THE USE OF OZONE IN A COMPLEX SPA TREATMENT AND ITS EFFECT ON FUNCTIONAL POTENTIAL OF CARDIO-VASCULAR SYSTEM AND ON SPECIFIC RESISTANCE IN PATIENTS WITH ISCHEMIC HEART DISEASE

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ABSTRACT

The aim of the work is to study the ozonetherapy effect in subtropical conditions of the Caucasian Black Sea coast on adaptive potentials of cardio-vascular system in patients with stenocardia of groups I, II and III.There were examined and treated 134 patients with cardio-vascular disorders, 80 having stenocardia.The ozonated saline (0,9%) NaCl) was prepared with "Medozon" ozonator. The course of ozonetherapy consisted of 6 sessions of ozonated saline infusions of 200ml (ozone concentration –1,0 mgr/l) done every second day. Apart from ozonetherapy, complex spa treatment included thalassotherapy, aerotherapy, heliotherapy, balneotherapy and diet therapy.The received results demonstrated positive dynamics of stroke and minute blood volume and cardiac index, testifying the improvement of blood circulation and of cardiac pump function. These data were confirmed by EKG veloergometry readings. Ozonetherapy proved to increase functional potentials of cardio-vascular system, its functional economy and capacity (tolerance to physical loads, the scope of work, etc).

INTRODUCTION

The city of Sochi as a major climatotherapeutic and balneological spa resort has been gaining more and more significance in the system of spa-resorts sanitation. Of great importance is the adaptation problem, particularly for people with cardio-vascular disorders. It is connected with a quick change of climate and geographical area and a change in habitual biological rhythms as a result of it. In this respect, ozonetherapy seems to be the most effective non-medicinal method to reinforce the adaptive capacities of the organism.

According to biochemists in Russia and abroad, oxidation-reduction system can be regarded as a trigger mechanism of ozone biological effect. An adequate mobilization of energetic metabolism of any organ makes it possible, due to the development of adaptive reactions, to bring forward the mechanisms of non-specific defense of the whole organism. It can be revealed in a better functioning of central and peripheral blood circulation (microcirculation, rheological blood properties), improvement of respiration and of blood transportation systems(5,8-9).

In the Medical Academy of Nizhni Novgorod there have been developed and approved a method of ozonetherapy for patients with ischemic heart disease. It consists of 5-7 sessions, done every other day, of intravenous infusions of ozonated saline (200ml with ozone concentration – 1mg/l)

The aim of work is to estimate the clinical efficacy and changes in the non-specific resistance in patients with ischemic heart disease in a course of complex spa treatment.

MATERIAL AND METHODS

77 patients with a stable angina on exertion of I -II-III functional class underwent a traditional spa treatment (climatotherapy, dietotherapy, hydrotherapy, balneotherapy, kinesitherapy, physiotherapy, medication – if necessary) in combination with ozonetherapy. 134 patients examined in dynamics were divided into two groups. The main group of 80 patients was on a complex spa treatment, combined with ozonetherapy. The control group of 54 patients received a traditional complex spa treatment.

All patients had a complex medical examination before and after the treatment. It included:

1) Clinical blood analysis and indices of non-specific adaptive reactions of the organism according to L.Garkavi (2) . The method is based on the fact that neuroendocrinal, immune and metabolic disorders connected with specific adaptive reactions are reflected in the morphological contest of "white" blood. The type of the reaction can be determined by the percentage of lymphocytes in leukocytic formula. The rest elements and the total number of leukocytes, being additional signs of the reaction, reflect the harmony in subsystems functioning, the level of reactivity and the rate of disbalance.
2) Oxygen metabolism kinetics test, based on the method of transcutaneous polarography, done with the use of "HUMARES' TM 300 T equipment. To assess the kinetics of oxygen metabolism in tissues we make a regionary ischemia test. It allows temporarily to exclude some part from the circulation and measure separately the process of oxygen delivery and oxygen consumption. The method can evaluate the rate of oxygen consumption, the state of microcirculation, the balance of oxygen in the intercellular space and to reveal functional energetic potential of cells as well as aerobic/anaerobic ratio. The assessment of oxygen metabolism kinetics is done according to the following parameters: oxygen tension in blood ($TcPO_2$), oxygen exhaustion time (OET), ½ of oxygen exhaustion time (½OET), constant of oxygen absorption rate (OARC) and of oxygen reduction rate (ORRC), critical concentration of oxygen (OCC), time of aerobic processes (APT) and of anaerobic processes (AnPT), coefficient of anaerobic glycolysis activity (AnGAC), coefficient of oxygen reserves (ORC).
3) Electrocardiograms taken with FCP – 4101 "Fukuda Denshi" electrocardiograph) Japan).
4) Estimation of hemodynamics with tetrapolar thoracic rheography.
5) Veloergometric test with gradually increasing loads using "Анкар-131"device (Taganrog,). Initial stage power was 50 W with additional 25 W every 3 minutes for women and with additional 50W –for men.
6) Psychodiagnostics with the use of Tailor's personal questionnaire, modified by T.Nemchin.

RESULTS AND MEASUREMENTS

All patients before and after the treatment were asked to fill in a questionnaire concerning their main complaints.

The received clinical results on completing the treatment course combined with ozonetherapy show the improvement of general condition (eliminating or significant relieving pain syndrome and breathlessness, stabilization of arterial pressure, taking lower doses or discontinuance of taking medicine, normalization of sleep, stabilization of psycho-emotional state, increase in capacity for work and in tolerance for physical loads, less fits of headaches and of rhythm regularity, of tachycardia).

Table I. Dynamics of Clinical Condition before and after the Treatment according to Patients' Complaints

Complaints	Traditional group		Control group	
	Before	After	before	After
	%	%	%	%
Cardiac pains in angina	50,7	18,2	52,1	27,1
Cardialgias of non-angina origin	44,2	28,6	43,8	33,3
Breathlessness	62,2	27,5	53,6	42,9
Accelerated heartbeats	41,9	21,6	32,1	21,4
Headaches, dizziness, ear noise	14,9	2,7	14,3	7,1
Sleep disturbances	50,0	17,6	57,1	35,7
Fatigue	82,4	24,3	75,0	39,3
Irritability	71,6	20,3	67,9	42,9
Meteolability	85,1	31,1	85,7	57,1
Use of nitrates and other medications	21,6	9,5	10,7	7,1

The efficiency of treatment after the course of ozonetherapy was estimated by the patients in the following way:

"Significant improvement"- complete elimination of symptoms- was indicated by 28.5%;
"Improvement"- 50% reduction of symptoms-by 48,1%;
"Satisfactory" – 25% reduction of symptoms –by 22%
"Unsatisfactory" – no improvement in patient's condition or feeling worse – by 1.2%.

Analysis of non-specific adaptive reactions before and after the course of ozonetherapy showed that the group of patients with initial reactions of quiet or increased activation of high levels of reactivity (37 patients) had no dynamics. The rest of the patients passed to the reactions of high levels training and reactions of high and medium levels activation. The latter are considered to be non-specific basis of the normal range. They were 63.51% and 94.60% before and after the course of treatment respectively. Only one patient stayed in the stage of peractivation reaction. It might be explained by severity of his disease, individual features of adaptive processes and by a short period of spa treatment.

Table II. General Adaptive Patients'Reactions before and after the Treatment

Adaptation reactions	Levels of Reactivity	The main group	
		before	After
		%	%
Increased and quiet activation	High	32,43	68,92
	Medium	17,57	9,46
	Low and very low	14,87	2,70
Training	High	13,51	16,22
	Medium	9,46	1,35
	Low and very low	-	-
Peractivation		8,1	1,35
Stress		4,06	-
Total		100	100

To estimate the kinetics of oxygen metabolism the patients were subdivided into three groups. The first group consisted of patients with inhibition of tissue respiration (OARC <0.045,c^{-1}). The second group was made of patients with stimulation of tissue respiration processes (OARC> 0.05, c^{-1}). The third group included patients with initially normal processes of tissue respiration (Table II).

It can be seen from the table that patients with OARC<0.045, initially inhibited processes of tissue respiration, after the course of ozonetherapy had reinforcement of functional potential of respiration enzymes. It became evident with significant OCC reduction. Valid reduction in OET and ½ OET data with simultaneous increase of OARC testify of normalization of oxygen utilization by body tissues. Patients with OARC> 0.05, initially stimulated processes of tissue respiration, also had normalization of oxygen consumption (valid increase of ½ OET parameter and OARC decreasing tendency, t= 1.9).Patients with normal OARC (0.045-0.05) showed significant ½ OET decrease with increased OARC (within normal range). It can be regarded as improvement in the processes of oxygen consumption.

Table III.The Parameters of Oxygen Metabolism before and after the Course of Ozonetherapy

Index	Before the treatment	After the treatment	P
OARC <0.045 (n=66_)			
Oxygen exhaustion time (OET),	154,23±3,69	131,79±3,48	<0,001
½ of oxygen exhaustion time (½OET),	39,66±0,64	32,64±0,53	<0,001
Constant of oxygen absorption rate (OARC)	0,032±0,001	0,04±0,001	<0,001
Constant of oxygen reduction rate (ORRC),	0,087±0,001	0,096±0,001	>0,05

Critical concentration of oxygen (OCC),	7,35±0,29	6,29±0,33	<0,001
Time of aerobic processes (APT)	84,33±2,08	74,41±2,25	<0,001
Time of anaerobic processes (AnPT),	67,51±2,61	59,2±2,11	<0,001
Coefficient of anaerobic glycolysis activity(AnGAC),	0,86±0,047	0,78±0,045	<0,01
Coefficient of oxygen reserves (ORC).	3,72±0,071	3,20±0,91	<0,001
OARC> 0.05,			
Oxygen exhaustion time (OET),	100,54±2,36	109,06±2,77	<0,05
½ of oxygen exhaustion time (½OET),	22,82±0,51	27,13±0,80	>0,05
Constant of oxygen absorption rate (OARC)	0,064±0,001	0,057±0,001	>0,05
Constant of oxygen reduction rate (ORRC),	0,086±0,002	0,093±0,001	>0,05
Critical concentration of oxygen (OCC),	5,43±0,41	5,95±0,43	<0,05
Time of aerobic processes (APT)	54,13±1,33	60,04±1,88	>0,05
Time of anaerobic processes (AnPT),	53,81±3,28	60,27±3,15	>0,05
Coefficient of anaerobic glycolysis activity(AnGAC),	0,62±0,1	0,69±0,08	<0,01
Coefficient of oxygen reserves (ORC).	1,83±0,03	2,00±0,03	<0,01
0.045 <OARC> 0.05,			
Oxygen exhaustion time (OET),	116,95±2,63	110,37±2,51	>0,05
½ of oxygen exhaustion time (½OET),	27,48±0,37	25,03±0,3	<0,05
Constant of oxygen absorption rate (OARC)	0,046±0,001	0,05±0,002	<0,001

Constant of oxygen reduction rate (ORRC),	0,084±0,001	0,085±0,003	>0,05
Critical concentration of oxygen (OCC),	4,74±0,47	5,39±0,44	>0,05
Time of aerobic processes (APT)	61,98±1,62	59,49±1,77	>0,05
Time of anaerobic processes (AnPT),	56,37±2,55	49,98±2,33	>0,05
Coefficient of anaerobic glycolysis activity(AnGAC),	0,93±0,02	0,89±0,04	>0,05
Coefficient of oxygen reserves (ORC).	2,66±0,22	2,68±0,24	>0,05

Estimation of central hemodynamics was done in 75 patients and is presented in Table IV. All patients were divided into three groups according to the type of hemodynamics: I-hyperkinetic (14 patients); II-eukinetic (31 patients); III –hypokinetic (30 patients). The first group was characterized by valid decrease of initially elevated stroke volume of blood, minute volume, cardiac index and left ventricle activity with the background of growing peripheral resistance. The second group showed significant improvement of all parameters within the normal range. The third group demonstrated valid elevation of stroke volume of blood, minute volume, cardiac index and left ventricle activity with the background of decreasing peripheral resistance.

Table IV.Parameters of Central Hemodynamics in Patients with Ischemic Cardiac Disease

Parameter	Before the treatment	After the treatment	P
Hyperkinetic type			
Real minute volume/normal minute volume	133,75±1,89	11,67±1,31	<0,001
Average dynamic pressure (mm Hg)	93,80±1,90	89,45±1,72	<0,01
Stroke volume(ml)	63,95±1,03	56,75±0,96	<0,001
Minute volume(l/min)	4,15±0,05	3,51±0,07	<0,01
Cardiac index ($L/min/m^2$)	2,38±0,02	2,01±0,01	<0,001
Left ventricle activity	78,28±1,99	63,72±2,33	<0,01
General peripheral resistance ($din/s/c^{-5}$)	1825,8±34,7	2016,2±3,82	<0,01
Eukinetic type			

Real minute volume/normal minute volume	93,65±1,15	103,97±1,24	<0,001
Average dynamic pressure (mm Hg)	92,78±1,27	89,01±1,35	<0,01
Stroke volume(ml)	51,83±1,08	56,02±1,12	<0,01
Minute volume(l/min)	3,24±0,09	3,53±0,07	<0,001
Cardiac index (L/min/m^2)	1,80±0,06	1,97±0,05	<0,01
Left ventricle activity	65,32±1,32	69,18±1,67	>0,05
General peripheral resistance (din/s/c^{-5})	2417,2±68,1	2124,1±51,3	<0,001
Hypokinetic type			
Real minute volume/normal minute volume	69,14±1,31	84,73±1,21	<0,001
Average dynamic pressure (mm HG)	100,12±2,42	94,69±2,05	<0,001
Stroke volume(ml)	41,75±1,05	50,93±1,22	<0,001
Minute volume(l/min)	2,67±0,08	3,25±0,03	<0,001
Cardiac index (L/min/m^2)	1,41±0,02	1,72±0,01	<0,001
Left ventricle activity	58,01±1,62	68,18±1,74	<0,001
General peripheral resistance (din/s/c^{-5})	3060,5±70,44	2467,3±53,53	<0,001

Thus, all patients of the three groups had the results close to due values or all the data returned to normal ones and, hence, testify the improvement of circulation process.

Veloergometric test was done in 44 (12 female and 32 male) patients. The results are presented in Table V.

Table V.Estimation of VEM Test before and after the Treatment.

Estimation of VEM test	Male		Female	
	before	after	Before	After
Positive	5	1	2	1
Negative	20	28	8	11
Non-informative	7	3	2	-

Analysis of veloergometric test findings revealed valid decrease of initial double product and of myocardium potential exhaustion coefficient in males and females. It gives evidences

of myocardium decreased oxygen consumption and of less cardiac sympatic influences. The patients of the both groups showed increased tolerance to loads, enlarged volume of performed work, higher index of left ventricle output. All these data can be regarded as significant elevation of functional potentials of the body.

Table VI. Veloergometric Test Parameters before and after Ozonetherapy

Parameter	Before the treatment	After the treatment	P
Males (n=32)			
Original double product	93,23±1,89	83,71±1,60	<0,001
Double product at the height of load	265,48±4,67	265,26±4,09	>0,05
Tolerance to load (kgm/min)	686,2±24,22	823,4±22,45	<0,001
Volume of work (kgm)	4249±22,59	5654±22,93	<0,001
Index of left ventricle output	4,88±0,33	5,79±0,38	<0,05
Myocardium potential exhaustion coefficient	4,89±0,29	3,56±0,32	<0,001
Maximal oxygen consumption	30,29±1,65	33,45±1,89	<0,001
MET number	8,72±0,43	9,59±0,38	<0,001
Females (n=12)			
Original double product	99,46±1,36	84,31±1,17	<0,001
Double product at the height of load	257,08±9,14	258,03±7,03	>0,05
Tolerance to load (kg m/min)	542,77±17,01	632,23±15,37	<0,001
Volume of work (kgm)	3487±211,9	4521±219,7	<0,001
Index of left ventricle output	3,75±0,19	4,17±0,16	<0,01
Myocardium potential exhaustion coefficient	6,43±0,46	4,99±0,42	<0,01
Maximal oxygen consumption	26,52±1,09	28,97±1,15	<0,01
MU number	7,58±0,38	8,27±0,42	<0,001

Tailor's test modified by T.Nemchin, done in 54 patients, showed valid decrease in anxiety indexes and, thus, testifies psychoemotional stabilization.

Table VII. Tailor's Test Parameters before and after Ozonetherapy.

Parameters	Before the treatment	After the treatment	P
Anxiety index	22,95±1,03	13,09±0,98	<0,001
Anxiety manifestations according to:			
-somatic condition	33,72±1,56	17,98±1,78	<0,001
-neuro-psychic activity	55,95±1,70	35,40±1,92	<0,001
-social state	31,71±2,24	26,24±1,65	<0,01

Conclusion

1.The method of ozonetherapy proves to be helpful in a complex spa-resort treatment of patients with stable angina to reinforce the cardio-vascular activity in conditions of humid subtropics.

2.The scheme of ozonetherapy should be chosen individually according to patient's condition, pulse, arterial pressure before and after the procedure. The following parameters should also be taken into consideration: control of adaptive reactions according to L.Garkavi, lipid peroxidation data and antioxidant system enzymes, oxygen metabolism kinetics findings received by transcutaneous polarography, etc.

3. Analysis of general non-specific reactions (according to L.Garkavi) allows to recommend ozonetherapy to be widely used in a complex spa-treatment in patients with cardio-vascular diseases in order to shorten the period of adaptation and reinforcement of the basic spa therapy.

4. The results of oxygen metabolism kinetics test show growing efficiency of oxygen consumption with the body tissues due to ozonetherapy.

5. Analysis of veloergometric test readings confirms the economical utilization of myocardium potentials after the course of ozonetherapy along with increasing tolerance to physical loads and volume of the performed work. Thus, functional myocardium potentials become reinforced, and it seems to be of particular importance for this group of patients.

6. Ozonetherapy was found to result in lowering down the anxiety level and it was confirmed by tailor's psycho-tests.

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