lymph and blood in the dynamics of FR were of the same direction (an increase) and appeared simultaneously. However, the content of K, Na, and Ca changed only after prolonged fever, while that of Mg changed after just a single administration of pyrogenal. Moreover, the level of Ca and Mg (in a prolonged FR, particularly) rose more significantly in the lymph than in the blood.

Since even slight shifts in the level of Na and K in biological fluids and tissues of the organism have with serious sequelae, sometimes incompatible with life, we consider that the long-term preservation of their constant concentration in FR in our study attests to excellent compensatory possibilities of the organism in this pathological process. It is known that in disease the constancy of the ionic composition of plasma is maintained better than

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TABLE 1. Electrolyte Content (mmol/liter) in Lymph and Blood in Febrile Reaction ($M \pm m$)

Administration of pyrogenal	Electrolyte							
	Na	K	Ca	Mg	Na	K	Ca	Mg
	Lymph of thoracic duct				*Hepatic lymph*			
Control	115.73±6.09	3.42±0.15	1.50±0.15	0.28±0.04	114.63±10.19	3.31±0.12	1.16±0.23	0.39±0.04
Single:								
after 2.5–3 h	107.41±7.14	3.44±0.08	1.67±0.37	0.54±0.06*	117.40±8.84	3.35±0.11	1.11±0.14	0.46±0.06
after 5–5.5 h	118.54±8.65	3.47±0.09	1.49±0.21	0.82±0.18***	113.01±7.62	3.37±0.09	1.42±0.20	0.87±0.10*
Three time:								
4th day	107.80±8.65	3.39±0.11	1.95±0.18	0.70±0.08*	113.00±6.25	3.48±0.07	1.62±0.27	0.26±0.07
6th day	113.27±5.40	3.39±0.12	1.75±0.25	0.29±0.07	111.57±4.67	3.45±0.08	1.28±0.24	0.26±0.07
10th day	115.98±8.77	3.39±0.09	1.35±0.17	0.26±0.08	113.58±8.02	3.40±0.06	1.82±0.21	0.32±0.022
Five times								
6th day	175.19±9.56*	4.04±0.14**	2.15±0.24***	0.93±0.09*	135.25±7.83	4.05±0.09*	2.02±0.13**	0.97±0.07
10th day	120.67±8.91	3.44±0.06	1.38±0.10	0.38±0.09	126.36±9.25	3.41±0.12	1.45±0.27	0.37±0.06
Nine times	178.91±8.81*	4.15±0.09*	3.00±0.25*	0.93±0.10*	171.26±10.68*	4.18±0.09*	2.91±0.45*	0.84±0.10*
	Intestinal lymph				*Blood plasma*			
Control	109.11±9.16	3.36±0.07	1.31±0.14	0.29±0.03	118.21±9.33	3.57±0.07	1.66±0.19	0.98±0.06
Single:								
after 2.5–3 h	112.16±8.92	3.31±0.07	1.80±0.20	0.88±0.12*	122.36±11.68	3.44±0.11	2.78±0.22*	3.39±0.42*
after 5–5.5 h	115.39±7.77	3.41±0.06	1.90±0.18	1.16±0.19*	127.24±15.03	3.53±0.15	2.64±0.08*	1.40±0.19***
Three times:								
4th day	116.21±6.99	3.42±0.07	2.03±0.23**	0.60±0.02**	127.92±11.48	3.58±0.14	2.25±0.32	2.70±0.43*
6th day	117.80±11.90	3.39±0.11	1.16±0.20	0.30±0.06	112.53±8.06	3.54±0.13	1.71±0.13	1.23±0.25
10th day	123.20±12.85	3.42±0.11	1.70±0.24	0.30±0.04	119.04±8.32	3.53±0.13	1.86±0.18	0.89±0.14
Five times:								
6th day	135.92±16.45	4.38±0.30**	2.50±0.21*	1.14±0.12*	148.42±17.61	4.92±0.30*	2.81±0.29*	3.20±0.55*
10th day	117.17±5.78	3.42±0.09	1.48±0.20	0.32±0.05	133.09±10.25	3.96±0.11***	1.60±0.20	1.30±0.26
Nine times	180.73±12.20*	4.60±0.18*	3.46±0.73** *	0.78±0.20***	189.18±8.53*	5.30±0.22*	2.95±0.28*	2.09±0.29*

Note. Asterisks indicate the reliability of differences: * – $p<0.001$; ** – $p<0.01$: *** – $p<0.05$.

that of erythrocytes, and so hyperkalemia and hypernatremia in prolonged fever are probably related to their release from erythrocytes due to the mechanism of "facilitated diffusion," in other words, by the transport of univalent ions using carriers [1,8]. At the same time, it has been established that the elevation of the Na content in the blood boosts the excitability of sympathetic nerve endings [4], which is significant in FR pathogenesis. The increase of cations in the lymph, however, stems from the rise of the blood-lymph barrier in fever.

In view of the fact that Mg is the main intracellular cation after K, the elevation of its level after short-term fever probably resulted from an accelerated Mg output from the cell due to an increase of the membrane permeability, because it is known that the Mg-phospholipids complex in cell membranes fixes them and lowers their fluidity and permeability. We think that the lymphatic system plays a significant role in Mg transport, this being confirmed by the greater increase of its concentration in the lymph as compared to the blood in prolonged FR. On the other hand, a deficiency of Mg in the cell leads to the loss of K and Ca, causes spasm of smooth muscles of organs, including coronary arteries, and promotes the development of arrhythmia. Unlike Ca ions, Mg activates acetylcholine hydrolysis by cholinesterase, whereby the excitability of nerve endings is inhibited and the muscles relax [6,10]. All the Mg effects mentioned above may contribute to the development of pathogenetic changes in organs and tissues in FR.

The mechanism of Ca dynamics in the lymph and blood in FR is probably as follows. It is known that the Ca level can rise due to ionizing forms as a result of the action of catecholamines [9]. Via adenylate cyclase activation catecholamines increase cAMP production, intensifying the transmembrane flow of Ca and boosting Ca metabolism in subcellular membranes [11]. At the same time, the activity of sympathetic neurons rises, and the processes of biosynthesis, release, and metabolism

of catecholamines are intensified in FR [2]. In view of the facts outlined, an increase of the Ca content in the body fluids would be expected after just one pyrogenal injection. But an increment was obtained only in the blood and not in the lymph. This apparent discrepancy may be explained by the fact that Ca is able to accumulate in lymph nodes which is significant in pathology for the maintenance of its constant level in the body fluids [7]. Moreover, the glucocorticoids released in FR probably delay intestinal Ca absorption stimulated by vitamin D [9].

Along with this, we assume that the factors promoting the rise of the lymph and blood Ca content dominate in prolonged FR. Since in the organism Ca is in the protein-bound state [9], its rise in FR may be due to a decrease of the Ca-binding capacity of the plasma proteins as well. There is reason to think that a marked increase of Ca concentration in the lymph during FR is observed due to a stepped-up transport function of the lymph system for it. Thus, in the course of FR the lymph system plays a key role in the redistribution of electrolytes in the body fluids. It may be assumed that the lymph nodes situated along the lymph route play an important role in the accumulation and release of electrolytes, thereby equalizing their content in the body fluids in FR.

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