ROLE OF MOFETTE THERAPY IN CARDIOVASCULAR REHABILITATION - THE COVASNA MODEL

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Abstract

The mofettes used for therapeutic purposes in Romania, in the Hospital of Rehabilitation in Cardiovascular Diseases Covasna, are unique in the world. Here, carbon dioxide in the form of carbogaseous baths and particularly, mofettes plays an important role not only in primary prevention, but also in secondary prevention and the rehabilitation of cardiovascular diseases.

Aim. The aim of this study is to evidence the role of mofette therapy as part of residential rehabilitation programs carried out at the Hospital of Rehabilitation in Cardiovascular Diseases Covasna.

Material and methods. The study included 92 patients admitted to the Hospital of Rehabilitation in Cardiovascular Diseases Covasna, Romania. All patients were evaluated for the presence of the main cardiovascular risk factors. The mean age was 66.31±9.00 years, with age limits between 42-85 years. All patients attended complex cardiovascular rehabilitation programs. Of these, 49 patients also underwent mofette therapy.

Results. By analyzing the profile of patients undergoing mofette therapy, the following were found: 36.7% of the patients were overweight, 40.8% obese, 83.7% hypertensive, 69.4% dyslipidemic and 24.5% diabetic. There were differences between the group treated with mofette therapy and the group without mofette therapy regarding total cholesterol and LDL-cholesterol values, which were significantly higher in the group undergoing mofette therapy. Significantly fewer patients with old myocardial infarction and atrial fibrillation, respectively, were subjected to mofette rehabilitation procedures: 4.1% vs. 16.3%, p=0.05 and 2% vs. 20.9%, p=0.004, respectively. 6.1% of the patients had peripheral arterial disease.

In conclusion, mofette therapy combined with other classical procedures can play an important role in the rehabilitation of cardiovascular patients.

Introduction

Mofettes are natural emanations that contain carbon dioxide (CO_2) in concentrations of 90-98% and small amounts of H_2S, N_2 and Rn. In Romania, such emanations are found along the Harghita volcanic massif. The mofettes used for therapeutic purposes in Romania, in the Hospital of Rehabilitation in Cardiovascular Diseases Covasna, are unique in the world. Here, carbon dioxide in the form of carbogaseous baths and particularly, mofettes plays an important role not only in primary prevention, but also in secondary prevention and the rehabilitation of cardiovascular diseases. The types of cardiovascular disorders indicated for balneotherapy in Covasna for secondary prevention or rehabilitation are mainly represented by the following: obliterative arterial disease of the lower limbs, Burger thromboangiitis, chronic ischemic heart disease (all its forms), drug-controlled hypertension, heart valve

disease without rhythm and hemodynamic disorders (including operated valvulopathies, after 3 months), post-stroke sequelae, chronic venous disease [1, 2]. In the literature, there are no data regarding the role of this special therapy in the secondary prevention and the cardiovascular rehabilitation of patients with ischemic heart disease.

In this context, the aim of this study is to evidence the role of mofette therapy as part of residential rehabilitation programs carried out at the Hospital of Rehabilitation in Cardiovascular Diseases Covasna.

Material and method

The study included 92 patients admitted to the Hospital of Rehabilitation in Cardiovascular Diseases Covasna, Romania. The mean age was 66.31±9.00 years, with age limits between 42-85 years. Of these, 49 patients underwent mofette therapy.

All patients were evaluated for the presence of the main cardiovascular risk factors. Thus, lipid fractions and glycemia were determined in all patients. The blood samples (10 ml) were obtained by venipuncture according to the standard Lipid Research Clinics protocol [3]. LDL-cholesterol was estimated using the Friedewald formula [4]. Serum glycemia levels were measured using the "glucose oxidase" method [5]. Blood pressure was measured according to the standard protocol, as the mean of two measurements, after the patient rested in a lying position for 5 minutes. The patients were evaluated for the presence of obesity, a body mass index value higher than 30 kg/m^2 being defined as obesity.

All patients attended, in addition to classical cardiovascular rehabilitation programs consisting of physical training, climatotherapy, CO_2 baths, aerotherapy, electrotherapy and hydrokinesitherapy, special rehabilitation procedures consisting of mofette therapy.

Patients with contraindications for mofette therapy, such as cardiac rhythm and conduction disorders, acute coronary syndromes, heart failure, bronchial asthma, drug-uncontrolled hypertension, pulmonary hypertension were excluded from the study.

Statistical analysis was performed using the SPSS for Windows program (v 16.0, IBM Corporation, Armonk, NY, USA) and the MedCalc program (v 10.3.0.0, MedCalc Software, Ostend, Belgium). The Kolmogorov-Smirnov test was used to assess the presence/absence of the normal distribution of continuous numerical variables. The results were presented as numbers and percentages for qualitative variables, as mean ± standard deviation or mean, respectively. Data for qualitative variables were compared using the $\chi 2$ test. For the comparison of quantitative data with a normal distribution, the Student test was used. A p value < 0.05 was considered as statistically significant.

The patients were informed about the study protocol and they signed an informed consent. The study was carried out according to the Ethical Code of the World Medical Association (Helsinki Declaration) regarding the involvement of human subjects in medical experiments.

Results

The main characteristics of the patients are synthesized in Table I.

By analyzing the profile of the patients who underwent mofette therapy, the following were found: 36.7% of the patients were overweight, 40.8% obese, 83.7% hypertensive, 69.4% dyslipidemic and 24.5% diabetic. Significantly fewer patients with old myocardial infarction and atrial fibrillation, respectively, were subjected to mofette rehabilitation procedures: 4.1% vs. 16.3%, p=0.05 and 2% vs. 20.9%, p=0.004, respectively.

There were no other statistically significant differences between the two groups of patients regarding the presence of cardiovascular diseases or cardiovascular risk factors.

As an exception, there were differences between the group treated with mofette therapy compared to the group without mofette therapy regarding total cholesterol and LDL-cholesterol values, which were significantly higher in the group receiving mofette therapy (Fig. 1).

In Figs. 2, 3, the biochemical profile of patients undergoing mofette rehabilitation procedures is analyzed depending on sex. In these cases, there were also no differences between patients with mofette therapy compared to those without mofette therapy.

Only 6.1% of the patients subjected to mofette procedures had peripheral arterial disease, without particular changes in cardiovascular risk factors.

Cardiovascular disease is currently the main cause of death worldwide, with an extremely high mortality rate in Eastern Europe and Romania [5, 6]. In this context, the goal of the Heart World Federation and the World Health Organization for 2025 is to reduce premature mortality from non-communicable diseases (cardiovascular disease, cancer, diabetes mellitus and chronic respiratory diseases) by 25%, which is known as the ”25 by 25” target [7]. This also means a 25% reduction of premature mortality from cardiovascular disease by the year 2025, through a 30% decrease in the prevalence of smoking, a 30% decrease in excessive salt consumption, a 25% decrease in the prevalence of hypertension, a 10% decrease in excessive alcohol consumption, a 0% increase in the prevalence of diabetes mellitus and a 10% decrease in sedentary lifestyle [8]. This means a 40% reduction of cardiovascular diseases by 2025 [9]. So, particular emphasis is placed on the role of prevention measures and physical training. Cardiovascular rehabilitation is currently the focus of attention. Cardiovascular rehabilitation modalities depend on cardiovascular pathology, the number of patients requiring rehabilitation, the addressability of patients, economic considerations (costs of inpatient vs. outpatient rehabilitation), the availability of rehabilitation centers (very few in Romania). In the Hospital of Rehabilitation in Cardiovascular Diseases Covasna, in addition to the drug treatment required for each patient depending on the disease, all patients undergo classical residential rehabilitation programs including: supervised physical training, psychotherapy, counseling for lifestyle change, diet therapy. At the same time, patients undergo other special rehabilitation procedures, specific to this hospital, which consist of climatotherapy, CO_2 baths, aerotherapy and mofette therapy.

Table I. Main characteristics of the patients

PATIENT CHARACTERISTICS	MOFETTE THERAPY +				MOFETTE THERAPY -					
	Global	**Women**	Men	P*	Global	**Women**	Men	P&	P%	P@
Sex (%)	49	**35 (71.4)**	14 (28.6)	-	43	**23 (53.5)**	20(46.5)		0.059	
Mean age (years)	65.02±8.94	**66.85±9.6**	61.35±5.8	0.06	67.79±8.94	**68.08±8.1**	67.45±9.9	NS	**NS**	0.03
Total cholesterol (mmol/ml)	5.57 ± 1.43	**5.70± 1.51**	5.24± 1.18	NS	4.94± 1.67	**5.44±1.11**	4.36±2.02	0.03	**NS**	NS
LDL-cholesterol (mmol/ml)	2.88 ± 1.57	**3.02 ± 1.57**	2.54± 1.57	NS	2.23±1.68	**2.74±1.55**	1.65±1.68	0.03	**NS**	NS
HDL-cholesterol (mmol/ml)	1.14 ± 0.57	**1.24±0.57**	0.9±0.51	0.06	0.96±0.65	**1.14±0.62**	0.75±0.64	0.05	**NS**	NS
Triglycerides (mmol/ml)	1.82 ± 0.86	**1.66±0.67**	2.20±1.16	0.04	1.84±1.52	**1.73±0.79**	1.98±2.09	NS	**NS**	NS
Glycemia (mmol/ml)	5.92 ± 1.46	**5.67±1.30**	6.54±1.71	0.06	6.08±2.25	**6.17±1.66**	5.98±2.83	NS	**NS**	NS
Hypertension (%)	41 (83.7)	**29 (82.9)**	12(85.7)	NS	32 (74.4)	**19(82.6)**	13(65)	NS	**NS**	NS
Dyslipidemia (%)	34 (69.4)	**24 (68.6)**	10(71.4)	NS	25 (58.1)	**12(52.2)**	13(65)	NS	**NS**	NS
Diabetes mellitus (%)	12 (24.5)	**8(22.9)**	4(28.6)	NS	16 (37.2)	**10(43.5)**	6(30)	NS	**NS**	NS
Overweight (%)	18 (36.7)	**12(34.3)**	6(42.9)	NS	0	**0**	0	NS	**0.004**	0.005
Obesity (%)	20 (40.**8**)	**13(37.1)**	7(50)	NS	14(32.6)	**9(39.1)**	5(25)	NS	**NS**	NS
Ischemic heart disease	44 (89.4)	**33(94.3)**	11(78.6)	NS	40(93)	**21(91.3)**	19(95)	NS	**NS**	NS
Myocardial infarction	2(4.1)	**1(2.9)**	1(7.1)	NS	7(16.3)	**2(8.7)**	5(25)	NS	**NS**	NS
Heart failure	8(16.3)	**6(17.1)**	2(14.3)	NS	12(27.9)	**5(21.7)**	7(35)	NS	**NS**	NS
AF	1(2)	**1(2.9)**	0	NS	9(20.9)	**4(17.4)**	5(25)	NS	**NS**	NS
Arterial disease (%)	3(6.1)	**1(2.9)**	2(14.3)		5(11.6)	**1(4.3)**	4(20)	NS	**NS**	NS
Heart valve disease	6(12.2)	**5(14.3)**	1(7.1)	NS	9(20.9)	**4(17.4)**	5(25)	NS	**NS**	NS
History of stroke	2(4.1)	**1(2.9)**	1(7.1)	NS	4(9.3)	**1(4.3)**	3(15)	NS	**NS**	NS

P* between women and men undergoing mofette therapy
P& between women and men NOT undergoing mofette therapy
P% between women with mofette therapy vs. women without mofette therapy
P@ between men with mofette therapy vs. men without mofette therapy

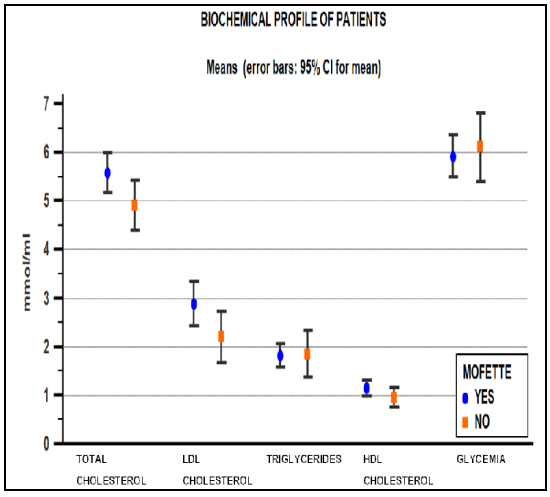

Fig. 1 Biochemical profile of patients undergoing mofette rehabilitation procedures

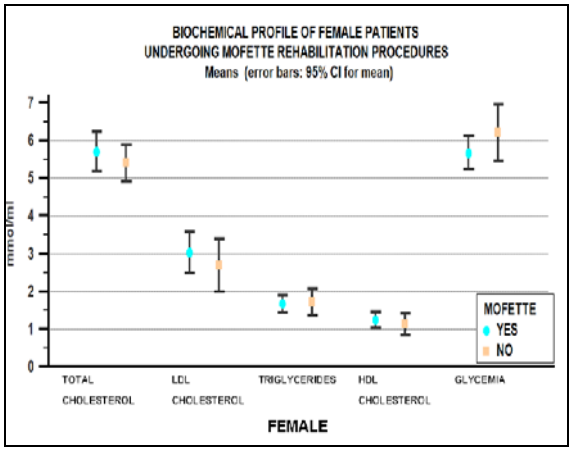

Fig. 2 Biochemical profile of female patients undergoing mofette rehabilitation procedures

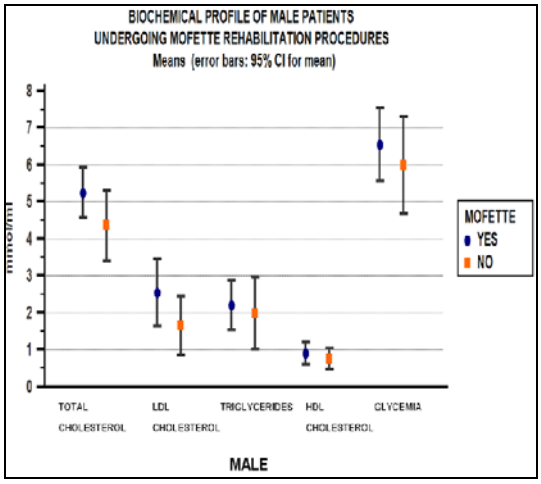

Fig. 3 Biochemical profile of male patients undergoing mofette rehabilitation procedures

Discussions

In a general natural mofette, the only therapeutic factor is mofette gas, which has the following composition: carbon dioxide (80-99 vol%), hydrogen sulfide, positive and negative air ions (2000-15 000 ions/cm^3) [2, 10]. It has a radioactivity of 0.3 µCi/l, with a safe pharmacological action, without cancer risk. The radon activity concentration levels in the mofette indoor air range between 548 and 10717 Bq/m3 [2, 5]. Mofette therapy at the Hospital of Rehabilitation in Cardiovascular Diseases Covasna is administered collectively in specially designed rooms, which have the shape of a Roman circus. Patients are positioned on a certain tier depending on the gas level, with the possibility of inhaling 1.5-5% CO_2 concentrations. Traditionally, the gas level is established with a match – the place where the flame goes out is considered the place up to which the CO_2 level rises. Carbon dioxide therapy, particularly in the form of natural mofettes, has many effects. Thus, this gas induces cutaneous vasodilation by direct action on metarterioles at this level. At the same time, inhaled into the body, it improves cerebral as well as skeletal muscle blood flow. It also influences the levels of urinary catecholamines and plasma renin, both in the short and long term. It contributes to the decrease of peripheral resistance and blood pressure. All these actions have important consequences on the heart hemodynamics (shortening of the pre-ejection period, prolongation of the ejection period, increase of stroke volume, increase of coronary perfusion).

There are few literature studies that approach the role of mofette therapy in the rehabilitation of cardiovascular patients. In our study, the majority of the patients who underwent mofette therapy were overweight, hypertensive and dyslipidemic. Significantly fewer patients with old myocardial infarction and atrial fibrillation, respectively, were subjected to mofette rehabilitation procedures. There were no other statistically significant differences between the two groups of patients regarding the presence of cardiovascular diseases or cardiovascular risk factors. As an exception, there were differences between the group treated with mofette therapy compared to that without mofette therapy regarding total cholesterol and LDL-cholesterol values, which were significantly higher in the group undergoing mofette therapy.

According to the literature data, both arterial and venous peripheral circulatory disorders are the most favored in terms of the results obtained [11]. The claudication index is significantly improved, the increase of the walking perimeter having a considerable positive mental effect. In our study, 6.1% of the patients with arterial diseases were subjected to mofette rehabilitation procedures. Brassai et al. demonstrated an improvement of the claudication index, of oscillometric values, of collateral circulation in the limbs affected by peripheral ischemia following mofette therapy [11].

In conclusion, mofette therapy combined with other classical procedures can play an important role in the rehabilitation of cardiovascular patients.

References

1. Autor colectiv sub egida Ministerului Sănătății. Cura balneoclimaterică, indicații şi contraindicații. Editura Medicală Bucureşti 1986.
2. Néda T, Szakács A, Cosma C, Mócsy I. Radon concentration measurements in mofettes from Harghita and Covasna counties, Romania. J Environ Radioact. 2008 ;99(12):1819-24.
3. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative centrifuge. Clin Chem. 1972;18:499–500.
4. Lott JA, Turner K. Evaluation of Trinder's glucose oxidase method for measuring glucose in serum and urine. Clin Chem. 1975;21:1754–60.
5. Nichols M, Townsend N, Scarborough P, Rayner M. Cardiovascular disease in Europe 2014: epidemiological update. Eur Heart J. 2014;35(42):2950-9.
6. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, de Ferranti S, Després JP, Fullerton HJ, Howard VJ, Huffman MD, Judd SE, Kissela BM, Lackland DT, Lichtman JH, Lisabeth LD, Liu S, Mackey RH, Matchar DB, McGuire DK, Mohler ER 3rd, Moy CS, Muntner P, Mussolino ME, Nasir K, Neumar RW, Nichol G, Palaniappan L, Pandey DK, Reeves MJ, Rodriguez CJ, Sorlie PD, Stein J, Towfighi A, Turan TN, Virani SS, Willey JZ, Woo D, Yeh RW, Turner MB. Heart disease and stroke statistics-2015 update: a report from the American Heart Association.
American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation. 2015;131(4):434-41.
7. United Nations General Assembly. Resolution adopted by the General Assembly:66/2: Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases. Adopted 19 September. 2011; published 24 January 2012.
8. Stone NJ, Robinson JG, Lichtenstein AH, et al. 2013 ACC/AHA guideline on the treatment of blood cholesterol to redu ce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;129(25 Suppl 2):S1-45.
9. Gielen S, Landmesser U. The Year in Cardiology 2013: cardiovascular disease prevention. Eur Heart J. 2014 ;35(5):307-12.
10. Hadnagy C, Benedek G. Information of action mechanism of mofettes in Covasna. Arch Phys Ther (Leipz). 1968;20(4):229-33.
11. Brassai Z, Mako K, Brassai A, Puskcas A. The role of carbogaseous baths and mofettes from Covasna in the treatment of lower limb arteriopathies. Ed Scientica. Cluj-Napoca, 2004.