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THE EFFECT OF "REMIVITAL" ON PLASMA AMINO ACID COMPOSITION IN DAIRY COWS WITH KETOSIS

M. R. Simonov, V. V. Vlizlo

Institute of Animal Biology, NAAS
38, V. Stusa Str., Lviv, Ukraine, 79034
e-mail: msimonov@inenbiol.com.ua

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Aim. To investigate plasma amino acid composition in dairy cows after ketosis conventional (oral administration of propylene glycol, intravenous injection of glucose and insulin) and proposed treatment (oral administration of propylene glycol, intravenous injection of "Remivital"). **Methods.** Study was performed on high yielding dairy cows with clinical ketosis during their 2nd to 4th lactation with milk yield above 8000 L per previous lactation. Content of free amino acids was determined in plasma before and after treatment using amino acid analyzer. **Results.** Lowering of the level of ketogenic amino acids was revealed after conducted treatment as well as increase in the level of glycogenic and branched amino acids. Significant lowering of the level of methylhistidine gives evidence of decreased catabolism of contractile proteins. **Conclusions.** Proposed treatment regimen has proven to be superior, since significantly higher level of ornithine and lower level of citrulline were revealed after administration of conventional regimen, which gives evidence of problems in disposal of ammonia and lactate. Moreover, in case of administration of traditional scheme, the concentration of markers of catabolism of contractile proteins was still high, in contrast with such in animals, which were administered proposed regimen, and high concentration of isoleucine contributes to aggravation of ketoacidosis.

Keywords: cows, ketosis, treatment, agent "Remivital", amino acids.
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INTRODUCTION

Ketosis is one of most widespread diseases of dairy cows characterized by disorders of carbohydrate, lipids and protein metabolism. It is associated with accumulation of ketone bodies, injury of central nervous and endocrine systems, liver, heart, kidneys and other organs [1]. Amino acids play extremely important role in pathogenesis of ketosiss, since they participate in synthesis of majority of endogenous biologically active substances, structural proteins, enzymes, some of hormones, nitrogenous bases, and neurotransmitters [2]. Metabolism of these substances is regulated with different biochemical and physiological mechanisms in order to maintain relatively constant concentration of amino acids in blood and tissues. Therefore, concentration of free amino acids and their derivatives in physiological liquids and tissues may be a specific showing of homeostasis, and patterns of formation of amino acid pool in organism may be a reliable reflection of a state of metabolic balance. Investigation of changes in free amino acids plasma content gives opportunity to get an insight into the very core of different diseases or their treatment. This will provide great diagnostic and prognostic value of such approach.

At the present day many treatment regimens are available for cows with ketosis. The most widespread is the conventional scheme with administration of glucoplastic agents, for example propylene glycol in combination with intravenous injections of glucose solution [3]. However, the given scheme of medicamentous therapy is effective only in case of subclinical form of disease, when liver remains unaffected. Moreover, physiological insulin resistance was revealed in high yielding cows, which is associated with formation of lactating dominant during afterpartum period [4]. Thus, exogenous glucose can not be used to its full extent by organism, since its utilization depends on the insulin level. Additional administration of in-

sulin would increase assimilation of injected glucose, but nevertheless its major part will be excreted with urine, due to decreased sensitivity of tissue receptors to insulin during this physiological period. Propylene glycol is considered to be a glucose precursor, since it is absorbed through rumen wall and enters liver, where it is included into tricarboxylic acid cycle. In order to decrease activity of ketogenesis, Krebs cycle should be supplied with starting compounds, because intensity of ketogenesis depends on activity of tricarboxylic acid cycle. Ketogenesis is an alternative pathway for utilization of acetyl CoA. However, in case of ketosis in dairy cows tricarboxylic acid cycle may be inhibited not only due to lack of propionates, but also due to deficit of cyanocobalamin and excess of ammonia. Summarizing all abovementioned, we may suggest that conventional regimen is obsolete and not enough effective.

Reasoning from this fact, the aim of our work was to investigate and to compare the plasma content of free amino acids in ketotic dairy cows, which were treated with conventional and proposed therapeutic regimens.

MATERIALS AND METHODS

Study was performed on high yielding dairy cows in their second to fourth lactation with milk yield above 8000 kg per previous lactation. Clinical examination was performed two weeks after calving using conventional methods. Sick animals (n = 20) were revealed on the basis of clinical examination and express diagnosis for the presence of ketone bodies in urine. Sick animals were divided into two groups and treatment was administered until decurrence of ketonuria. Cows from the first study group (n = 10) were administered conventional for the farm treatment regimen. In particular, animals were given propylene glycol in daily dose 400 ml per head, intravenous 20 % solution of glucose (500 ml/head/day) and intramuscular insulin (200 U/head/day). Animals in the second group (n = = 10) were fed with analogous to the first group dose of propylene glycol and were given agent "Remivital" intravenously in dose of 500 ml/head/day. In this case treatment lasted five days. Samples of blood were withdrawn from jugular vein before feeding, before initiation of the therapy and after its discontinuation (on the sixth day). Obtained results of laboratory investigations were compared with parameters of clinically healthy animals (n = 10) with negative test for the presence of ketone bodies in urine, kept in analogous to study animals conditions. The plasma level of free amino acids was determined using amino acid analyzer Biotronik LC 6001 (Germany).

Agent "Remivital" was developed in the Institute of Animal Biology of the NAAS. It contains fructose, amino acids and B-group vitamins. Advantage of the given agent against conventional glucoplastic substances used in treatment of cows is correction of metabolism simultaneously due to the agent's hepatoprotective and antioxidant properties. In particular, this agent contains fructose, which in contrast to glucose is quickly consumed in organism irrespective of the level of insulin. Another compound of "Remivital" is L-carnitine, which exerts antioxidant properties, participates in fatty acids transport through mitochondrial membrane and is great factor in maintenance of coenzyme A level. L-ornithine induces synthesis of carbamoyl phosphate synthetase, a crucial enzyme in synthesis of urea in hepatocytes. L-asparagine serves as raw material for synthesis of other vital amino acids and aspartic acid, which in its turn is essential in synthesis of urea. L-lysine under deficit of carbohydrates can be metabolized with formation of glucose, which is important source of energy for organism. Nicotinamide and cyanocobalamin participate in metabolism of fatty acids and elimination of ketone bodies.

RESULTS AND DISCUSSION

Results of conducted research (table) showed increase of the level of ketogenic and decrease of concentration of glycogenic amino acids in plasma of dairy cows affected with ketosis. The main reason for this is deficit of metabolic energy after calving and activation of gluconeogenesis. Amino acids, which are involved into tricarboxylic acid cycle or are converted into pyruvate can directly be transformed into glucose under the low concentration of the latter at the beginning of lactation. Consequently, the carbohydrate residue of amino acids accounts for 15 to 35 % of gluconeogenesis [5].

After conducted treatment of sick cows, improvement of general condition and absence of ketonuria were established. Herewith the plasma level of ketogenic amino acids in cows decreased. In particular, the level of leucine decreased by 24.8 % ($p < 0{,}001$) and the level of phenylalanine was lower by 12.5 % ($p < < 0{,}01$) in group of animals treated using conventional regimen. Levels of leucine and phenylalanine were lower by 35 % ($p < 0.001$) and 16.9 % ($p < 0.001$) respectively in group of animals, which were injected "Remivital". Moreover, administration of "Remivital" caused significant decrease of the level of methionine (by 34.7 %; $p < 0.001$), tryptophan (by 27.4 %; $p < 0.001$) and tyrosine (by 23.2 %; $p < 0.001$). It is worthy of note that plasma level of some ketogenic amino

acids in animals from the first study group was significantly higher than corresponding level in healthy animals (table). Namely, the level of leucine was higher by 21.6 % ($p < 0.001$), tryptophan by 43.3 % ($p < 0.001$), phenylalanine by 13.3 % ($p < 0.001$) and methionine by 35.3 % ($p < 0.001$). The plasma level of ketogenic amino acids after administration of proposed treatment regimen was within the range of statistical error, except for the level of lysine (that was higher by 27 %; $p < 0.001$), which is obviously related to its presence in the composition of "Remivital". Lysine decreases serum level of triacylglycerols, enhances uptake of calcium from blood and improves its transport into bone tissue [6]. The content of other ketogenic amino acids was significantly lower after administration of alternative treatment in comparison with such in case of conventional therapy (table).

Significant increase of the glycogenic amino acids plasma concentration was revealed in cows from the first group after administration of antiketotic therapy (table). In particular, the level of asparagine was higher by 11.2 % ($p < 0.001$), histidine by 33.3 % ($p < 0.001$) and cysteine – 2.4 times ($p < 0.001$; table). No significant changes of the level of alanine, arginine and proline were observed. Herewith the level of alanine was lower by 19.3 % ($p < 0.01$), arginine by 15.5 % ($p < 0.001$), asparagine by 21.2 % ($p < 0.001$), histidine by 23.8 % ($p < 0.001$), and cysteine by 30.3 % ($p < 0.001$) in comparison with healthy animals. Increase in the plasma level of alanine by 39.6 % ($p < 0.001$), arginine by 31.8 % ($p < 0.001$), asparagine by 49.7 % ($p < 0.001$), histidine by 51.4 % ($p<0.001$), proline by 29.7 % ($p < 0.01$) and cysteine – 4.2 times ($p < 0.001$) was established in animals from the second study

Plasma content of free amino acids in dairy cows, $n = 10$, μmol/l

Parameter	Healthy animals	Group I			Group II		
		Before treatment	After treatment	p <	Before treatment	After treatment	p <
Alanine	153.5 ± 8.93	116.1 ± 2.27^{ooo}	123.9 ± 3.90^{oo}	0.1	117.9 ± 2.61^{ooo}	164.6 ± 9.77***	0.001
Arginine	58.2 ± 1.15	46.4 ± 1.06^{ooo}	49.2 ± 2.21^{ooo}	0.1	46.5 ± 0.84^{ooo}	61.3 ± 1.71***	0.001
Asparagine	26.4 ± 1.07	18.7 ± 0.38^{ooo}	20.8 ± 0.46^{ooo}	0.001	18.5 ± 0.38^{ooo}	27.7 ± 0.61***	0.001
Valine	122.4 ± 2.71	100.1 ± 2.60^{ooo}	153.3 ± 4.93^{ooo}	0.001	102.3 ± 1.65^{ooo}	136.6 ± 8.08	0.001
Histidine	36.2 ± 1.40	20.7 ± 0.87^{ooo}	27.6 ± 1.01^{ooo}	0.001	21.6 ± 0.83^{ooo}	32.7 ± 1.67**	0.001
Glycine	412.4 ± 14.34	309.9 ± 8.02^{ooo}	331.7 ± 9.23^{ooo}	0.1	291.7 ± 5.73^{ooo}	436.8 ± 31.68^{oo}**	0.001
Glutamine	106.5 ± 3.45	202.4 ± 4.40^{ooo}	134.5 ± 5.24^{ooo}	0.001	207.6 ± 7.47^{ooo}	113.4 ± 6.61**	0.001
Isoleucine	69.4 ± 3.52	65.6 ± 3.18	101.4 ± 3.78^{ooo}	0.001	60.4 ± 3.54	81.4 ± 2.57^{oo}***	0.001
Leucine	48.6 ± 1.15	78.6 ± 2.94^{ooo}	59.1 ± 3.11^{ooo}	0.001	81.8 ± 3.95^{ooo}	53.2 ± 2.27	0.001
Lysine	56.6 ± 3.99	59.3 ± 2.17	42.4 ± 6.10^{o}	0.01	61.3 ± 2.66	71.9 ± 2.13^{ooo}***	0.01
Methionine	17.3 ± 0.78	24.9 ± 0.83^{ooo}	23.4 ± 0.57^{ooo}	0.1	24.2 ± 0.81^{ooo}	15.8 ± 0.43***	0.001
Ornithine	39.3 ± 2.91	25.2 ± 1.35^{ooo}	31.4 ± 1.60^{o}	0.01	25.6 ± 0.87^{ooo}	48.7 ± 1.89^{oo}***	0.001
Proline	131.7 ± 2.95	115.2 ± 7.50^{o}	117.5 ± 7.44	1.0	113.0 ± 8.82^{o}	146.6 ± 6.03**^{o}	0.01
Serine	55.1 ± 3.13	62.9 ± 2.94	49.6 ± 2.43	0.001	64.8 ± 3.11^{o}	54.5 ± 2.96	0.01
Taurine	17.5 ± 0.47	26.9 ± 1.63^{ooo}	20.5 ± 0.80^{ooo}	0.01	27.8 ± 1.39^{ooo}	19.2 ± 0.82	0.001
Tyrosine	28.9 ± 1.26	33.5 ± 1.64^{oo}	30.3 ± 1.11	0.1	32.3 ± 1.66	24.8 ± 0.69***	0.001
Threonine	45.7 ± 2.07	38.3 ± 3.69	41.9 ± 1.91	0.5	36.0 ± 4.13^{o}	48.3 ± 0.80***	0.01
Tryptophan	38.8 ± 1.43	55.8 ± 2.38^{ooo}	55.6 ± 3.41^{ooo}	1.0	57.3 ± 2.26^{ooo}	41.6 ± 1.96***	0.001
Phenylalanine	24.0 ± 0.58	31.1 ± 1.24^{ooo}	27.2 ± 0.52^{ooo}	0.01	30.2 ± 1.07^{ooo}	25.1 ± 0.50**	0.001
Cysteine	6.6 ± 0.24	1.9 ± 0.25^{ooo}	4.6 ± 0.37^{ooo}	0.001	1.7 ± 0.24^{ooo}	7.1 ± 0.31***	0.001
Citrulline	41.6 ± 2.99	76.6 ± 1.61^{ooo}	55.9 ± 3.51^{oo}	0.001	78.4 ± 2.59^{ooo}	39.2 ± 1.84***	0.001
3-Methylhistidine	6.3 ± 0.57	27.7 ± 0.82^{ooo}	9.9 ± 1.48^{oo}	0.001	30.5 ± 0.78^{ooo}	7.2 ± 1.11	0.001

Note. Difference between healthy and sick animals before and after treatment: °$p < 0.05$; °°$p < 0.01$; $^{ooo}p < 0.001$; difference between I and II study groups after treatment: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

group. Thus, obtained results give evidence of positive effect of administered medicamentous therapy on compensation of energy deficit. Activity of compensatory mechanisms directed towards stimulation of gluconeogenesis decreased after treatment. Significant increase in concentration of cysteine is apparently related to its involvement in detoxification processes [7].

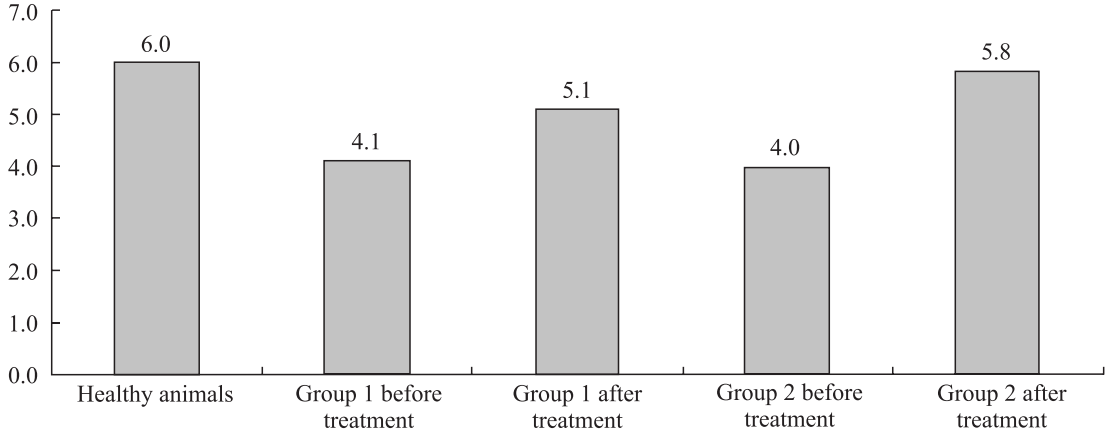
Comparing obtained results for animals of the first and the second study groups, significantly higher level of alanine (by 32.8 %; $p < 0.001$), arginine (by 24.6 %; $p < 0.001$), asparagine (by 33.2 %; $p < 0.001$), histidine (by 18.5 %; $p < 0.01$), proline (by 24.8 %; $p < 0.01$) and cysteine (by 54.3 %; $p < 0.001$) were revealed after administration of "Remivital".

Serine plays an important role in metabolism of fatty acids. Under the influence of serine-oximethyltransferase in the presence of tetrahydrofolic acid serine is converted to glycine. Simultaneously this reaction is the first in catabolism of serine and formation of glycine [8]. In the process of degradation in organism serine undergoes direct or indirect deamination with formation of pyruvate, which is subsequently included in tricarboxylic acid cycle. Glycine in its turn exhibits antioxidant, adrenoblocking and antitoxic activity. Moreover, glycine regulates the function of glutamate receptors [9]. As can be seen from the results presented in table, decrease of serine concentration in plasma was found after medicamentous therapy in cows from the first (by 21.1 %; $p < 0.001$) and the second (by 15.9 %; $p < 0.01$) study groups. In concurrence with this increase of glycine content was observed, particularly in the first study group its level was higher by 7 %, but in comparison with healthy cows the concentration was lower by 19.6 % ($p < 0.001$). In plasma of cows from the second study group after treatment the content of glycine increased almost by 50% ($p < 0.001$) and was somewhat higher than in healthy cows (table). On the basis of the foregoing material it might be suggested that administered schemes of therapy, primarily with agent "Remivital" stimulate antioxidant and antitoxic systems of organism defence.

It is widely known [9] that glycine and serine are often synthesized in organism from threonine. The latter as well as methionine is a lipotropic substance and participates in fight against the fat deposition in liver and is essential in synthesis of purines, which in their turn decompose urea, waste product of protein synthesis. As can be seen from table data, administered conventional scheme of therapy had no significant influence on the concentration of threonine in plasma. An increase in its level by 34.2 % ($p < 0.01$) was revealed after administration of "Remivital" and propylene glycol. Simultaneously we observed significant decrease in taurine concentration (table). After administration of conventional regimen the concentration decreased by 23.8 % ($p < 0.01$), and after using of proposed scheme the level was lower by 30.9 % ($p < 0.001$). It is important to mention that the plasma concentration of taurine in animals from the first study group was higher than in healthy animals by 17.1 % ($p < 0.001$), and in the second group it reached the level of clinically healthy animals. Taurine is a sulphonic acid, synthesized in human and animal organism from cysteine and it plays vital role in digestion and lipid assimilation, is one of the constituents of bile. Moreover, taurine is an important antioxidant [10].

It facilitates digestion and producing of bile in liver, enhances cholesterol degradation, improves the function of gall bladder by formation of taurocholate from bile acids, which increases cholesterol elimination in the bile. Taurine is a key component of bile acids, which helps to maintain optimal liver function and is necessary for elimination of toxic chemical substances and metabolic waste products [11]. In view of this it might be suggested that normalization of taurine concentration is an evidence of restoration of bile secretion.

Increase of the level of valine and isoleucine was revealed during investigation of the content of branched amino acids. The blood level of leucine decreased in cows from both study groups (table), which is considered to be positive effect of therapy since this amino acid is ketogenic. The plasma concentration of valine in the first study group increased by 53.1 % ($p < 0.001$), and in the second by 33.5 % ($p < 0.001$; table). The content of isoleucine was higher by 54.6 % ($p < 0.001$) and 34.8 % ($p < 0.001$) respectively (table). These three amino acids predominantly disintegrate in muscle tissue and play an important role in energy metabolism, particularly in formation and deposition of glycogen [5]. It is considered that during muscle work they may be used for synthesis of intermediate compounds for tricarbonic acid cycle and gluconeogenesis, i.e. serve as source of energy. It should be mentioned that the plasma content of valine in cows, which were given conventional regimen of treatment, was higher by 25.2 % ($p < 0.001$) in comparison with healthy animals (table). Furthermore, significantly higher level of isoleucine should be pointed out (table). For example, after administration of conventional regiment of treatment, the plasma concentra-



Ratio of glycogenic to ketogenic amino acids in plasma of cows

tion of isoleucine was higher by 24.6 % ($p < 0.001$) in comparison with animals which were treated with "Remivital" or by 46.1 % ($p < 0.001$) in comparison with healthy animals. High level of isoleucine on the one hand is linked to a compensation of energy deficit, but on the other hand, under the deficit of enzymes catalyzing isoleucine decarboxylation, leads to development of ketoacidosis [8].

Extremely important role in utilization of ammonia and lactate, which in significant quantities are present in organism of ketotic cows, belongs to ornithine and citrulline. As table data show, plasma content of ornithine was higher, and the level of citrulline was lower in cows after combined administration of "Remivital" and propylene glycol. In particular, concentration of ornithine increased by 90.2 % ($p < 0.001$). The main reason of elevation of ornithine concentration is exogenous supply of the substance with agent "Remivital". L- ornithine stimulates the synthesis of carbamoyl phosphate synthetase, crucial enzyme for synthesis of urea in hepatocytes. The content of citrulline was 2-fold lower ($p < 0.001$). Citrulline also promotes elimination of ammonia and urea from organism. Besides of that arginine the main donor of nitrogen, which improves blood flow in muscles, is synthesized from citrulline [12]. It might be suggested that significant elevation of the arginine level and decrease of citrulline concentration is explained exactly by this fact. Use of conventional regimen was associated with an increased level of ornithine (by 24.6 %; $p < 0.01$) and decreased concentration of citrulline (by 27.0 %; $p < 0.001$) in comparison with pre-treatment parameters. However, attention should be given to significantly lower level of ornithine (by 35.5 %; $p < 0.001$) and higher concentration of citrulline (by 42.6 %; $p < 0.001$; table) in comparison with proposed therapeutic regimen.

Conducted determination of amino acids, markers of muscle protein catabolism (3-methylhistidine, glutamine) revealed significant decrease of their content after therapy both in the first and the second study groups of cows (table). After administration of conventional regiment the concentration of 3-methylhistidine decreased 2.8-fold ($p < 0.001$) and the level of glutamine was lower by 33.5 % ($p < 0.001$). However the level of 3-methylhistidine was higher by 57.1 % ($p < 0.01$), and glutamine by 26.3 % ($p < 0.001$) in comparison with healthy cows. After administration of conventional therapy four of ten cows had the level of 3-methylhistidine exceeding the upper physiological limit. Administration of proposed scheme of therapy was associated with a more than 4-fold ($p < 0.001$) and 1.8-fold ($p < 0.001$) decrease in the level of 3-methylhistidine and glutamine respectively. In the second study group eight of ten cows had the level of 3-methylhistidine within the physiological limits for healthy animals (table). In comparison with the first study group the concentrations of 3-methylhistidine and glutamine were lower by 27.3 % and 15.7 % ($p < 0.01$) respectively. Obtained results give evidence of less active protein catabolism in dairy cows after treatment due to liquidation of energy deficit [13].

Increase in the level of glycogenic amino acids and decrease of the concentration of ketogenic amino acids after treatment caused an increase of ratio of glycogenic to ketogenic amino acids, which is a sign of normalization of protein metabolism (Figure). In the first group an increase was by 24.4 % ($p < 0.001$), and in the second by 45 % ($p < 0.001$).

CONCLUSIONS

After 5-day-long medicamentous therapy given to animals in the first and the second study groups, following changes were observed: improvement of general condition, absence of ketouria, increase of the level of glycogenic and decrease of ketogenic amino acids. Conducted determination of amino acids, markers of muscle protein catabolism (3-methylhistidine, glutamine) revealed significant decrease of their content after conducted therapy; however in animals from the first group their concentration was significantly higher in comparison with cows from the second group and healthy cows. Increase in the plasma level of glycogenic amino acids and decrease of the plasma concentration of ketogenic amino acids after treatment caused an increase of ratio of glycogenic to ketogenic amino acids, which is a sign of normalization of protein metabolism. In the first group an increase was by 24.4 % ($p < 0.001$), and in the second by 45 % ($p < 0.001$). Administration of conventional regimen of therapy was associated with significantly higher level of ornithine and lower concentration of citrulline, which give evidence of problems in utilization of ammonia and lactate, and the high level of isoleucine contributes to aggravation of ketoacidosis.

Вплив препарату "Ремівітал" на амінокислотний склад плазми крові молочних корів, хворих на кетоз

М. Р. Сімонов, В. В. Влізло

e-mail: msimonov@inenbiol.com.ua

Інститут біології тварин НААН
Вул. В. Стуса, 38, Львів, Україна, 79034

Мета. Дослідити амінокислотний склад плазми крові молочних корів, хворих на кетоз, після застосування традиційної схеми лікування (згодовування пропіленгліколю, в/в введення глюкози та інсуліну) та схеми, запропонованої авторами (згодовування пропіленгліколю, в/в введення препарату "Ремівітал"). **Методи.** Використано високопродуктивних молочних корів, хворих на клінічний кетоз, 2–4-ї лактації, продуктивністю понад 8000 л молока за попередню лактацію. За допомогою амінокислотного аналізатора у плазмі крові визначали вміст вільних амінокислот до та після лікування. **Результати.** Встановлено зниження рівня кетогенних амінокислот, зростання вмісту глікогенних амінокислот та амінокислот з розгалуженими ланцюгами. Відмічено значне зменшення концентрації 3-метилгістидину, що свідчить про послаблення катаболізму скорочувальних білків. **Висновки.** Запропонована схема лікування виявилася ефективнішою порівняно з традиційною, оскільки при застосуванні останньої встановлено вірогідно вищий рівень орнітину та нижчий – цитруліну. Це дає підстави стверджувати, що існує проблема в утилізації амоніаку та лактату. Крім цього, за використання традиційної терапії величина показників маркерів катаболізму скорочувальних білків лишається високою на відміну від тварин після запропонованого лікування, а значний вміст ізолейцину сприяє посиленню кетоацедозу.

Ключові слова: корови, кетоз, лікування, препарат "Ремівітал", амінокислоти.

Влияние препарата "Ремивитал" на аминокислотный состав плазмы крови молочных коров, больных кетозом

М. Р. Симонов, В. В. Влизло
Институт биологии животных НААН

e-mail: msimonov@inenbiol.com.ua

Ул. В. Стуса, 38, Львов, Украина, 79034

Цель. Исследовать аминокислотный состав плазмы крови молочных коров, больных кетозом, после применения традиционной схемы лечения (скармливание пропиленгликоля, в/в введение глюкозы и инсулина) и схемы, предложенной авторами (скармливание пропиленгликоля, в/в введение препарата "Ремивитал"). **Методы**. Использованы высокопроизводительные молочные коровы, больные клиническим кетозом, 2−4-й лактации, продуктивностью более 8000 л молока за предыдущую лактацию. С помощью аминокислотного анализатора в плазме крови определяли содержание свободных аминокислот до и после лечения. **Результаты.** Установлено снижение уровня кетогенных аминокислот, возрастание содержания гликогенных аминокислот и аминокислот с разветвленными цепями. Отмечено значительное уменьшение концентрации 3-метилгистидина, что свидетельствует об ослаблении катаболизма сократительных белков. **Выводы.** Предложенная схема лечения оказалась эффективнее в сравнении с традиционной, поскольку при использовании последней установлен достоверно более высокий уровень орнитина и более низкий – цитруллина. Это дает основание утверждать, что существует проблема утилизации аммиака и лактата. Кроме того, при применении традиционной терапии величина показателей маркеров катаболизма сократительных белков остается высокой в отличие от животных после предложенного лечения, а значительное содержание изолейцина способствует усилению кетоацедоза.

Ключевые слова: коровы, кетоз, лечение, препарат "Ремивитал", аминокислоты.

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