

CHOLESTEROL-CONTROL AGENT

The invention is related to medicine and can be used to make a cholesterol-lowering drug.

Blood cholesterol is an important characteristic of lipid metabolism. Cholesterol-lowering therapy in patients with atherosclerosis and coronary heart disease results in a reduction of the cardiovascular death rate by 30-40%. There is a direct relationship between blood cholesterol levels and coronary diseases.

Cholesterol-lowering drugs are known which are based on plant preparations.

In particular, a cholesterol-lowering drug (see RF Patent No. 2162333 according to IPC A61K35/78, published on Jan. 27, 2001) is known which contains Lycopodium (wolfs-claws), Aurum iodatum (auric iodate), Barium carbonicum (barium carbonate), Allium sativum (garlic) taken in equal proportions at C 12 dilution.

This drug is a mix of homeopathic preparations, each of these preparations being used for specific indications from arterial hypertension and atherosclerotic processes to chronic liver disease, urolithiasis, adiposity, etc. Use of a multicomponent drug like that described above is equivalent to polyprogamy which usually makes patient's response to treatment difficult to interpret and ultimately precludes from making up an optimal treatment plan.

A cholesterol-lowering drug based on plant preparation (see RF Patent No. 2152221 according to IPC A61K35/78, published on Jul. 10, 2000) is known which contains Salsola Collina herb dry extract as active substance.

Use of this plant preparation based on Salsola Collina is equivalent to use of a combination of chemical substances because, as stated in the patent description, the active complex contains flavonoids, polysaccharides, carotinoids, sterines, saponins, lipids, amino acids and trace elements. As with above analogue, the variety like this is equivalent to polyprogamy and will interfere with correct interpretation of patient's response to treatment.

Furthermore, the content of active substance in the drug varies from 0.25 to 99.9% which is indicative of a low level of the drug standardization.

Cholesterol-lowering drugs based on chemical preparations are known. Of particular interest are such drugs as nicotinic acid and its derivatives, bile acids sequestrants, fibric acid derivatives (fibrates), probucol (see Okorokov, A.N. Treatment of Internal Diseases / Practical Guide. Minsk: Vysheshaya Shkola, Vitebsk: Belmedkniga, 1996, vol. 3, book 1, pp. 19-41).

However, treatment with nicotinic acid is associated with a number of side effects, such as liver function impairment, exacerbation of chronic gastritis, gastric ulcer, and also can cause hyperglycemia, skin hyperemia and an elevation of blood levels of uric acid.

Therapy with sequestrants is associated with such side effects as nausea, flatulence, constipation and diarrhea. The treatment can also lead to elevation of triglycerides levels and impairment of digestion of fat-soluble vitamins (A, D, K) and folic acid.

Side action of fibrates' use (bezafibrate, fenofibrate, gemfibrozil) is muscle affection, enhancement of lithiasis in biliary tracts and possibility to cause leucopenia, thrombocytopenia, anemia.

Probucol favors ventricular arrhythmias, dyspeptic disorders and can enhance liver dysfunction.

Lovastatin (synonyms: Mevacor, Lovacor, Medostatin, Recol, Rovacol), a cholesterol-lowering drug which regulates metabolic processes and contains an active substance of a chemical origin and special-purpose excipients, is the most closely related to the applied drug (see Vidal's Guide. Drugs in Russia. Moscow: AstraFarmServis, 2000, pp. B-364 to B-365).

The active substance belongs to statins and is [IS(I α (R*), 3 α , 7 β , 8 β (2S*, 4S*), 8 $\alpha\beta$] 1,2,3,7,8 α , - Hexahydro-3,7-dimethyl-8[2-(tetrahydro)-4-hydroxy-6-oxo-2H-pyran-2-yl]-1-naphthalenyl 2-methyl butanoate. The substance acts by inhibiting cholesterol biosynthesis. In the body, lovastatin is metabolized to give β - oxyacid which is a competitive inhibitor of an enzyme 3-hydroxy-3-methyl-glutaryl coenzyme A (HMG-CoA) reductase.

The drug also contains lactose, gelated starch, microcrystalline cellulose, butylated hydroxyanisol, indigotin (E132), and magnesium stearate as excipients.

A drawback of statins, including lovastatin, is that these drugs should be taken for long. Furthermore, statins can affect liver, muscles, gastrointestinal tract, cause sleep disturbances, headaches. In repeated drug administrations, the efficacy of the drug therapy can be reduced (tachyphylaxis) (see Cromwell W.C. Ziajka P.E. Development of tachyphylaxis among patients taking HMG CoA reductase inhibitors./ Am J. Cardiol 2000; 86: 1123-1127// The translation is published in CONSILIUM medicum journal, 2001, vol. 3, no.2. Translated by Elagin, R.I. Razvitie takhifilaksii u patsientov, poluchayushchikh inhibitory HMG-CoA reductasy). In addition, statins show xenobiotic properties.

The goal of the invention is to develop a physiologically acceptable cholesterol-lowering preparation causing no toxicity and tachyphylaxis.

For solution of the assigned task the preparation contains aqueous solution of formaldehyde with 36,5-40% concentration as an active substance and isotonic solution of sodium chloride for injections with 0,85-0,95% concentration as a special-purpose excipient at the following correlation of the weight parts:

aqueous solution of formaldehyde with 36,5-40% concentration - 2 – 6

isotonic solution of sodium chloride for injections
with 0,85-0,95% concentration - 994-998

To the authors' knowledge, no data is available in patent and scientific technical literature on any drugs lowering cholesterol levels through increasing receptor affinity.

Formaldehyde is known to be a natural product of cellular metabolism (see Hunter B.K. et al. Formaldehyde metabolism by *Escherichia coli*. Carbon and solvent deuterium incorporation into glycerol, 1,2-propanediol and 1,3-propanediol.// *Biochemistry*, 1985, vol. 24, no. 15, pp. 4148-4155). Formaldehyde is produced as a result of metabolic activities from alcohols and amino acids in eukaryotes and prokaryotes and found in cells either free or bound to other metabolites, primarily, to tetrahydrofolate and glutathione. Formaldehyde is also known to be used as immunomodulator (see RF Patent No. 2077882 according to IPC A61K31/115, published on Apr. 27,1997).

The mechanism of regulation of blood cholesterol is based on the ability of formaldehyde established by the authors to trigger a hypermutation mechanism which leads to increase of the affinity of receptors regulating cholesterol levels.

We established experimentally that introduction of formaldehyde in vitro leads to the level lowering of the transforming growth factor which provokes apoptosis or programmed cell death. Apoptosis participates in pathogenesis of atherosclerosis of heart coronary vessels (see, for example, Storozhakov G.I., Uteshev D.B. Apoptosis' role in the development of atherosclerosis, myocardial ischemia and cardiac insufficiency/ *Cardiac insufficiency* -2000. – vol. 1. - №4). In pathogenesis of atherosclerosis one of the important aspects is impairment of endothelium function. Now endothelium dysfunction is understood as (see, for example, Cherkashin D.V. Clinical significance and correction of endothelium function - [http://www. Cardiolg.ru](http://www.Cardiolog.ru)) imbalance between mediators providing normally optimal course of all endothelium depending processes, including also the transforming growth factor, relating to prosclerous cytokines (see, for example, Cooper M.E., Rumbler Y., Komers R. et. al. – *Diabets*. – 1994. - №43 - P. 1221-1228).

At that not only abnormal cells of vascular walls but also of other tissues such as liver, thyroid, adrenals are exposed to apoptosis. This, in turn, results in functional recovery of the organs, including reactivation of enzymes responsible for lipid breakdown, and normalization of physicochemical condition of blood proteins which, ultimately, leads to normalization of blood cholesterol levels.

An aqueous solution of formaldehyde is a transparent colorless liquid with a specific sharp odor, miscible with water and alcohol in all proportions.

Formaldehyde belongs to the class of aldehydes HCOH and is a colorless gas with a sharp odor, having molecular weight 30.03, density at 20°C 0.815, melting point 92°C and boiling point 19.2°C . It is well soluble in water and alcohol. The substance is easily polymerized to form paraformaldehyde in an aqueous medium or polyoxymethylene in non-aqueous media (butane, hexane).

Isotonic solution of sodium chloride for injections is a colorless liquid with saline taste. The solution is sterile and apyrogenic.

Sodium chloride is cubic crystals or white crystalline powder with saline taste, odorless and soluble in water (1:3).

The applied preparation is a transparent colorless solution odorless slightly saline in taste.

The preparation is made in the following way.

Take 2-6 weight parts of 36,5-40% medicinal solution of formaldehyde, add it to 998-994 weight parts of sterile 0,85-0,95% solution of sodium chloride for injections to receive 0,07-0,24% solution of formaldehyde. The preparation should be stored in a dark place at temperature of $15-35^{\circ}\text{C}$.

Example 1. Take 0,2 ml of 37% medicinal solution of formaldehyde, add it to 99,8 ml of sterile 0,9% (or 0,95%) isotonic solution of sodium chloride. Solution mixture is stirred thoroughly. The final concentration of formaldehyde in the received preparation will make 0,074 mass%.

Example 2. Take 0,6 ml of 37% medicinal solution of formaldehyde, add it to 99,4 ml of sterile 0,9% (or 0,95%) isotonic solution of sodium chloride. Solution mixture is

stirred thoroughly. The final concentration of formaldehyde in the received preparation will make 0,222 mass%.

Example 3. Take 0,6 ml of 40% medicinal solution of formaldehyde. Make the preparation according to the method described in example 2. The final concentration of formaldehyde will make 0,24 mass%.

Example 4. Take 3 ml of 40% medicinal solution of formaldehyde, add it to 997 ml of sterile 0,95% isotonic solution of sodium chloride. Solution mixture is stirred thoroughly. The final concentration of formaldehyde in the received preparation will make 0,12 mass%.

To prove the absence of any toxic effect of the claimed preparation, experiments on mice were performed.

The experimental study was conducted on 56 outbred ICR male and female mice weighing 18 to 24 g. The experimental animals were kept in a standard living and care environment of a vivarium on steady diet and provided with unlimited access to water and feed.

Animal observations were carried out during 14 days post administration of the preparation. During the follow-up period, general condition, motor activity, behavior, reaction to stimuli and reflexes were assessed. When required by the protocol of experiments, animals were weighted and consumptions of food and water were determined. The animals, died during the experiments, were dissected and an assessment of changes was made and organ weight ratios were determined (brain, liver, heart, spleen, kidneys, adrenals, testicles, ovaries). The survived animals were crucified at the end of the follow-up period by dislocation of the cervical spine and dissected. A postmortem examination was conducted to assess macroscopic changes of the internals, if any.

Toxicity was assessed by the Litchfield and Wilcoxon method of probit analysis using S. Rot's nomograms.

The preparation containing 0.2 mL of 37% formaldehyde solution and 99.8 mL of 0.9% sodium chloride solution was administered once intramuscularly at doses of 5, 25 and 50 mL/kg body weight. During the follow-up period, test animals were weighted trice (1, 7 and 14 days post dose administration).

The study did not reveal any changes in general condition and behavior of the test animals after injection of the preparation at a dose of 5.0 mL/kg. There was no case of animal death during the follow-up period. Weight gains were within the normal range. No difference was found in general condition and behavior between male and female animals.

In the 25 mL/kg group, the picture was close to that described above. General condition, behavior, food and water consumptions, weight gains were within normal ranges both in male and female animal subgroups.

In the 50 mL/kg group, animals showed a short-term (lasting up to 1 min) slight agitation, but after that the condition of the animals in this group did not differ significantly from that in other experimental groups.

At the end of the follow-up period (14 days post dose administration), test animals were crucified by dislocation of the cervical spine, dissected and subjected to macroscopic examination. After that, the internals were removed, weighted and organ weight ratios were determined. The post mortem study showed that organ weight ratios did not differ significantly between experimental groups and were within normal ranges. No local reactions (infiltrate, hyperemia, hair loss, etc.) were observed.

In another study, the preparation was administered at a concentration as high as 10 times the strength of drug product, i.e. containing 2 mL of 37% formaldehyde solution and 98 mL of 0.9% sodium chloride solution.

The preparation was administered i.m. to ICR mice (male and female) at doses of 6, 12.5 and 25 mL/kg.

During the first 5-6 hours post dose administration, test animals showed a moderate depression of excitability and reactivity. There was a gradual acceleration of breathing and

heart beating. However, no case of animal death was registered during the first 24 h post administration of the preparation. Only one mouse died from respiratory arrest on day 4 post administration of the dose of 25 mL/kg.

Post dose administration, all animals developed a local reaction as muscular tissue induration. At the end of the experiment, hair loss and formation of dense infiltrate were seen at the site of injection.

The study showed that the initial toxic dose did not have any significant influence on weight gain of the test animals. Variations of the values of weight gain in male and female groups were within limits of tolerance.

At the end of the experiment, test animals were crucified and subjected to macroscopic examination, the internals were removed, weighted and organ weight ratios were calculated.

The study showed that in test animals, both male and female, who received the preparation at a dose as high as 10 times therapeutic dose, organ weight ratios for brain, heart, liver, spleen, kidney, adrenals, testicles (ovaries) at the end of study period did not differ significantly from respective normal values in general population.

Thus, the results obtained suggest a low toxicity of the applied preparation.

The method of treatment consists in that the preparation is given as intramuscular injections at a dose of 5 mL at 7, 21, 30 and 60-day intervals.

To measure cholesterol levels in patients, venous blood samples were taken from the ulnar vein in the morning hours.

The clinical study of the preparation was conducted at Republican Infectious Hospital of the Republic of Belarus (Minsk) in compliance with principles of Declaration of Helsinki, requirements of international ethic standards and scientific standards of quality and design of studies involving human subjects, Public Health Law of the Republic of Belarus and Order of

the Ministry of Health of the Republic of Belarus No.254 dated Aug. 18, 2000 On Conducting Clinical Studies of Drugs.

Efficacy of the treatment was determined 7, 28, 35 and 65 days post dose administration. Patients with cholesterol levels up to 5.2 mM/L are considered normal (see Okorokov, A.N. Treatment of Internal Diseases / Practical Guide. Minsk: Vysheshaya Shkola, Vitebsk: Belmedkniga, 1996, vol. 3, book 1, pp. 19-41), from 5.2 to 6.2 mM/L moderately and higher than 6.2 mM/L heavily hypercholesterinemic.

The results of cholesterol level correction are given in Table 1.

Table 1.

Treatment efficacy (n=20)

Blood serum cholesterol levels, mM/L				
Baseline (M ± m)	7 days post dose administration (M ± m)	28 days post dose administration (M ± m)	35 days post dose administration (M ± m)	65 days post dose administration (M ± m)
4.35 ± 0.26	4.67 ± 0.45	5.31 ± 0.46	3.58 ± 0.15	3.17 ± 0.18

P<0.05 for differences between days 35 and 65 and baseline.

Data presented in Tables 2 and 3 are demonstrative of the efficacy of treatment in patients with moderate and heavy hypercholesterinemia.

Table 2.

Results of treatment of moderately hypercholesterinemic patients

Patient	Blood serum cholesterol levels, mM/L				
	Baseline	7 days post dose administration	28 days post dose administration	35 days post dose administration	65 days post dose administration
K.	5.4	8.5	8.5	4.6	3.6
P.	5.7	4.3	3.0	2.8	4.6

Table 3.

Results of treatment of heavily hypercholesterinemic patients

Patient	Blood serum cholesterol levels, mM/L				
	Baseline	7 days post dose	28 days post dose	35 days post dose	65 days post dose
V.	6.8	7.3	4.6	3.08	2.8
O.	6.8	3.3	4.6	3.2	1.96

Thus, the applied preparation lowers blood cholesterol levels without causing toxicity and tachyphylaxis.

Claims

1. Use of an active substance of a chemical origin and a special-purpose excipient comprising 2-6 weight parts of 36.5-40% aqueous solution of formaldehyde and 994-998 weight parts of 0.85-0.95% solution of sodium chloride in the manufacture of a medicament for lowering cholesterol levels in blood.
2. The use according to claim 1, wherein the medicament is administered by an injection.