ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

STUDY OF BIOCHEMICAL MARKERS OF CARBOHYDRATE AND LIPID METABOLISM IN MALE AND FEMALE LABORATORY ANIMALS MODELING METABOLIC SYNDROME AND BONE DESTRUCTION

Anvar Akhmadovich Mavlonov[1], Jurayeva Gulrux Bafoyevna[2]

1.Bukhara State Medical Institute, Associate Professor of the Department of Clinical Pharmacology.

2. Bukhara State Medical Institute, assistant kafedra Oftalmology

E-mail: anvar.mavlonov@minzdrav.uz Tel: +998997077755

Abstract: In the experiment, changes in laboratory and biochemical indicators in blood were studied in male and female rabbits modeled with metabolic syndrome and osteoporosis, and the effect of metformin+zinc+omega3 complex was evaluated. Metformin+zinc+omega3 drug can be recommended in practice as a means of pathogenetic treatment of metabolic syndrome and bone destructive changes.

Key words: metabolic syndrome, osteoporosis, metformin+zinc+omega3 complex.

Аннотация. В эксперименте изучали изменения лабораторных и биохимических показателей крови у кроликов-самцов и самок на модели метаболического синдрома и остеопороза, оценивали действие комплекса метформин+цинк+омега3. Препарат Метформин+цинк+омега3 может быть рекомендован на практике как средство патогенетического лечения метаболического синдрома и деструктивных изменений костной ткани. **Ключевые слова: метаболический синдром, остеопороз, комплекс метформин+цинк+омега3.**

Аннотация. Тажрибада метаболик синдром ва остеопороз моделлаштирилган эркак ва урғочи жинсли қуёнларда қонда лаборатор ва биохимявий кўрсаткичлардаги ўзгаришлар ўрганилиб, метформин+цинк+омега3 комплексини қўллаб, унинг таъсири бахоланди. Метформин+цинк+омега3 препаратини амалиётда метаболик синдром ва суяк деструктив ўзгаришларни патогенетик даволаш воситасида тавсия қилиш мумкин.

Калит сўзлар: метаболик синдром, остеопороз, метформин+цинк+омега3 комплекси.

Relevance

Metabolic syndrome (MS) in practice is established with the simultaneous presence of abdominal obesity and two of four factors: an increase in the level of triglycerides (TG) in the blood (more than 1.7 mmol/l), a decrease in the level of high-density lipoprotein (HDL) (less than 1.3 mmol /l in men and less than 1.29 mmol/l in women), increases in blood pressure more than 130 and 85 mm Hg. Art., an increase in fasting plasma glucose level more than 5.6 mmol/l. The pathogenesis of MS consists of the interaction of a number of causes, the leading ones being hereditary (genetic) factors and certain environmental conditions. Among the genetic factors that lead to the development of MS and abdominal

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

obesity, mutations in the genes of adiponectin, leptin, β-3 adrenoreceptors, melanocortin receptor type 4 and a number of other genes are currently identified prima. For the manifestation of genetic predisposition, acquired factors are important, in particular, poor nutrition and a sedentary lifestyle. The key mechanism of MS pathogenesis, according to most researchers, is insulin resistance (IR), which unites and connects various components of MS. IR is understood as a decrease in the sensitivity of peripheral tissues to the biological effects of insulin and the development of compensatory hyperinsulinemia.

The scientific literature shows that experimental models based on diets are most adequate to the disorders that occur in human metabolic syndrome, which affect the metabolism of the whole organism through hormonal, carbohydrate and lipid metabolism.

In scientific research, combined experimental models of MS with diets high in both fat and carbohydrates are widely used. The composition of such diets is very close to the diet of modern humans. It has been shown that a combined diet (fats plus sucrose) causes metabolic syndrome faster than fats alone. Diets have been created for rats and mice that cause signs of MS in them: with an increased amount of fat 30–60% of the caloric intake, cholesterol 0.1–1.25% of the caloric intake, table salt 8%, sucrose and fructose 60–70% on the caloric intake of both genetically modified animals (rats of the ZDF, DahlSS lines, mice AKR, A/J) and wild breeds of animals (rats of the Wistar and Sprague Dawley (SD), C57BL/6 mice, golden hamsters, guinea pigs). In wild-type C57BL/6J mice, adding 45–60% fat to the diet promotes the development of obesity and hyperglycemia within 8 weeks. However, the biochemical processes, namely lipid metabolism, differ between rodents and humans, which makes rodents resistant to the development of atherosclerosis and coronary heart disease. Thus, mice and rats lack cholesteryl ester transfer protein (CETP), which provides reverse cholesterol transport.

Large-scale genomic studies in humans have found a more significant correlation between CETP gene polymorphisms and HDL cholesterol concentrations than among other loci, which to a certain extent influences the effectiveness of lipid-lowering drug therapy. It was revealed that with a lack of protein - the carrier of cholesterol esters, the development of age-related atherosclerotic changes significantly slows down and life expectancy increases. There are other differences in the metabolism of rodents and humans. Thus, 70% of cholesterol in humans is synthesized in the body and 30% comes from food, while in rodents most of the cholesterol comes from food. HDL predominates in the blood plasma of mice and rats, while LDL predominates in humans and rabbits. It has long been established that in rabbits on a regular diet, approximately 40% of the cholesterol in the blood plasma is contained in HDL, and in rabbits on a cholesterol (atherogenic) diet, more than 90% of the cholesterol is contained in VLDL and LDL. There is now evidence that abdominal obesity and metabolic syndrome in general are associated with a decrease in bone mineral density, which in turn leads to an increased risk of fractures. On the other hand, it is known that abdominal obesity or arterial hypertension in trauma victims complicates the course of traumatic shock and worsens the prognosis. A high incidence of osteoporosis and vertebral fractures in patients with MS has been proven. Thus, MS can be considered a new risk factor for osteoporosis. According to foreign publications, 70% of patients who have suffered an osteoporotic hip fracture have pathology of the cardiovascular system.

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

The purpose of the study was to study the mechanism of influence of the metformin+zinc+omega3 complex on biochemical changes in the blood in experimental rabbit models.

Materials and methods:

Experimental studies were carried out on 30 rabbits weighing 2.0-2.5 kg (male and female). The animals were kept in standard vivarium conditions with a natural 12-hour light-and-dark cycle, at an air temperature of 20±20C. The experiments were carried out in accordance with the rules adopted by the "International Convention for the Protection of Vertebrate Animals Used for Experimental and Scientific Purposes" (Strasbourg, 1986).

Metabolic syndrome modeling

Metabolic syndrome was induced in rabbits on a combination diet with the addition of crystalline cholesterol to the daily diet at a dose of 250 mg/kg body weight mixed with grated carrots (approximately 100 g) against a background of physical inactivity. A freshly prepared 5% sucrose solution was poured into the animals' drinking bowl every day. Every 2 days, insulin was injected subcutaneously into the animals from the back at a dose of 0.1 units/100 g body weight. For modeling, mature male rabbits weighing at least 2000 are taken. MS modeling lasts up to 2 months.

Osteoporosis modeling

Modeling of osteoporosis in rabbits was carried out by administering dexamethasone at a rate of 1.675 mg/kg intramuscularly once a day for 2 weeks.

Modeling metabolic syndrome associated with osteoporosis

Cholesterol was added to the standard daily diet of the animals at a dose of 250 mg/kg body weight and a 5% sucrose solution was used instead of water for 8 weeks, while every 2 days insulin was injected subcutaneously from the back of the animals at a dose of 0.1 unit/100 g body weight, and the animals were kept under conditions of physical inactivity; to enhance the development of hypercholesterolemia, hyperglycemia and reduce bone mineral density, the animals were administered intramuscular dexamethasone daily at a dose of 0.1 mg/kg. Blood pressure in rabbits was measured non-invasively using a blood pressure monitor from Little Doctor 2, using veterinary cuffs for cats and rabbits of the Neo#2 series (China) every 7 days of observation.

Blood sampling for biochemical analysis

To obtain blood from the marginal ear vein, the rabbit was fixed in its natural position using special boxes. The most suitable place for a puncture is the lateral edge of the ear. Here the vein is firmly fixed to the surrounding tissues. At the puncture site, the fur was cut off with scissors, and the skin was wiped with alcohol-ether. Immediately before blood collection, additional arterial hyperemia of the ear was induced by rubbing with a cotton swab soaked in xylene. The base of the ear was slightly pinched. The marginal vein was cut with a blade closer to the tip of the ear or pierced with a needle. The escaping blood was collected into

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

prepared capillaries or tubes. After blood collection, the tube was placed in a thermostat for 30 minutes at 37°C to form a blood clot. The formed blood clot was carefully separated from the walls. The sample was centrifuged at 1500 – 2000 rpm (189 – 335g). After centrifugation, the supernatant liquid, blood serum, was carefully collected without capturing the sediment.

When studying the blood composition, C-peptide, glucose, triglycerides, cholesterol, LDL and HDL in the blood serum were determined every 15 days (1st day, 15th, 30th, 45th and 60th day). The study of biochemical parameters of blood serum was carried out in a semi-automatic biochemical analyzer from HUMAN (Germany) using appropriate open-type test kits, following the manufacturer's instructions.

Table 1. Blood glucose level (mmol/l) and c-peptide (ng/ml)

Group	Observation days			
	15	30	45	60
Metabolic syndrome (M+m)				
Males Gl level M	8,82	9,45	10,48	11,03
m	0,14	0,18	0,22	0,12
Change in GL level compared to control, %	+92	+111	+136	+133
c-peptide level M	438,86	433,29	444,40	505,50
m	35,91	12,17	11,11	30,32
Change in c-peptide level compared to control, %	+37	+35	+38	+57
Females Gl level M	8,68	9,52	10,43	10,40
m	0,22	0,27	0,32	0,18
Change in GL level compared to control,%	+89	+104	+124	+113
c-peptide level M	449,96	449,95	483,28	483,28
m	33,05	7,46	23,95	39,20
Change in c-peptide level compared to control, %	+40	+40	+50	+50

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

Metabolic syndrome + osteoporosis (M+m)				
Males Gl level M	10,22	11,18	12,12	13,37
m	0,06	0,14	0,16	0,14
Change in GL level compared to control,%	+123	+150	+156	+183
c-peptide level M	562,45	550,72	550,46	555,96
m	12,86	20,53	11,27	11,00
Change in c-peptide level compared to control, %	+75	+71	+71	+73
Females Gl level M	10,98	11,90	13,20	15,08
m	0,16	0,08	0,11	0,12
Change in GL level compared to control, %	+139	+156	+184	+209
c-peptide level M	617,06	619,73	624,94	626,63
m	4,22	5,01	3,09	3,32
Change in c-peptide level compared to control, %	+92	+93	+95	+95
Osteoporosis (M+m)				
Males Gl level M	10,17	10,37	10,58	10,78
m	0,20	0,20	0,25	0,25
Change in GL level compared to control, %	+122	+132	+124	+128
c-peptide level M	455,5	449,955	400,96	399,96
m	55,54	52,87	24,63	24,34
Change in c-peptide level compared to control, %	+42	+40	+25	+25
Females Gl level M	9,68	9,98	10,18	10,13
m	0,12	0,11	0,15	0,13

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

Change in GL level compared to control, %	+110	+115	+119	+108
c-peptide level M	372,185	372,185	366,63	349,965
m	13,37821	10,24291	8,605769	20,63591
Change in c-peptide level compared to control, %	+16	+16	+14	+9
Control (M+m)				
Males Gl level M	4,58	4,47	4,73	4,73
m	0,16	0,13	0,15	0,18
c-peptide level M	320,74	320,69	320,73	320,74
m	0,008	0,047	0,011	0,013
Females Gl level M	4,60	4,65	4,65	4,87
m	0,17	0,13	0,13	0,22
c-peptide level M	320,72	320,73	320,73	320,72
M	0,010	0,008	0,008	0,008

The general trend of lipid metabolism disorders demonstrates an increase in blood cholesterol, triglycerides, LDL and a decrease in HDL (Table 4). At the same time, in male and female rabbits with MS, the cholesterol content increases by 7.4 and 7.7 times compared to the control, the level of triglycerides - by 2 times in both groups, LDL - by 1.7 and 2.14 times, and the level HDL is reduced by 24 and 34%, respectively. With metabolic syndrome associated with bone destruction, male and female rabbits exhibit more profound disorders of lipid metabolism, the level of which differs slightly from each other. Thus, cholesterol levels increase by about 10 times compared to the control, triglycerides by 33-39 times, LDL by 2.7-2.9 times, HDL levels decrease by 63% in males and 75% in females. In the model of bone destruction, serious disturbances in lipid metabolism were also observed, however, less pronounced than in the two previous models: an increase in cholesterol in males and females by 5-5.5 times, triglycerides by 72 and 103%, LDL by 2.5 -2.6 times, HDL drop by 13-14%.

Table 2. Indicators of lipid metabolism in rabbits

Group	**Males**				**Females**				
Observation days	15	30	45	60	15	30	45	60	
Metabolic syndrome (M+m)									
XL M	4,93	6,62	7,50	9,27	5,35	7,27	8,27	9,82	

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

m	0,13	0,12	0,10	0,19	0,12	0,11	0,22	0,15	
Increase in CL level compared to control, x times	4,93	6,3	6,0	7,4	5,2	6,7	6,9	7,67	
TG M	1,92	2,01	2,21	3,13	2,00	2,13	2,38	3,24	
M	0,03	0,04	0,04	0,06	0,02	0,03	0,04	0,06	
Increase in TG level compared to control, %	31	34	84	100	38	42	59	100	
LPVP M	47,13	46,88	46,62	46,35	44,68	44,37	44,03	43,73	
m	0,31	0,30	0,31	0,26	0,18	0,15	0,13	0,13	
Change in HDL level compared to control,%	-23	-24	-25	-25	-31	-32	-33	-34	
LPVP M	132,02	182,52	254,67	306,77	129,08	209,27	284,30	354,88	
m	6,33	11,57	17,12	2,80	1,99	4,43	12,28	19,08	
Change in LDL level compared to control,%	+17	+61	+125	+171	+14	+85	+151	+214	
Metabolic syndrome + osteoporosis (M+m)									
XL M	5,81	8,35	9,36	11,80	7,02	8,80	10,02	12,85	
m	0,25	0,24	0,18	0,37	0,15	0,15	0,13	0,19	
Increase in CL level compared to control, x times	5,8	7,95	7,8	9,44	7,0	8,0	8,35	10,0	
TG, mmol/l M	1,97	2,17	2,94	3,41	2,07	2,41	3,27	3,59	
M	0,01	0,02	0,02	0,03	0,01	0,02	0,03	0,02	
Increase in TG level compared to control, %	35	49	100	133	43	60	118	139	
LPVP M	36,47	36,35	35,97	35,73	34,43	34,23	33,90	33,37	
m	0,20	0,14	0,19	0,17	0,09	0,05	0,06	0,12	
Change in HDL level compared to control,%	-59	-60	-61	-63	-70	-71	-73	-75	
LPVP M	134,70	224,28	317,73	416,45	141,32	229,20	340,57	442,07	
m	2,00	2,74	3,19	3,60	2,57	2,28	2,90	2,66	
Change in LDL level	+19	+98	+181	+268	+25	+102	+200	+291	

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

compared to control,%									
Osteoporosis (M+m)									
XL M	2,68	4,05	5,12	6,12	3,16	4,55	5,88	7,045	
m	0,12	0,12	0,15	0,14	0,10	0,19	0,06	0,11	
Increase in CL level compared to control, x times	2,68	3,86	4,3	4,9	3,13	4,17	4,9	5,5	
TG M	1,66	1,81	2,04	2,66	1,78	1,95	2,21	2,95	
m	0,02	0,03	0,02	0,05	0,02	0,02	0,01	0,10	
Increase in TG level compared to control, %	14	21	34	72	23	34	52	103	
LPVP M	51,98	51,82	51,45	51,15	51,15	50,82	50,50	50,30	
m	0,18	0,14	0,16	0,16	0,08	0,10	0,13	0,12	
Change in HDL level compared to control,%	- 12	-12	-13	-14	-11	-12	-13	-13	
LPVP M	123,18	164,98	223,57	292,42	125,40	179,25	209,28	275,73	
m	0,85	2,29	1,17	1,65	1,14	2,10	1,93	2,84	
Change in LDL level compared to control,%	+9	+50	+100	+264	+9	+159	+189	+252	
Control (M+m)									
XL M	1,0	1,05	1,20	1,25	1,01	1,09	1,20	1,28	
m	0,03	0,03	0,02	0,02	0,02	0,03	0,03	0,02	
TG M	1,46	1,50	1,52	1,55	1,45	1,50	1,55	1,59	
m	0,01	0,02	0,02	0,02	0,01	0,01	0,01	0,01	
LPVP M	58,17	56,90	55,62	54,45	58,52	56,88	56,42	55,88	
m	0,16	0,33	0,38	0,47	0,17	0,19	0,15	0,14	
LPVP M	112,98	109,80	109,82	110,53	113,13	112,13	110,68	109,22	
m	1,31	2,08	1,85	1,95	2,10	1,73	1,25	1,78	

Results and discussions

The rabbits were divided into 6 groups according to weight (2000-2600) g, age (10-14) months;

Each group included 6 male and 6 female rabbits in the following composition:

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

Control group - simulated metabolic syndrome (No. 1-6) 6 male rabbits of the untreated group.

• The second group of 6 male rabbits with model metabolic syndrome (No. 7-12) received metformin orally at a dose of 120 mg/kg for 35 days.

• The third group modeled metabolic syndrome (No. 13-18) 6 male rabbits + metformin + zinc + omega-3 orally for 35 days.

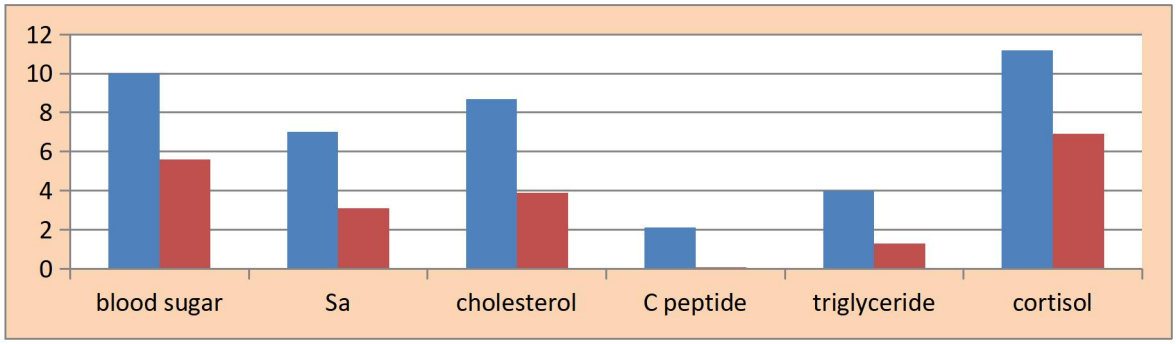
• The fourth control group modeled metabolic syndrome (No. 19-24) of 6 female rabbits.

In the fifth group of metabolic syndrome modeling (No. 25-30), 6 female rabbits received metformin at a dose of 120 mg/kg orally for 35 days.

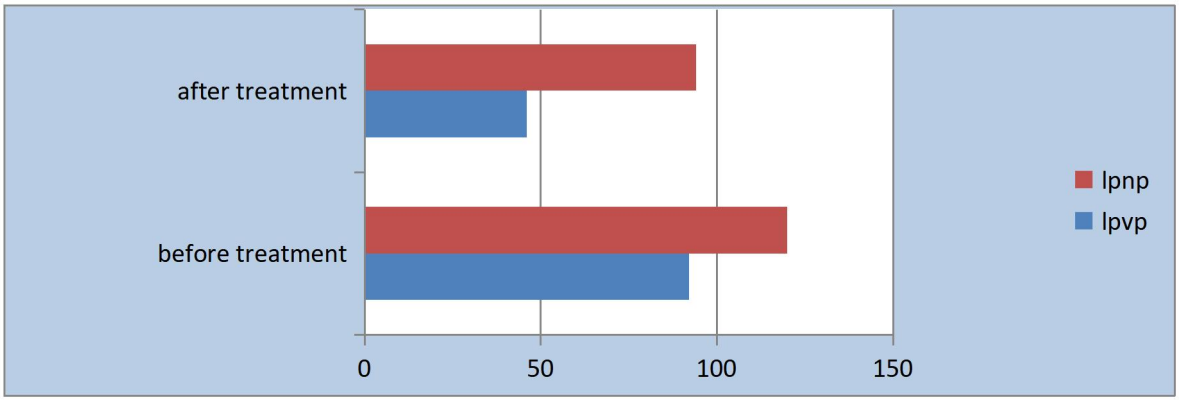
• The sixth group of metabolic syndrome modeled (No. 31-36) 6 female rabbits receiving + metformin + zinc + omega-3 orally for 35 days.

Twenty-four hours after the last administration of the drug, the results of biochemical blood tests were studied in all groups of animals using the methods we previously described. Blood samples were collected on days 0 and 10-20-30 to determine blood lipid and glucose levels. All experiments were carried out in compliance with the requirements of the European Convention for the Protection of Vertebrate Animals Used for Experimental or Other Scientific Purposes (Strasbourg, 1986). The results of the study were statistically processed using the Biostat 2009 software package and the data are presented as the mean (M) and the error of the mean (μ). A statistically significant change was considered to be a difference at a probability level of 95% or higher ($p < 0.05$).

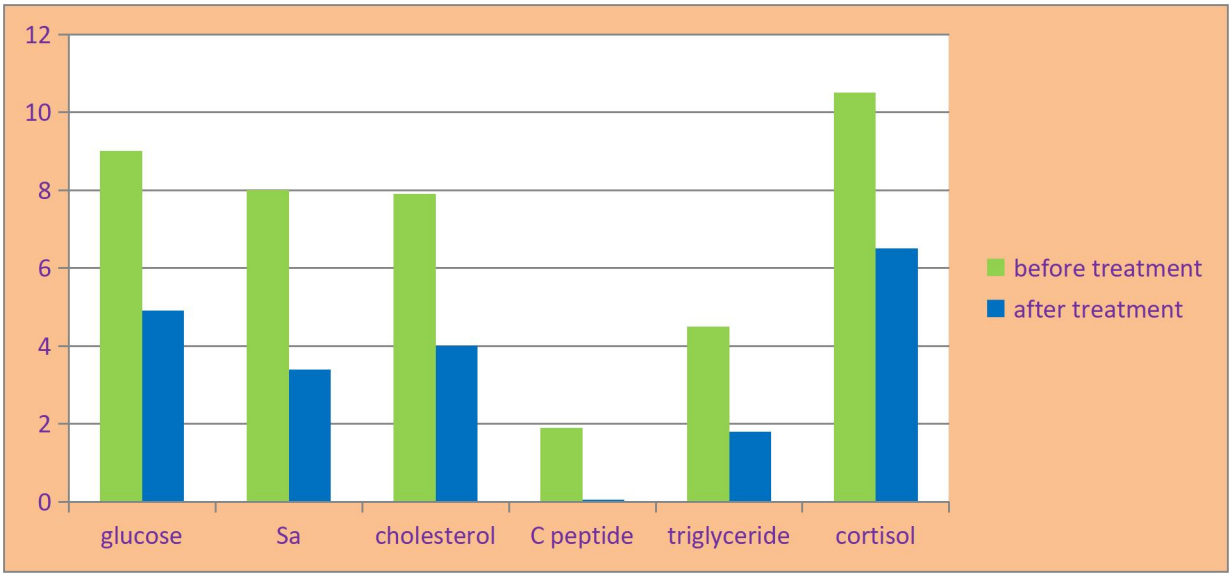
Results of biochemical blood parameters after treatment in male rabbits on a model of osteoporosis and metabolic syndrome

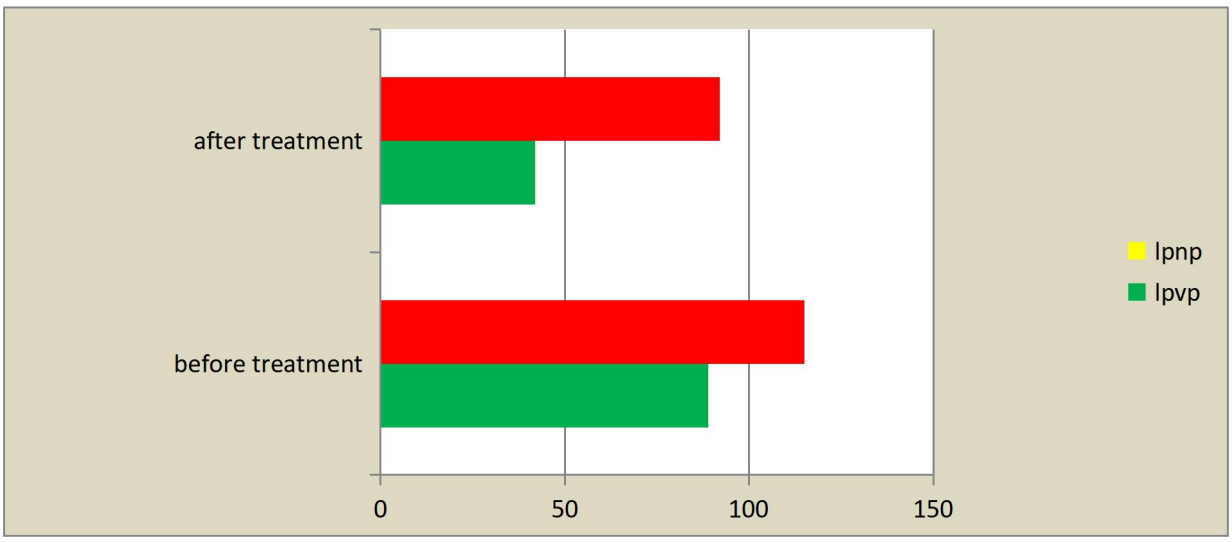


ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES



Results of biochemical blood parameters after treatment in female rabbits when modeling osteoporosis and metabolic syndrome





ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

After treatment, serum C-peptide, glucose, triglycerides, cholesterol, high-density lipoprotein and HDL were examined. Blood from the capillaries was collected into pre-prepared test tubes. After blood collection, the tube was placed in a thermostat for 30 minutes at a temperature of 37°C to induce blood clotting. The sample was centrifuged at 1500-2000 rpm (189-335 g). The study of biochemical parameters of blood serum was carried out on a semi-automatic biochemical analyzer from HUMAN (Germany), following the manufacturer's instructions, using appropriate open-type test kits. An analysis of the latest treatment results showed that the biochemical parameters in the blood of male and female rabbits with metabolic syndrome and osteoporosis were almost the same as in healthy rabbits.

Summary

1. In all the groups of male and female rabbits in the experiments, when the density parameters were studied according to the Hounsfield scale, at 0, 4, 8, 12 and 16 weeks, bone tissue was mainly axial, proximal (frontal), when the sagittal sections were examined by MSCT, changes in MSCT in male and female rabbits modeled with osteoporosis and metabolic syndrome compared to other groups showed that mainly changes were observed in the proximal and distal parts of the bone, in the rib cage, in the heart and liver area, and this was accompanied by an increase in body weight, hypertension was found to be related.

2. The results and experimental studies showed that the studied drug metformin+zinc+omega 3 complex has a positive effect on male and female rabbits modeled with metabolic syndrome and osteoporosis.

Used literature

1.Alessi M. C., Juhan–Vague I. PAI–1 and the metabolic syndrome: the links, causes and consequences. Arterioscler Thromb Vasc Biol 2006; 26 (10): 2200–7.

2.Grundy SM, Brewer HB, Cleeman JI, Smith SC, Lenfant C. Defining the metabolic syndrome: report of the National Heart, Lung, and Blood Institute/American Heart Association Conference on Scientific Issues in Definition. . 2004;

3.Schmerbach K., Patzak A. Metabolic syndrome: 2014; 210 :702–704. doi: 10.1111/apha.12230.

4.I. Watt , M. Doherty Plain Radiographic Features of Osteoarthritis KD Brandt , M. Doherty , LS Lohmander (Eds.) , Osteoarthritis , Oxford University Press , New York (2003) , LC Rovati Radiographic Evaluation. 7 (1999), 427-429)

5.M.A. D'Anjou, M. Moreau, E. Troncy, J. Martel. Pelletier, F. Abram, JP Raynauld et al. Osteophytosis, subchondral bone sclerosis, joint effusion and soft tissue in canine experimental stifling osteoarthritis tissue thickening: a comparison

ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

between 1.5 T magnetic resonance imaging and computer radiography. Vet Surg, 37 (2008), 116-177).

6.Van Ginneken B, ter Haar Romeny BM, Viergever MA. Computer-aided diagnosis in chest radiography: a survey. IEEE Trans Med Imaging (2001) 20:1228–41. doi: 10.1109/42.974918).

7. Мавлонов А.А. Бобоева Р.Р Метаболик синдром ва остеопороз моделлаштирилган тажриба ҳайвонларида метформин+цинк+омега3 комплексини суяк деструкциясига таъсирини МСКТ ёрдамида бахолаш International Multidisciplinary Research in Academic Science (IMRAS). 2024 September 98-109

8. Kovaleva M.A., Makarova M.N., Selezneva A.I., Makarov V.G. Primenenie zhivotnyh so spontannoj gipertenziej dlja modelirovanija metabolicheskogo sindroma. Obzory po klinicheskoj farmakologii i lekarstvennoj terapii, 2012; 4: 91–94
9.Neuhofer A., Wernly B., Leitner L., Sarabi A., Sommer N.G., Staffler G., Zeyda M., Stulnig T.M. An accelerated mouse model for atherosclerosis and adipose tissue inflammation. Cardiovasc Diabetol. 2014 Jan 17;13:23. DOI: 10.1186/1475-2840-13-23

10. Yunuskhodjaev.A., Mavlonov.A., Saidov.S., Boboeva.R..Estimation of Bone Tissue Changes in Experimental Animals with Metabolic Syndrome under Using MSCT American Journal of Medicine and Medical Sciences 2024, 14(6): 1475-1482

11. Mavlonov.A., Saidov.S., Mirsultanov.J., Boboeva.R.Features of bone destruction in rabbits with experimental metabolic syndrome The Scientific Temper. (2024) Vol. 15 (1): 1941-1948
12.Wong SK, Chin KY, Suhaimi FH, Fairus A, Ima-Nirwana S. Animal models of metabolic syndrome: a review. Nutrition & metabolism. 2016; 13:65
13.Звягина М.В., Маль Г.С., Бушуева О.Ю., Быканова М.А., Летова И.М., Грибовская И.А., Солодилова М.А., Полоников А.В. Влияние генотипов белка-переносчика эфиров холестерина на эффективность гиполипидемической терапии розувастатином у больных ишемической болезнью сердца с атерогенными гиперлипидемиями // Фундаментальные исследования. – 2015. – № 1-3. – С. 517-521
14.Nomura A., Won H.H., Khera A.V. et al. (2017) Protein-Truncating Variants at the Cholesteryl Ester Transfer Protein Gene and Risk for Coronary Heart Disease. Circ. Res., 121(1): 81–88
15.Shiomi M., Koike T., Ito T. Contribution of the WHHL rabbit, an animal model of familial hypercholesterolemia, to elucidation of the anti-atherosclerotic effects of statins. Atherosclerosis. 2013, vol. 231. no. 1. P.39-47
16.Roberts D.C.K., West C.E., Redgrave T.G., Smith J.B. Plasma cholesterol concentration in normal and cholesterol-fed rabbits. Atherosclerosis. 1974. vol. 19. no. 3. P. 369-380
17.Tall A.R. Plasma cholesteryl ester transfer protein. J. Lipid Res. 1993. vol. 34. no. 8. P. 1255-1274
18.Апрятин С.А., Мжельская К.В.,Трусов Н.В., Балакина А.С., Кулакова С.Н., Сото С.Х., Макаренко М.А.,Ригер Н.А., Тутельян В.А. Сравнительная характеристика in vivo моделей гиперлипидемии у крыс линии Вистар и мышей линии C57Bl/6. Вопр. питания. 2016. № 6. С. 14-23