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Diabetic Cardiovascular Autonomic Neuropathy: Effects of Simvastatin and Omega-3 Polyunsaturated Fatty Acids on Insulin Resistance and Lipid Profile Parameters

Introduction. The majority of patients with type 2 diabetes mellitus (T2DM) are diagnosed with coronary heart disease (CHD) due to coronary artery atherosclerosis. Metabolic alterations in the myocardium are combined with early coronary atherosclerosis. The development of diabetic cardiac autonomic neuropathy (CAN) is associated with the lesion of the autonomic nervous system and may be accompanied by coronary vessels ischemia, arrhythmias, "silent" myocardial infarction, severe orthostatic hypotension and sudden death syndrome [22-24, 26, 30]. Therefore, the problem of effective CAN treatment is particularly relevant. Pathogenetic treatment of CAN includes diet and physical activity; reducing of insulin resistance (IR); optimal glycemic control; treatment of dyslipoproteinemia (DLP); prevention and treatment of thrombosis; symptomatic treatment [2, 4, 24, 27].

Classically, statins are used to manage DLP, but they also present beneficial effects beyond lipid-lowering; for instance, blood pressure (BP) reduction in central and peripheral sympathetic activity, and improvement in anti-inflammatory responses. A number of mechanisms have been proposed to explain the pleiotropic effect of statin therapy to reduce sympathetic outflow in cardiovascular diseases (CVD) [6, 15, 20]. Evidence from randomized clinical trials and meta-analysis supports statin treatment for the primary and secondary prevention of CVD [20].

Numerous studies report salutary effects of ω-3 polyunsaturated fatty acids (ω-PUFAs) on CVD risk factors. These effects include lowering of triglyceride (TG); lowering of BP; decreasing platelet aggregation and inflammation; protection from arrhythmias. Systematic meta-analysis suggests that high doses of ω-3 PUFAs (~3.0 g/day) produce a small, but significant decrease in systolic BP in older and hypertensive subjects [4, 12].

The aim of the study was to investigate the effects of simvastatin (SIM) and ω-3 polyunsaturated fatty acids on blood lipid profile and insulin resistance in patients with type 2 diabetes mellitus and definite cardiac autonomic neuropathy.

Materials and methods. This was an open-label comparative controlled randomized study. Study inclusion criteria: age 45-60 years old; T2DM with optimal or suboptimal glycemic control; T2DM patients with confirmed CAN; clinical stages of diabetic polyneuropathy; body mass index (BMI) within 20.0-30.0 kg/m^2; consent to observe the dietary regime with the limited use of foods containing saturated fatty acids during the study; consent to maintain appropriate physical activity. The examination excluded persons with uncontrolled diabetes mellitus (DM), ketosis, peripheral vascular diseases, ischemic form of diabetic foot, distal neuropathy caused by other reasons than diabetes (neurological disease, chronic alcoholism, pharmacological agents), neoplasms, hypothyroidism, history of acute pancreatitis, affected activity of lipoprotein lipase and/or DLP type III, women during pregnancy and lactation, patients with type 1 DM, hypersensitivity to the components of the medicinal product. Treatment with antidepressants, anticonvulsants, opiates, capsaicin, neuroleptic agents, cytostatic agents, B group vitamins, benfotiamine, γ-linoleic acid, aldose reductase inhibitors, isotretinoin (accutane), warfarin, antioxidants (including α-lipoic acid medications), ω-3 PUFAs for six months prior to the inclusion in the study was also exclusion criteria. Patients suffering from severe diseases of the heart, lungs, liver, pancreas, and intestines were also excluded from the study.

The study has been conducted for 2 years. Each patient examined before the beginning of the study did not take ω-3 PUFAs and was on a stable regime of hypoglycemic and antihypertensive treatment for 6 months. After CAN diagnosing SIM and/or ω-3 PUFAs was prescribed to patients from the treatment groups according to the study design. The treatment of the control group was unchanged. The duration of the treatment period was 3 months. To determine the metabolic effects of the treatment the glycemic, lipids and IR parameters were performed initially and after the end of treatment.

All patients were residents of the city of Lviv observed by an endocrinologist at the Department of Endocrinology of the Danylo Halytsky Lviv National Medical University based on Lviv Regional State Clinical Treatment and Diagnostical Endocrinological Center. On the basis of these institutions, patients were examined and treated.

Examination plan included determination of glucose, glycated hemoglobin A1c (HbA1c), lipids, IR parameters in the blood, Electrocardiography (ECG) and Holter-ECG. All patients underwent screening for CAN that included five cardiovascular autonomic reflex tests, in addition, time-domain and frequency-domain heart rate variability (HRV) tests were performed [26, 30, 32].

The study involved 72 patients with T2DM and definite CAN. Clinical characteristics of studied patients with T2DM and definite CAN are given in tabl. 1.

Table 1

Baseline characteristics of patients included in this study

Parameters	Patients with T2DM and definite CAN (*n* = 72)			
	Control (*n* = 15)	SIM (*n* = 22)	Ω-3 PUFAs (*n* = 18)	SIM + Ω-3 PUFAs (*n* = 17)
	Group 1	Group 2	Group 3	Group 4
Age, yrs	55.33 ± 0.95	54.14 ± 0.89	54.83 ± 0.87	52.35 ± 1.12
DM duration, yrs	3.60 ± 0.42	4.68 ± 0.62	3.44 ± 0.42	4.82 ± 0.84
BMI, kg/m^2	28.89 ± 0.16	28.50 ± 0.39	28.28 ± 0.33	28.91 ± 0.19
Systolic blood pressure, mmHg	143.00 ± 3.06	149.50 ± 3.15	146.60 ± 2.19	152.12 ± 3.74
Diastolic blood pressure, mmHg	90.60 ± 1.84	91.14 ± 2.12	92.72 ± 1.86	93.06 ± 2.22
Pulse pressure, mmHg	52.40 ± 2.04	58.36 ± 2.83	54.01 ± 3.01	58.47 ± 2.83
Heart rate (HR), bpm	95.20 ± 2.81	90.55 ± 2.31	97.78 ± 3.25	89.88 ± 2.41

All participants signed an informed consent prior to their inclusion in the study. Patients were divided into four treatment groups: 1st group (*n* = 15) received standard hypoglycemic therapy (control group); 2nd group (*n* = 22) - standard hypoglycemic therapy and SIM 20 mg/q.d.; 3rd group (*n* = 18) -standard hypoglycemic therapy and 1 capsule/q.d. of the ω-3 PUFAs (1 g, including ~90.0 % ω-3 PUFAs, mainly eicosapentaenoic (EPA) and docosahexaenoic acid (DHA) and 4.0- mg of α-tocopherol acetate); 4th (n = 17) - standard hypoglycemic therapy, SIM 10.0 mg/q.d. and 1 capsule/q.d. of the ω-3 PUFAs for three months. The standard hypoglycemic treatment of DM included dietary regime, appropriate physical activity, and oral antihyperglycemic drugs. The therapy of the control group remained unchanged during the treatment period.

The concentration of glucose in the blood was determined by the glucose oxidase method while HbA1c level was assessed by using a highly sensitive method of ion-exchange liquid chromatography with D-10 analyzer and BIO-RAD reagents (United States). Determination of immunoreactive insulin (IRI) was performed using commercial kits from Immunotech insulin immunoradiometric assay reagents (Czech Republic). Lipid metabolism was assessed by the concentration of total cholesterol (TC), TG, low-density lipoprotein (LDL-C), high-density lipoprotein (HDL-C); atherogenic coefficient (AC), TG/LDL-C, TG/TC, TG/LDL-C, TG/HDL-C parameters. The TG-glucose (TyG) index was calculated by the Ln [fasting TG (mg/dL) x fasting glucose (mg/dL)/2] [25]. The use of the homeostasis model assessment (HOMA) IR (HOMA-IR) [29], the insulin suppression test [1], and the hyperinsulinemic-euglycemic clamp suggested that the TyG index correlated with IR [1]. The lipid fractions were determined by using HUMAN reagents (Germany) for the analyzer Humanlayzer 2000. HOMA-IR index was calculated according to the formula: fasting IRI (mcIU/mL) x fasting glucose (mmol/L)/22.5 [14].

Resting 12-lead surface ECG with a paper speed of 25 mm/s and a signal size of 10 mm/mV was recorded in the morning period. We performed resting ECG analysis included measurement of the following parameters: heart rhythm, HR, conduction intervals, and Holter-ECG [(ECG ″EC-3H″ (″Labtech″, Hungary)] analysis included measurement of 24 hours ECG, circadian indexes and HRV parameters.

The work was done according to the principles of the Declaration of Helsinki (2004) and was approved by an Ethics Committee of the Danylo Halytsky Lviv National Medical University, protocol N 2 from 18 February 2013. The research performed corresponded to the generally accepted norms of morality and observance of the rights, interests and personal dignity of the persons participating in the study.

Statistical analysis was based on the variational method using a statistical parametric t-test, nonparametric F. Wilcoxon t-test, and R. A. Fisher's-K. Pearson correlation coefficient. Data are presented as mean ± standard error of the mean (SEM). All tests were performed using the ANOVA (MicroCal Origin v. 8.0) software. Statistical significance was set at $p < 0.05$.

Results and discussion. We found out that the baseline level of HbA1c, HOMA-IR parameters, and the blood lipids profile after three months do not present statistically significant differences in the control group. Changes of HbA1c, IRI and HOMA-IR parameters among patients with T2DM and definite CAN after 3-months of SIM, ω-PUFAs, and combined SIM plus ω-PUFAs therapy are given in tabl. 2.

Table 2

Changes of the HbA1c, IRI, and HOMA-IR in patients with T2DM and definite CAN after 3-months of SIM and ω-3 PUFAs therapy

Parameter	Patients with T2DM and definite CAN (n = 72)			% change
	Groups	Baseline	After treatment	
HbA1c, %	Control (n = 15)	7.17 ± 0.18	7.21 ± 0.19	+0.60 ± 1.07
	SIM (n = 22)	7.40 ± 0.23	7.34 ± 0.19	-1.18 ± 1.25
	Ω-3 PUFAs (n = 18)	7.03 ± 0.17	7.07 ± 0.14	+0.87 ± 1.22
	SIM + Ω-3 PUFAs (n = 17)	6.96 ± 0.22	6.88 ± 0.22	-1.04 ± 1.33
IRI, μIU/mL	Control (n = 15)	27.39 ± 2.13	26.01 ± 2.25	-6.43 ± 3.00
	SIM (n = 22)	29.53 ± 1.99	26.16 ± 1.60	-8.91 ± 4.21
	Ω-3 PUFAs (n = 18)	25.07 ± 2.65	23.44 ± 2.34	-4.23 ± 5.62
	SIM + Ω-3 PUFAs (n = 17)	26.37 ± 1.99	20.24 ± 1.09*	-21.07 ± 2.05
HOMA-IR	Control (n = 15)	9.04 ± 0.99	8.46 ± 0.99	-6.12 ± 4.06
	SIM (n = 22)	8.99 ± 0.94	7.43 ± 0.60	-8.86 ± 6.84
	Ω-3 PUFAs (n = 18)	7.90 ± 1.06	7.29 ± 0.86	-8.86 ± 6.84
	SIM + Ω-3 PUFAs (n = 17)	7.40 ± 0.92	5.12 ± 0.44*	-25.35 ± 3.16

Note: Data are presented as absolute values and as % change from baseline (Δ%, Mean ± SEM); $p < 0.05^*$ compared to baseline.

It was established that SIM and ω-3 PUFAs therapy do not contribute to statistically significant changes in such parameters as HbA1c, IRI, and HOMA-IR parameters. The combined prescription of SIM and ω-3 PUFAs was accompanied by a statistically significant decrease in the level of IRI and HOMA-IR parameters.

Changes of some lipid parameters and lipid ratios in patients with T2DM and definite CAN after 3-months of SIM, ω-PUFAs, and combined SIM plus ω-PUFAs therapy are given in tabl. 3 and tabl. 4.

Table 3

Changes of some lipid parameters in patients with T2DM and definite CAN after 3-months of SIM and ω-3 PUFAs therapy

Parameter	Patients with T2DM and definite CAN (n = 72)			% change
	Groups	Baseline	After treatment	
TC, mmol/L	Control (n = 15)	6.59 ± 0.18	6.13 ± 0.15	-6.73 ± 1.09
	SIM (n = 22)	6.18 ± 0.29	4.81 ± 0.23§§	-21.83 ± 1.55
	Ω-3 PUFAs (n = 18)	6.00 ± 0.20	5.64 ± 0.24	-5.52 ± 3.16
	SIM + Ω-3 PUFAs (n = 17)	6.41 ± 0.13	4.56 ± 0.15§§	-28.69 ± 1.99
LDL-C, mmol/L	Control (n = 15)	4.59 ± 0.16	4.25 ± 0.17	-8.27 ± 1.44
	SIM (n = 22)	4.27 ± 0.27	2.72 ± 0.14§§	-34.23 ± 2.55
	Ω-3 PUFAs (n = 18)	4.09 ± 0.18	3.78 ± 0.27	-8.08 ± 5.58
	SIM + Ω-3 PUFAs (n = 17)	4.42 ± 0.12	2.57 ± 0.11§§	-41.58 ± 2.26
HDL-C, mmol/L	Control (n = 15)	0.84 ± 0.03	0.87 ± 0.03	+4.09 ± 0.97
	SIM (n = 22)	0.77 ± 0.03	0.92 ± 0.06*	+12.10 ± 2.32
	Ω-3 PUFAs (n = 18)	0.78 ± 0.03	0.90 ± 0.05*	+9.73 ± 2.57
	SIM + Ω-3 PUFAs (n = 17)	0.76 ± 0.03	0.89 ± 0.04*	+16.51 ± 1.16
TG, mmol/L	Control (n = 15)	2.52 ± 0.12	2.31 ± 0.11	-8.28 ± 1.17
	SIM (n = 22)	2.50 ± 0.27	1.83 ± 0.18*	-22.57 ± 1.20
	Ω-3 PUFAs (n = 18)	2.47 ± 0.15	1.62 ± 0.09§§	-33.35 ± 2.73
	SIM + Ω-3 PUFAs (n = 17)	2.75 ± 0.15	1.57 ± 0.15§§	-43.28 ± 2.91

Note: Data are presented as absolute values and as % change from baseline (Δ%, Mean ± SEM); $p < 0.05^*$ compared to baseline; $p < 0.01^§$ compared to baseline; $p < 0.001^{§§}$ compared to baseline.

Table 4

Changes of some lipid ratios in patients with T2DM and definite CAN after 3-months of SIM and ω-3 PUFAs therapy

Parameters	Patients with T2DM and definite CAN (n = 72)			% change
	Groups	Baseline	After treatment	
AC	Control (n = 15)	7.05 ± 0.43	6.20 ± 0.37	-11.79 ± 1.38
	SIM (n = 22)	7.40 ± 0.59	4.73 ± 0.48§	-37.16 ± 2.51
	Ω-3 PUFAs (n = 18)	6.90 ± 0.47	5.60 ± 0.44*	-20.17 ± 7.24
	SIM + Ω-3 PUFAs (n = 17)	7.56 ± 0.54	4.25 ± 0.32§§	-43.54 ± 2.39
TG/LDL-C	Control (n = 15)	0.55 ± 0.02	0.54 ± 0.03	-0.39 ± 2.06
	SIM (n = 22)	0.64 ± 0.06	0.71 ± 0.08	+18.15 ± 5.57
	Ω-3 PUFAs (n = 18)	0.61 ± 0.03	0.46 ± 0.03§§	-22.20 ± 5.61
	SIM + Ω-3 PUFAs (n = 17)	0.64 ± 0.06	0.65 ± 0.08	-0.03 ± 0.41
TG/TC	Control (n = 15)	0.38 ± 0.01	0.37 ± 0.02	-1.07 ± 1.80
	SIM (n = 22)	0.40 ± 0.04	0.38 ± 0.03	-0.12 ± 4.08
	Ω-3 PUFAs (n = 18)	0.41 ± 0.016	0.29 ± 0.01§§	-28.34 ± 3.47
	SIM + Ω-3 PUFAs (n = 17)	0.43 ± 0.03	0.35 ± 0.04	-19.30 ± 4.54
TG/HDL-C	Control (n = 15)	3.09 ± 0.21	2.74 ± 0.20	-11.65 ± 1.58
	SIM (n = 22)	3.46 ± 0.43	2.21 ± 0.28*	-33.10 ± 3.06
	Ω-3 PUFAs (n = 18)	3.29 ± 0.27	1.89 ± 0.15§§	-41.22 ± 2.24
	SIM + Ω-3 PUFAs (n = 17)	3.78 ± 0.35	1.83 ± 0.18§§	-51.26 ± 2.68
TC/ LDL-C/ HDL-C	Control (n = 15)	1.75 ± 0.06	1.70 ± 0.07	-2.74 ± 1.74
	SIM (n = 22)	2.03 ± 0.12	2.17 ± 0.17	+5.89 ± 5.02
	Ω-3 PUFAs (n = 18)	1.91 ± 0.05	1.77 ± 0.06	-6.87 ± 3.08
	SIM + Ω-3 PUFAs (n = 17)	1.99 ± 0.11	2.10 ± 0.12	+6.90 ± 4.19
TyG index	Control (n = 15)	9.53 ± 0.06	9.44 ± 0.05	-0.89 ± 0.39
	SIM (n = 22)	9.27 ± 0.14	8.96 ± 0.13	-3.29 ± 0.30
	Ω-3 PUFAs (n = 18)	9.46 ± 0.08	9.05 ± 0.08§§	-4.24 ± 0.68
	SIM + Ω-3 PUFAs (n = 17)	9.41 ± 0.09	8.76 ± 0.12§§	-6.94 ± 0.61

Note: Data are presented as absolute values and as % change from baseline (Δ%, Mean±SEM); $p < 0.05^{*}$ compared to baseline; $p < 0.01^{§}$ compared to baseline; $p < 0.001^{§§}$ compared to baseline.

Obtained results of our study could testify that the prescription of SIM was accompanied by a statistically significant decrease in TC ($p < 0.001$), LDL-C ($p < 0.001$), TG concentrations ($p < 0.05$). In parallel, SIM induced the decrease of AC ($p < 0.01$), TG/HDL-C ($p < 0.05$), and increase in HDL-C levels ($p < 0.05$), and does not affect the TG/LDL-C, TG/TC, TC/LDL-C/HDL-C, TyG index parameters. The use of ω-3 PUFAs has contributed to a significant reduction in TG ($p < 0.001$), AC ($p < 0.05$), TG/LDL-C ($p < 0.001$), TG/TC ($p < 0.001$), TG/HDL-C ($p < 0.001$), TyG index ($p < 0.001$), increase in HDL-C levels ($p < 0.05$), and was not accompanied by statistically significant changes in TC, LDL-C, and TC/LDL-C/HDL-C index parameters. The combined prescription of SIM and ω-3 PUFAs was accompanied by more pronounced, statistically significant changes in the blood lipid spectrum, as well as a decrease in the level of IRI ($p < 0.05$), and HOMA-IR parameters ($p < 0.05$).

Type 2 DM is known to be characterized by the presence of hypertriglyceridemia, one of the key components of diabetic DLP, which significantly increases the risk of CVD development. Statin therapy is considered as the cornerstone of clinician's efforts toward primary and secondary CVD prevention in patients with T2DM [7, 19]. Patients with T2DM are deemed as prime candidates for receiving statin therapy, which has been endorsed by most of the clinical practice guidelines [9]. In accordance with what has been recommended earlier by American College of Cardiology/American Heart Association guidelines, American Diabetes Association standards of care recommend moderate-intensity statins for all T2DM patients over the age of 40 years as a primary prophylaxis [21]. On the other hand, higher doses of statins are required for the secondary prophylaxis of diabetic patients with coronary artery disease (CAD) or at increased CVD risks such as those with abnormal LDL-C levels, smokers, hypertension, or albuminuria [9]. Adherence to clinical guidelines that recommend statins for T2DM patients as the main CVD prophylaxis treatment is modulated by many factors. These determinants may play a crucial role in ensuring success following the decision to prescribe statins. Moreover, having prescribed statins, some factors related to both clinicians and patients alike can also affect compliance with statin therapy. Initiatives to enhance statin therapy prescribing should recognize the comprehensive nature of the prescribing process. Efforts to assure proper statin utilization and prescribing may help in achieving better clinical outcomes of statin therapy among patients with T2DM [20].

There are quite a number of conflicting reports regarding the potential positive effects of ω-3 PUFAs in patients with T2DM and CVD. In particular, the recently published results of several meta-analyses indicate that ωa-3 PUFAs are not capable of reducing the risk of cardiovascular events [3]. No benefits of taking ω-3 PUFAs in patients with T2DM and atherosclerotic vascular disease, in particular, no significant effects on oxidative stress, chronic low-intensity inflammatory process parameters, coagulation status and metabolic status have been found out [18]. In contrast, the results of a large meta-analysis of randomized controlled trials have shown that the addition of ω-3 PUFAs has a favorable lipid-lowering effect, reduces the level of pro-inflammatory cytokines and improves glycemia [16, 22]. The positive findings of this meta-analysis are complemented by the results of a number of recent studies that have demonstrated that ω-3 PUFAs have beneficial effects on metabolism in patients with T2DM [11, 13, 21]. In patients with impaired glucose metabolism and CAD, EPA has been reported to contribute to the correction of postprandial hypertriglyceridemia, hyperglycemia, insulin production, endothelial dysfunction [21]. Omega-3 PUFAs have been reported to have a positive effect on glucose, Hb1Ac, leptin and leptin/adiponectin ratios in patients with T2DM [11]. The conflicting results of different original studies and a meta-analysis can be partially explained by the different dosage and duration of supplementation, each of which can modify the effects of ω-3 PUFAs on cardio-metabolic biomarkers [10]. Meta-analyses are usually limited by the inability to draw conclusions regarding the dosage, duration, and interaction of the dosage, and duration of administration of ω-3 PUFAs. However, almost all endpoints in the so-called ″negative″ meta-analyses tended to benefit, with an almost 10.0 % decrease in cardiovascular outcomes and borderline statistical significance. In many studies included in these meta-analyses, an insufficient daily dose of ω-3 PUFAs of less than 1000.0 mg was tested [28].

Therefore, dietary consumption of ω-3 PUFAs is recommended in international guidelines for the general population to prevent the occurrence of CHD. However, the precise mechanisms underlying the cardioprotective effects of ω-3 PUFAs are not fully understood. Omega-3 PUFAs can be incorporated into the phospholipid bilayer of cell membranes and can affect membrane fluidity, lipid microdomain formation, and signaling across membranes. Omega-3 PUFAs also modulate the function of membrane ion channels, such as Na^+ and L-type Ca^{2+} channels, to prevent lethal arrhythmias. Moreover, ω-3 PUFAs also prevent the conversion of arachidonic acid into pro-inflammatory eicosanoids by serving as an alternative substrate for cyclooxygenase or *lipoxygenase pathways,* resulting in the production of less potent products. In addition, a number of enzymatically oxygenated metabolites derived from ω-3 PUFAs were recently identified as anti-inflammatory mediators. These ω-3 metabolites may contribute to the beneficial effects against CHD that are attributed to ω-3 PUFAs [5, 8]. The OMEGA study including 94.2 % statin users failed to prevent cardiovascular events [31]. The ORIGIN trial including 53.8 % statin users also failed [31]. In the previous two studies (GISSI-P and GISSI-HF), EPA + DHA may be effective to prevent cardiovascular events because of fewer combined use of statins. In the recent studies (OMEGA and ORIGIN) which included many participants who had taken statins, EPA + DHA failed to reduce cardiovascular events. The combination of ω-3 PUFAs and rosuvastatin in patients with residual hypertriglyceridemia, despite treatment with statins, led to a greater decrease in TG and non-HDL cholesterol than rosuvastatin-monotherapy [13].

However, the present study has several limitations. The duration of treatment was short. Additional long-term studies on the efficacy and tolerability of ω-3 PUFAs are needed.

Conclusions. Our results suggest that the efficacy of simvaststin and ω-3 polyunsaturated fatty acids is not associated with improved glycemic control of type 2 diabetes mellitus in patients with definite cardiac autonomic neuropathy but is rather the result of a direct effect of the pharmacological agent on the investigated metabolic indexes. Therefore, the appointment of combined statins and ω-3 polyunsaturated fatty acids is necessary for the treatment of dyslipoproteinemia in patients with type 2 diabetes mellitus and definite cardiac autonomic neuropathy. However, existing data are not consistent perhaps due to a significant heterogeneity (variable doses of statins and ω-3 polyunsaturated fatty acids, different duration of intake, different populations, and end-points) in the interventional studies. For prevention/treatment of cardiac autonomic neuropathy events supplementation with statins and ω-3 polyunsaturated fatty acids should be integrated into a more global strategy that includes focusing on other components of a healthy lifestyle (diet, weight control, physical activity, smoking cessation) and on tight control of glucose and lipid profile when indicated. Thus, further research to understand the mechanism of action and confirmation the beneficial effects of combined statins and ω-3 polyunsaturated fatty acids on the heart rate variability and artery stiffness parameters is needed.

Author's contribution

Victoria Serhiyenko, Marta Hotsko, Samir Azhmi and Olexandr Serhiyenko contributed substantially to all aspects of this manuscript, including conception and design; acquisition, analysis, and interpretation of data; and drafting the article. Victoria Serhiyenko and Olexandr Serhiyenko contributed substantially to the conception of this manuscript; and acquisition and analysis of data. All authors approved the final version of this article.

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Diabetic Cardiovascular Autonomic Neuropathy: Effects of Simvastatin and Omega-3 Polyunsaturated Fatty Acids on Insulin Resistance and Lipid Profile Parameters

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Introduction. Currently, there is no standard treatment algorithm of cardiac autonomic neuropathy (CAN) in patients with type 2 diabetes mellitus (T2DM).

The aim of the study was to investigate the effects of simvastatin (SIM) and ω-3 polyunsaturated fatty acids (ω-3 PUFAs) on blood lipid profile and insulin resistance (IR) in patients with type 2 diabetes mellitus and definite cardiac autonomic neuropathy.

Materials and methods. The study involved 72 patients with T2DM and definite CAN. Patients were divided into four groups: 1st - received standard hypoglycemic therapy - control (n = 15); 2nd (n = 22) – in addition simvastatin (SIM) 20.0 mg/q.d.; 3rd (n = 18) - in addition 1 capsule/q.d. of the ω-3 PUFAs; 4th (n = 17) - in addition SIM 10.0 mg/q.d and 1 capsule/q.d of the ω-3 PUFAs for three months. The concentration of glucose, glycated hemoglobin A1c, immunoreactive insulin (IRI), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides (TG) in the blood were determined. Homeostasis model assessment IR (HOMA-IR), atherogenic coefficient (AC), TG/LDL-C, TG/TC, TG/LDL-C and TG and glucose index (TyG) were calculated.

Results. Prescription of SIM was accompanied by a statistically significant decrease in TC, LDL-C, TG concentrations. In parallel, SIM induced a decrease of AC, TG/HDL-C, increase in HDL-C, and does not affect the IRI, HOMA-IR, TG/LDL-C, TG/TC, TC/LDL-C/HDL-C, TyG. The use of ω-3 PUFAs has contributed to a significant reduction in TG, AC, TG/LDL-C, TG/TC, TG/HDL-C, TyG index, increase in HDL-C, and was not accompanied by changes in IRI content, HOMA-IR, TC, LDL-C, and TC/LDL-C/HDL-C. The combined prescription of SIM and ω-3 PUFAs was accompanied by more pronounced, statistically significant changes in the blood lipid spectrum, as well as a decrease in the IRI and HOMA-IR.

Conclusions. Obtained results justify the appropriateness of combined simvastatin and ω-3 polyunsaturated fatty acids prescription to patients with type 2 diabetes mellitus and definite cardiac autonomic neuropathy.

Keywords: diabetes mellitus, cardiac autonomic neuropathy, treatment.

Діабетична кардіоваскулярна автономна нейропатія: вплив симвастатину та омега-3 поліненасичених жирних кислот на резистентність до інсуліну, показники ліпідного профілю

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Вступ. Пошук шляхів і способів ефективного лікування кардіоваскулярної автономної нейропатії (КВАН) належить до пріоритетних завдань сучасної діабетології. Використання статинів вважається первинною ланкою у фармакотерапії атерогенної дисліпопротеїнемії, що базується на переконливих результатах численних клінічних випробувань. Ефективність ω-3 поліненасичених жирних кислот (ω-3 ПНЖК) зумовлюється впливом на інсулінову резистентність (ІР) і гомеостаз глюкози, ймовірно, пригніченням секреції інсуліну, впливом на стан ліпідного обміну тощо. Однак інформація про особливості використання статинів і ω-3 ПНЖК для лікування хворих на цукровий діабет (ЦД) 2-го типу з КВАН є предметом дискусії, а тому вимагає подальшого уточнення.

Мета. З'ясувати особливості впливу симвастатину та ω-3 поліненасичених жирних кислот на показники ліпідного спектра крови та інсулінову резистентність у хворих на цукровий діабет 2-го типу з кардіоваскулярною автономною нейропатією.

Матеріали й методи. Дослідження здійснено на базі діабетологічного відділу Львівського обласного державного клінічного лікувально-діагностичного ендокринологічного центру. 72 хворих на ЦД 2-го типу з функціональною стадією КВАН стратифіковано на чотири групи, які впродовж трьох місяців отримували стандартне цукрознижувальне лікування: 1-ша – контрольна (n = 15); 2-га (n = 22) – симвастатин – 20,0 мг/добу; 3-тя (n = 18) – 1 капсулу на добу ω-3 ПНЖК; 4-та (n = 17) – симвастатин – 10,0 мг/добу та 1,0 г ω-3 ПНЖК на добу.

Концентрацію глюкози в крові визначали глюкозооксидазним методом, HbA1c – високочутливої йонообмінної рідинної хроматографії; імунореактивного інсуліну (ІРІ) – тест-наборів Insulin IRMA (Immunotech, Чехія). Обчислювали індекс ІР (НОМА-ІР). Стан ліпідного обміну оцінювали за показниками загального холестеролу (ЗХС), тріацилгліцеринів (ТГЕ), холестеролу ліпопротеїдів високої щільности (ХС ЛПВЩ) і ХС ліпопротеїдів низької щільности (ЛПНЩ). Обчислювали коефіцієнт атерогенности (КА), ТГЕ/ХС ЛПНЩ, ТГЕ/ЗХС, ТГЕ/ХС ЛПВЩ, ЗХС/ХС ЛПНЩ/ХС ЛПВЩ, показники ТГЕ-глюкозного індексу (TyG)-індексу.

Статистичний аналіз: ANOVA (MicroCal Origin v. 8,0). Отримані показники наведені у вигляді M ± m, а відсоток змін після проведеного курсу лікування (стосовно показників до лікування) визначали у вигляді дельти (Δ %, M ± m). Найменш статистично значущим вважали значення p < 0,05.

Результати. З'ясовано, що використання симвастатину супроводжувалось статистично значущим зменшенням концентрації ЗХС, ТГЕ, ХС ЛПНЩ, КА, ТГЕ/ХС ЛПВЩ й зростанням умісту ХС ЛПВЩ і водночас не впливало на показники HbA1c, препрандіальної глікемії, ІРІ, НОМА-IR, ТГЕ/ХС ЛПНЩ, ТГЕ/ ЗХС, ЗХС/ ХС ЛПНЩ/ХС ЛПВЩ й TyG-індексу (порівняно з контролем).

Призначення ω-3 ПНЖК не супроводжувалось значущими змінами концентрації HbA1c, препрандіальної глікемії, ІРІ й НОМА-ІР. Проте ω-3 ПНЖК сприяли статистично значущому зниженню вмісту ТГЕ (2,47 ± 0,15 ммоль/л (до лікування) і 1,62 ± 0,09 ммоль/л (після лікування), (p < 0,001)), КА, ТГЕ/ХС ЛПНЩ, ТГЕ/ ЗХС, ТГЕ/ХС ЛПВЩ, TyG-індексу й підвищенню вмісту ХС ЛПВЩ (0,78 ± 0,03 ммоль/л (до лікування) і 0,90 ± 0,05 ммоль/л (після лікування), (p < 0,05)).

Використання симвастатину й ω-3 ПНЖК супроводжувалось найбільш виразними, позитивними, статистично значущими змінами показників гіперінсулінемії (ГІЕ)/ІР (зменшенням ІРІ, НОМА-IR) й ліпідного обміну. У контрольній групі не виявлено позитивної динаміки вмісту показників ліпідного обміну, параметрів ГІЕ/ІР.

Висновки. Отримані результати обґрунтовують доцільність комбінованого використання симвастатину й ω-3 поліненасичених жирних кислот для лікування функціональної стадії кардіоваскулярної автономної нейропатії у хворих на цукровий діабет 2-го типу.

Ключові слова: цукровий діабет 2-го типу, кардіоваскулярна автономна нейропатія, інсулінова резистентність, ліпідний спектр крови, статини, ω-3 поліненасичені жирні кислоти, лікування.

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