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LACTATE CONCENTRATION AND ITS CHANGES IN THE BLOOD OF 3-MONTH-OLD RABBITS

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КОНЦЕНТРАЦИЯ ЛАКТАТА И ЕЕ ИЗМЕНЕНИЯ В КРОВИ У 3-МЕСЯЧНЫХ КРОЛИКОВ

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Abstract. It was performed on 3-month-old rabbits, which were exposed to acute (20 minutes) and severe form of exogenous hypoxia (forced breathing in a nitrogen atmosphere with 5% O_2 in pressure chamber conditions). Immediately after that (in the 1st, 3rd and 6th hours), the amount of lactate in their blood was determined. First, we studied the normal level of lactate in the blood of 3-month-old guinea pigs, then we subjected them to a hypoxia load and determined lactate. This series of experiments conducted by us allows us to get an idea of how blood lactate levels initially change in 3-month-old rabbits that have not yet reached sexual maturity under normal conditions and during the effects of various severe loads (such as acute hypoxia, long-term immobilization, and fast running). Here, we want to mention once again about lactate that this simple carbohydrate metabolite, along with other simple carbohydrates such as pyruvate (pyruvic acid) in the human and animal body, when there is a lack of oxygen in its cells, the glycolysis process (anaerobic decomposition of glucose) is carried out even faster, is an indicator of metabolic and functional importance that allows us to make judgments about its end products and at the same time its intensity and duration. As a final product of glycolysis, lactate accumulated in cells and tissues causes a change in the buffer systems there, an increase in the activity of the acidic range of pH (acidosis) and other negative reactions. An increase in the amount of lactate in the blood is considered a relatively weak toxic factor for the body. From this point of view, lactate is one of the harmful metabolites of the body. But studies have shown that the lactate formed as a result of glycolysis and other carbohydrate exchange processes is also used for the resynthesis (resynthesis) of sugars that are energetically useful for the body, that is, the body uses it as an energetic substrate. Therefore, the pronounced change in the level of lactate in the blood can also be considered as a kind of adaptive-defense reaction.

Аннотация. В представленной статье рассматриваются результаты наблюдений на 3-месячных кроликах, подвергшихся острой (20 минут) и тяжелой форме экзогенной гипоксии (принудительное дыхание в атмосфере азота с 5% O_2 в барокамерных условиях). Сразу после этого (в 1, 3 и 6 часы) определяли количество лактата в крови. Сначала нами изучен нормальный уровень лактата в крови у 3-месячных морских свинок, затем подвергшихся гипоксической нагрузке, где определялся лактат. Проведенная нами серия экспериментов позволяет получить представление о том, как первоначально изменяется уровень лактата в крови у 3-месячных кроликов, еще не достигших половой зрелости, в нормальных условиях и при воздействии различных тяжелых нагрузок (например, острой гипоксии) длительная иммобилизация и быстрый бег). Здесь мы хотим еще раз упомянуть о лактате, этом простом метаболите углеводов, наряду с другими простыми углеводами, такими как пируват (пировиноградная кислота), в организме человека и животных при недостатке кислорода в его клетках происходит процесс гликолиза (анаэробное разложение глюкозы) осуществляется еще быстрее, что является показателем метаболической и функциональной значимости, позволяющим судить о его конечных продуктах и одновременно о его интенсивности и продолжительности. Являясь конечным продуктом гликолиза, лактат, накапливающийся в клетках и тканях, вызывает изменение там буферных систем, повышение активности кислого диапазона pH (ацидоз) и другие негативные реакции. Увеличение количества лактата в крови считается относительно слабым токсическим фактором для организма. С этой точки зрения лактат является одним из вредных метаболитов организма. Но исследования показали, что лактат, образующийся в результате гликолиза и других процессов углеводного обмена, используется и для ресинтеза (ресинтез) энергетически полезных для организма сахаров, то есть организм использует его как энергетический субстрат. Поэтому выраженное изменение уровня лактата в крови также можно рассматривать как своеобразную адаптивно-защитную реакцию.

Keywords: 3-month-old rabbit, hypoxia, physical loads, lactate.

Ключевые слова: кролик 3-х месяцев, гипоксия, физические нагрузки, лактат.

In extreme and stressful conditions, the primary needs of the body for energy (ATA) are met due to the oxidation (“burning”, complete breakdown) of glucose, which has the function of “emergency fuel” in cells, in the O_2 environment. This aerobic energetic process is carried out more intensively in intensively functioning structures such as the brain, heart, working skeletal muscles, kidneys, and this process directly depends on the amount of glucose in the blood flowing to them [6]. High O_2 tension (pO_2) in organs and blood circulation are important physiological tasks and are regulated through different mechanisms.

Anaerobic glycolysis, which functions as an evolutionarily older and universal energy exchange mechanism, i. e. incomplete “oxidation” of glucose in cells without oxygen, enzymatically, in stages and quickly (decomposition) reactions are reported [5].

Anaerobic glycolysis is a temporary metabolic process that occurs under the influence of various specific enzymes, especially for muscles that work hard for short periods of time. Anaerobic glycolysis is aggravated during intense nervous and cardiac activity, rapid physical movements (quick locomotor acts). For example, during a 100 m sprint, anaerobic glycolysis in the athlete’s “white muscles” quickly reaches a very high level [7].

Biochemical characteristics of anaerobic glycolysis are also interesting. This incomplete process results in 2 molecules of ATA (biological energy carrier) from one glucose molecule ($C_6H_{12}O_6$) and two important final intermediate metabolites — in one case 2 molecules of pyruvate (pyruvic acid, $C_3H_6O_3$) and in the other case 2 molecules of lactate (lactic acid, $C_3H_6O_3$) results in formation.

Materials and methods

For our experimental work, lactate is of particular importance. Lactate is actually a product of pyruvate reduction due to the effects of NAD and NAD*H cofactors and lactate dehydrogenase (LDH) enzyme; it is an active and multifunctional metabolite involved in turn reactions.

As a result of fast and temporary anaerobic glycolysis in the tissues, a large amount of lactate accumulates in the plasma of cells, and with the help of a special cellular mechanism, a significant part of it passes into the blood and circulates in the body with the blood [7].

According to the physiological and biochemical ideas about lactate, for a long-time lactate accumulated in intensively working skeletal muscles as well as in the blood can cause weak poisoning, fatigue, shortness of breath, acidosis and other pathological effects in the body. Lactate "decontamination" and involvement in metabolic processes (anabolic processes) takes place in the liver. Here, the catalytic activity of the LDH enzyme is very high, and a significant part of the lactate is used for resynthesis reactions of glycogen reserve polysaccharide, especially glucose [4].

Lactate undergoes aerobic decomposition (oxidation reactions) when aerobic respiration is restored when sufficient O_2 enters the body and its tissues (cells). Thus, lactate is characterized as one of the main products of glycolysis occurring in the body during the effects of heavy loads such as hypoxia, intense physical activity, etc., and it has a wide range of metabolic and adaptive properties. It should be noted that the increase of lactam in the blood indicates the degree of ischemia (lack of blood, hence hypoxia) occurring in the tissues. During hypoxia, the level of lactate in cells and blood definitely increases [6].

Results and discussion

Experimental evidence and theoretical studies on the quantitative changes and metabolism of lactate in blood and other tissues in different functional states are not abundant. Most of the studies in this direction were carried out on school-age children and young athletes exposed to various physical loads.

According to some literature materials, the activity of lactate dehydrogenase enzyme in the blood and the amount of lactate in early age, both in boys and girls, change according to complex dynamics in relation to age. It is shown that the activity of LDH enzyme is weak in schoolchildren from 7 to 10 years old, while it increases in the later age period (13-15 years old), and then it changes little and remains at a relatively stable level. The level of lactate in the blood is determined in high limits with age. Thus, the blood lactate index in boys at the age of 7-14 is 7.6±0.38-14.6±1.63 mg %, and the blood lactate index in girls at the same age is 8.3±0.48-13.8±0 It fluctuates between 0.99 mg % [2].

Exercises on a bicycle ergometer, which strengthens the physical endurance of the body, activate the aerobic mechanisms of energy supply (requiring oxygen consumption) in young athletes to a high degree. After performing a cycle ergometry test, the levels of pyruvate and lactate, which are the end products of anaerobic glycolysis, in their blood significantly increase compared to the norm — pyruvate rises 1.5 times, lactate is 5.6±0.7 mmol/l (normal level is 0.5-2.2 mmol/l) [3].

It is clear from these facts that the production of lactate as a metabolite and its involvement in carbohydrate and energy metabolism in the animal or human body at different ages and under the influence of various external factors is one of the most interesting, important physiological and biochemical issues. Taking this into account, it was important for us to study the initial level of lactate in the blood and its dynamics in different conditions — during hypoxia and physical loading — on young laboratory animals.

As in our previous experimental studies, this series of experiments was also performed on immature 3-month-old rabbits, which were exposed to acute (20 minutes) and severe form of exogenous hypoxia (forced breathing in nitrogen atmosphere with 5% O_2 in pressure chamber conditions). Immediately after that (in the 1st, 3rd and 6th hours), the amount of lactate in their blood was determined [1].

First, we studied the normal level of lactate in the blood of 3-month-old intake donkeys, then we exposed them to the above-mentioned hypoxia load and determined the lactate. The experimental results obtained at this time are given in Table 1.

Table 1

QUANTITATIVE INDICATORS OF BLOOD LACTATE
IN NORMAL AND AFTER HYPOXIA IN 3-MONTH-OLD RABBITS
(M±m, n=5).

Research conditions	*The amount of lactate*		
Unspoilt in rabbits	Normally 4.8±0.6 mg%		
Hypoxic in rabbits	After hypoxia		
	In the 1st hour	In the 3rd hour	At the 6th hour
	6.2±0.34 mg% ($p < 0.05$)	7.6±0.58 mg% ($p < 0.78$)	5.3±0.20 mg%

When we pay attention to the numerical indicators obtained during this research, we get the impression that lactate in the blood of 3-month-old rabbits with relative motor activity in normal and vivarium conditions is found in the amount of 4.8±0.6 mg%. It seems that such a high level of lactate in the blood, as a product of glycolysis and other carbohydrate exchange reactions that occur naturally in the tissues of the animal body, primarily in working skeletal muscles, at this age and performing relatively active locomotor acts (displacement movements) is probably normal.

During the impact of acute and severe hypoxia, the animal's body undergoes a high stress state in the first moments, they try and try to get rid of the hypoxic situation, and this and the subsequent posthypoxic reactions, primarily the intensification of anaerobic glycolysis, can lead to a significant increase in the level of lactate in the blood.

Table 1 shows that the blood lactate concentration increases to 6.2-7.6 mg% in 1-3 hours after acute and severe hypoxia exposure in 3-month-old rabbits. It is also worth noting that the blood lactate level decreases to normal limits (up to 5.3±0.20 mg%) in the 6th hour after the hypoxia test. Probably, this trend can become stronger later.

Following this experiment, we carried out further experiments to determine lactate in the blood of 3-month-old rabbits subjected to 1-hour immobilization and 10-minute forced running loads. The results of the experiment are shown in Table 2.

Table 2

QUANTITATIVE CHANGES IN BLOOD LACTATE IN 3-MONTH-OLD RABBITS IMMEDIATELY AFTER 1-HOUR IMMOBILIZATION ON THE PLATFORM AND 10-MINUTE TREADMILL RUNNING TESTS (M±m, n=5, in mg%)

Types of experience	*Blood lactate determination times*		
	1 hour later	*3 hours later*	*6 hours later*
Immobilization on the platform	5.4±0.10 mg%	5.0±0.16 mg%	4.1±0.23 mg%
On the thread band escape	5.9±0.43 mg%	5.20±0.24 mg%	4.2±0.30 mg%

Note: * — sign indicates the reliability of the difference between experimental and control indicators at $P<0.05$

The results we obtained in these experiments, performed by applying different types of physical loads, are also interesting in themselves.

As it is clear from the facts we received, the amount of lactate in the blood of 3-month-old rabbits that were firmly fixed to the platform and kept in this position for 1 hour fluctuated almost within the limits of the normative indicator, that is, it did not change at noticeable levels. It seems that the metabolic processes that enable the formation of lactate do not develop as much in the animal body that remains in a state of relative immobility or submaximal kinesthetic for a long time. But since the load of forced and fast running is related to acute muscle work, first of all, as a result of the increased energy demands of the working muscles and the obstacles in the process of supplying the muscles with blood and therefore oxygen, anaerobic glycolysis intensifies. This definitely causes an increase in lactate in the blood in the first moments. As can be seen from the table, 1 hour after running for 10 minutes on the treadmill, the concentration of lactate in the blood is significantly higher than the norm (norm — 4.8±0.6 mg%, immediately after the running test-5.9±0.43 mg%, $p<0,05$).

The last experiment in this series of studies involved forcing 3-month-old rabbits to run on a treadmill for 10 minutes under severe hypoxia for 20 minutes. Our experiments conducted in the previous series showed that blood glucose, pH, and hemoglobin levels are characterized by specific changes when one or another physical load (in our experience, immobilization and forced running loads) is applied immediately after severe hypoxic exposure.

It should also be noted that the level of lactate in the blood is directly related to the anaerobic breakdown of glucose in cells, the level of pH and the amount of oxygen delivered to cells through hemoglobin, the level of activity of glycolytic enzymes and other biochemical, metabolic and functional conditions, as well as accumulated in blood and other tissues. is an indicator determined by the degree of utilization of lactate for exchange purposes. The last condition is mostly determined by the activity of enzymes regulating lactate metabolism (LDH, etc.).

In this series of experiments, the most important issue for us was to monitor the amount of lactate changes in the blood when applying severe exogenous hypoxic exposure to 3-month-old rabbits in a complex case and the subsequent fast running test. Thus, in our previous experiments, it became clear to us that when applying the severe exogenous hypoxia + immobilization experimental model, the observed effect develops and manifests itself mainly as a result of the effect of severe hypoxia, where the role of immobilization is quite minimal.

The issue of lactate formation and accumulation in the blood under complex loads such as 20 minutes of severe exogenous hypoxia in the chamber and 10 minutes of forced running on a rapidly rotating drum wheel (tread band) was very interesting and important for us in a number of ways. In the experiments we conducted in this variant, the results we obtained on the concentration of lactate in the blood, when a 10-minute running load was applied separately to 3-month-old rabbits, are compared with the dynamic indicators of the concentration of lactate in the venous blood. It is presented in the shape of a curve.

The experimental results presented here show that changes in the level of lactate in the blood are more pronounced during physical loading against the background of postnatal hypoxia, which is the most important component of our research. Let’s pay attention to the following indicators for comparison: First, we determined that the determined amount of lactate in venous blood in normal (intact) 3-month-old rabbits is on average 4.8±0.6 mg%. When experimental rabbits of this age were exposed to severe hypoxia for 20 minutes in a pressure chamber, this level increased significantly and reached 6.2±0.34 mg% in the 1st hour after this test, 7.6±0.58 mg% in the 3rd hour, 6- It was 5.3±0.20 mg% in the second hour. The amount of lactate in the venous blood of 3-month-old rabbits forced to run for 10 minutes on a rapidly rotating trend ban wheel was 5.9±0.43 mg%, 5.2±0.24 mg% and 4.2 mg%, respectively has done. The last experiment of this series of studies, that is, subjecting 3-month-old rabbits to a forced run test for 10 minutes on a rapidly rotating wheel immediately after placing them in a state of severe hypoxia for 20 minutes, yielded significantly different experimental results than those mentioned above. Thus, this complex extreme load is characterized by an even sharper increase in the amount of lactate in the blood and its high level remaining for 6 hours after a heavy complex effect, that is, this reaction is more stable.

Table 3

COMPARATIVE DESCRIPTION OF LACTATE QUANTITY CHANGES IN THE VENOUS BLOOD OF 3-MONTH-OLD RABBITS IN THE EXPERIMENTS WITH RUNNING LOAD AND HYPOXIA + RUNNING LOAD SEPARATELY (M±m, n=5, lactate in mg%)

Conditions of experiments	*The amount of lactate in the blood*		
	In the 1st hour	*In the 3rd hour*	*At the 6th hour*
After running for 10 minutes on a treadmill that spins at a speed of 40-45 rpm	5.9±0.43	5.2±0.24	4.46±0.30
After 20 minutes of hypoxia in a pressure chamber followed by 10 minutes of treadmill running	7.8±0.37** p <0.01	7.5±0.28** p <0.01	5,2±0.20* p <0.05

Note: * and ** — signs indicate the degree of statistical reliability of the results of the last experiment compared to the previous “experience” and norm indicators

Conclusion

Thus, this series of experiments conducted by us allows us to get an idea of how blood lactate changes initially in normal conditions and during the effects of various heavy loads (factors such as acute hypoxia, long-term immobilization, and fast running) in 3-month-old rabbits that have not yet reached the period of sexual maturity. Here, we want to mention once again about lactate that this simple carbohydrate metabolite, along with other simple carbohydrates such as pyruvate (pyruvic acid) in the human and animal body, when there is a lack of oxygen in its cells, the glycolysis process (anaerobic decomposition of glucose) is carried out even faster.) is an indicator of metabolic and functional importance that allows us to make judgments about its end products and at the same time its intensity and duration.

As a final product of glycolysis, lactate accumulated in cells and tissues causes a change in the buffer systems there, an increase in the activity of the acidic range of pH (acidosis) and other negative reactions. An increase in the amount of lactate in the blood is considered a relatively weak toxic factor for the body. From this point of view, lactate is one of the harmful metabolites of the body. But studies have shown that the lactate formed as a result of glycolysis and other carbohydrate exchange processes is also used for the resynthesis (resynthesis) of sugars that are energetically useful for the body, that is, the body uses it as an energetic substrate. Therefore, the pronounced change in the level of lactate in the blood can also be considered as a kind of adaptive-defense reaction.

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