Effects of physical therapy and CO_2 treatment in patients with hypertension and lumbar pathology in Buziaș resort

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Abstract

One of the key benefits of carbon dioxide water bath treatment in Buzias resort is the arterial vasodilatation which will have the effect of lowering blood pressure, relieving the feeling of joint stiffness and promoting muscle relaxation. Cardiac rehabilitation carried out in the Spa Medical Centre of the Parc Hotel Complex aims at restoring the patient's functional capacity, damaged by diseases as well as developing compensatory mechanisms that improve and maintain the quality of life.

Keywords: cardiac rehabilitation, Buziaș spa resort, carbon dioxide treatment, functional capacity

INTRODUCTION

Hypertension is the most important risk factor for stroke and one of the three major risk factors for coronary heart disease. The risk of coronary heart disease or stroke correlates directly with blood pressure across the entire spectrum of blood pressure values, and it is impossible to draw a line between blood pressure levels that do not pose a risk and those that are associated with cardiovascular disease risk. Hypertension is therefore best defined pragmatically, for example as the blood pressure level above which treatment trials have shown that lowering blood pressure values brings benefits [1].

Given that cardiovascular disease is common in the general population and also one of the major public health problems, we thus understand the seriousness and implications for health status. Cardiac rehabilitation is an interdisciplinary approach to patients with functional limitations secondary to cardiac disease and it is concerned with the optimal rehabilitation of patients from medical, physical, psychological, social and vocational perspectives [2].

Balneotherapy is important in cardiovascular rehabilitation because it makes use of the remedies offered by nature, i.e. carbon dioxide waters and climate. Buziaş is a spa resort of national interest, in Timiş county, located in the south-west of Romania, in the Banat Plain, and is known for its beauty, historical importance and, of course, for the main balneological profile represented by the cardiac rehabilitation [3]. The most important natural therapeutic factors of the Buziaş spa resort are CO_2 -water baths, dry CO_2 bathing called mofette and sedative bioclimate.

The carbon dioxide water from Buziaş – Parc Hotel Complex are used in cardiovascular rehabilitation, they are a mixture of bicarbonate, magnesium-calcium, chloride, bromide and calcium waters. Mofettes are free CO_2 emanations, i.e dry CO_2 bathing, used for therapeutic purposes in specially designed rooms in the form of a "Roman circus" that allow the gaseous carbon dioxide to accumulate in a sloping way, as it is heavier than air. The existing mofettes in the Medical Center of the Parc Hotel Complex in Buziaş are characterised by dry gas emanations rich in carbon dioxide in concentrations of about 98% associated with low amounts of CH_4, O_2 and N_2. Increased carbon dioxide in the blood increases the extensibility of cardiac muscle fibers during diastole and consequently has a favorable effect on heart filling, increasing cardiac output.

Physical actvity counseling and individually prescribed and supervised exercise training are core components of a comprehensive cardiac rehabilitation program, comprimising 30-50 % up to 70% of all cardiac rehabilitation activities [4].

Aim and objectives

The main aim of this study was to observe changes in cardiac parameters in cases of prehypertension and hypertension associated with lumbar spondylosis and intervertebral disc pathology after CO_2 treatment and specific physical therapy.

In this case, physical therapy can be used for therapeutic and rehabilitation purposes. During the kinetotherapy session, the aim is to restore mobility, increase muscle strength, exercise training, restore balance and proprioception. The intensity and frequency of the exercises should be dosed according to the patient's capacity, taking into account warm-up at the beginning and cool-down or stretching at the end. Hydrokinetic therapy through physical exercises helps to increase muscle strength without loading the joints with body weight [5,6].

Exercises in cardiac rehabilitation are based mostly on aerobic endurance training. Further components such as resistance exercises, coordination exercises, flexibility and strength exercise training are to be added [4].

MATERIALS AND METHODS

Patients

Patients addressing to physical medicine and rehabilitation services with hypertension and prehypertension, lumbar spondylosis and intervertebral disc pathology were recruited to be included in the study. Inclusion criteria were 1) age over 18 years, 2) lumbar spondylosis, 3) intervertebral disc pathology with no clinical neurologic deficit, 4) patients with hypertension stage I and II, 5) patients with prehypertension, 6) no history of cardiac failure.

The study included 32 patients, 13 with prehypertension, and 19 patients with stage I (n=14) and stage II (n=5) hypertension. All patients had history of lumbar spondylosis and intervertebral disc pathology. All patients received gaseous CO_2 bathing, CO_2 water baths and physical therapy.

Study protocol was explained to all participants and those who fulfilled the inclusion criteria and agreed to participate in the study signed an informed consent. The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of „Victor Babes" University of Medicine and Pharmacy Timisoara, Romania.

Assessments

Clinical assessment was performed at the first visit including physical examination (posture and mobility assessment). Demographic data were collected, including age, sex, weight and height. Patients who were included in the study were evaluated at the beginning, on the first day of treatment and then on the fourteenth day of treatment by measuring cardiac parameters using blood pressure monitor and pulseoximeter. The treatment applied to patients consisted in carbon dioxide baths, moffettes associated with physical therapy.

The spa treatment with CO_2 water was made in a rectangular bathtub made of acrylic material (Figure 1) to keep the water at a constant temperature. The recording was performed at room temperature, with patient in relaxed position. The exposure time in the carbon dioxide water bath at 33-34 °C was 15 minutes.

Figure 1. Spa treatment with CO_2 water bath

All patients included in this study underwent the treatment with mofettes, which are gaseous CO_2 baths, used in specially designed rooms in the form of a "Roman circus" (Figure 2) that allow the gas to accumulate in a sloping way, as it is heavier than air. The exposure time was 10 minutes on the second and third step.

Figure 2. Mofettes treatment

After finishing the CO_2 water bath and mofettes, we evaluated blood pressure and heart rate with a blood pressure monitor and peripheral oxygen saturation with a pulseoximeter. After clinical evaluation and balneotherapy treatment every subject received back-friendly cardiovascular exercise and lumbar stabilization exercises organized in group therapy sessions (Figure 3 The program included: gymnastic exercises such as analytical mobilization of body segments at a slow pace, associated with breathing, with a warm-up role, exercises to intensify muscle group metabolism to achieve vasodilation and decrease peripheral resistance, aerobic endurance training using cycle ergometer up to 75% of maximum heart rate. The kinetotherapy program included also several lumbar stabilization exercise in order to improve the strength, endurance and motor control of the abdominal and lumbar trunk musculature and back school education. The exercise program was conducted carefully taking into consideration patients' cardiac pathology.

Figure 3. Group exercise training

Pain intensity was quantified on the visual analogue scale (VAS) from 0 (no pain) to 100 (maximal pain). Patients also completed the EQ-5D-5L questionnaire, a standardized measure of health status [7]. The five dimensions assessed by EQ-5D-5L questionnaire are mobility, self-care, usual activities, pain/discomfort and anxiety/depression. The answers are ranked on 5 levels, from 1 indicating no problem, to 5 indicating unable/ extreme problems.

Statistical analysis was performed with MedCalc software. All normal distributed data are presented as mean and standard deviation. Paired student t tests were performed to compare cardio-vascular parameters, pain and quality of life parameters before and after

therapy. One way Anova analysis was performed to identify differences between groups. Statistical significance was set at $p<0.05$.

RESULTS

Thirty-two patients (mean age 62.1 ±7.14 years; 53.13% males) met the inclusion criteria and were included in the study. 13 of these patients had prehypertension, 14 had stage I hypertension and 5 stage II hypertension [8]. Patients characteristics are presented in Table 1.

Table 1. Characteristics of patients with prehypertension

	Prehypertension patients (n=13)	**Stage I hypertension patients (n=14)**	**Stage II hypertension patients (n=5)**
Age (years) mean±SD	60.1 ± 8.40	61.71 ± 6.17	66.8 ± 4.97
Weight (kg) mean±SD	75 ± 10.27	85.65 ± 7.35	99.6 ± 9.15
Height (cm) mean±SD	166.23 ± 9.35	173.36 ± 8.30	174.8 ± 8.93
BMI (kg/m^2) mean±SD	27.07 ± 2.11	28.48 ± 1.33	32.60 ± 1.84
Lumbar spondylosis, %	61.54	50	80
Intervertebral disc pathology, %	38.46	50	20

In the group of patients with prehypertension kinetoterapy was performed by 61.54% of patients, the rest of 38.46% had physiotherapy. Kinetotherapy was performed by 64.29% of patients with stage I hypertension, and by 40% of patients with stage II hypertension. The rest performed physiotherapy. The cardio-vascular parameters before and after CO_2 therapy are presented in Table 2. A significant decrease of both systolic and diastolic blood pressure was observed after therapy.

Table 2. Cardio-vascular parameters before and after therapy, for all patients

	Before therapy	**After therapy**	**p**
Systolic blood pressure (mmHg)	138.91±16.64	120.06±14.68	<0.0001
Diastolic blood pressure (mmHg)	82.25±9.43	69.81±6.85	<0.0001
Heart rate (b/min)	72.09±10.65	73±7.64	>0.05
SpO2 (%)	96.5±2.04	97.03±2.04	>0.05

data are presented as mean±SD

A significant decrease in systolic and diastolic blood pressure was observed after therapy in patients with prehypertension, as well as in those with stage I hypertension ($p<0.0001$). In patients with stage II hypertension, only the systolic blood pressure had significantly decreased after treatment ($p<0.0001$). A significant increase in SpO2 was observed only in stage II hypertension patients ($p=0.04$). All parameters are presented in Table 3.

Table 3. Cardio-vascular parameters before and after therapy, according to hypertension stages

	Prehypertension patients (n=13)		**Stage I hypertension patients (n=14)**		**Stage II hypertension patients (n=5)**	
	Before	After	Before	After	Before	After
Systolic blood pressure (mmHg)	123.46±9.19	105.46±9.31	146.42±6.61	126.21±5.02	162±4.47	136.8±7.32
Diastolic blood pressure (mmHg)	76.3±8.07	65.92±6.42	86.78±8.27	73.28±5.99	85±9.66	70.2±5.63
Heart rate (b/min)	68.3±8.17	70.07±6.22	75.28±11.8	74.71±8.03	73±11.91	75.8±8.89
SpO2 (%)	97.23±1.69	97±1.82	95.64±2.37	96.57±1.65	97±1	98.4±0.89

data are presented as mean±SD

Pain was significantly improved, with a decrease of VAS score from 6.5±1.16 to 3.37±0.83 ($p<0.0001$), and a decrease in the pain dimension of the EQ-5D-5L questionnaire ($p<0.0001$). All EQ-5d-5L questionnaire dimensions were significantly lower after CO_2 therapy and physical therapy (Table 4).

Table 4. Pain and EQ-5D-5L scores before and after therapy, for all patients

	Before therapy	After therapy	p
VAS	6.5±1.16	3.37±0.83	<0.0001
EQ-5D-5L Mobility	2.87±0.7	2.12±0.33	<0.0001
EQ-5D-5L Self- care	2.62±0.49	1.62±0.49	<0.0001
EQ-5D-5L Usual activities	3.53±0.5	2	<0.0001
EQ-5D-5L Pain/ Discomfort	3.56±0.5	2.4±0.49	<0.0001
EQ-5D-5L Anxiety/ depression	3.65±0.48	2.21±0.42	<0.0001

data are presented as mean±SD

Pain, as well as all dimensions of EQ-5d-5L questionnaire significantly decreased, except for EQ-5d-5L Mobility in stage II hypertension patients where no significant difference was noted. All pain and EQ-5D-5L scores before and after therapy, according to hypertension stages, are presented in Table 5.

Table 5. Pain and EQ-5D-5L scores before and after therapy, according to hypertension stages

	Prehypertension patients (n=13)		Stage I hypertension patients (n=14)		Stage II hypertension patients (n=5)	
	Before	After	Before	After	Before	After
VAS	6.69±1.43	3.46±0.96	6.42±0.93	3.42±0.64	6.2±1.09	3±1
EQ-5D-5L Mobility	3±0.91	2.23±0.43	2.78±0.42	2	2.8±0.83	2.2±0.44
EQ-5D-5L Self- care	2.61±0.5	1.61±0.5	2.64±0.49	1.64±0.49	2.6±0.54	1.6±0.54
EQ-5D-5L Usual activities	3.61±0.5	2	3.42±0.51	2	3.6±0.54	2
EQ-5D-5L Pain/ Discomfort	3.61±0.5	2.53±0.51	3.42±0.51	2.28±0.46	3.8±0.44	2.4±0.54
EQ-5D-5L Anxiety/ depression	3.61±0.5	2.23±0.43	3.71±0.46	2.28±0.46	3.6±0.54	2

data are presented as mean±SD

DISCUSSIONS

This study aimed to evaluate the dynamics of cardiac parameters, e.g. blood pressure(BP), heart rate(HR) and peripheral oxygen saturation (SpO_2) before and after treatment with mofettes, carbon dioxide water baths and physical therapy treatment in patients diagnosed with prehypertension and stage I and II hypertension associated with lumbar spondylosis and intervertebral disc pathology. We found a significant decrease of both systolic and diastolic blood pressure after CO_2 therapy.

The CO_2 water from Parc Hotel Complex in Buziaș spa resort is used for therapeutic purposes for cardiovascular rehabilitation, being the main profile of the resort. They are a mixture of bicarbonate, magnesium-calcium, chloride, bromide and calcium waters. The composition of the mineral water is as follows: CO2 1443.2 mg/l, Cl 579.9 mg/l, Bicarbonate 2025.2 mg/l, Mg 110.2 mg/l, Fe 3 mg/l, Na 685.5 mg/l, K 19 mg/l, Ca 206.8 mg/l, Bromine 0.3 mg/l, Iodine 0.1 mg/l, mineralization 3743.7 mg/l [9].

Elimban et al. [10] observed in their study that CO_2 water bath temperature influences blood flow and vascular density in a group of rat hind limb ischemia. In their study CO2 water bath therapy at 34°C increased maximum, minimum and mean blood flow by 190%-

600% in the ischemic rat limb. In our study we applied carbon dioxide water baths to patients at 33°C to 34°C for 15 minutes over a period of two weeks.

In this study we found a significant decrease of both systolic and diastolic blood pressure after CO_2 therapy, from 120.06±14.68 for systolic blood pressure and 69.81±6.85 for diastolic blood pressure. When comparing the systolic and diastolic blood pressure values before and after therapy, we observed a significant decrease for bot types of blood pressure, except of the diastolic blood pressure in patients with stage II hypertension.

Finzgar et al. [11] studied one lower limb of 33 subjects exposed to gaseous CO2 to improve the perfusion and oxygenation of tissues. During CO2 therapy the flux in cutaneous microcirculation in the studied extremity increased, thus results confirm a local vasodilatory effect of applied CO2 therapy. In our study we found an increase in both parameters, respectively heart rate (b/min) from 72.09±10.65 to 73±7.64 ($p>0.05$) and peripheral oxygen saturation (SpO_2) from 96.5±2.04 % to 97.03±2.04 ($p>0.05$), although the differences were not statistically significant.

In this study, we also evaluated the percentage of physical exercises represented by kinetotherapy. We observed that the stage I Hypertension group had the best percentage of kinetotherapy performance, which was 64.29% compared to 40% of stage II Hypertension patients. Meng et al, in 2015 studied the effect of aerobic exercise in patients with chronic low back pain concluding that aerobic exercises decrease pain, increase fitness [12].

Aerobic exercise can reduce disability and improve the functional status of patients with CLBP by increasing fitness levels, helping patients conduct activities of daily living. Gordon and Bloxham in 2016 studied the effects of aerobic exercises on patients with chronic low back pain. A general exercise programme which combines muscular strength, flexibility and aerobic fitness would be beneficial for rehabilitation of non-specific chronic low back pain [13].

Ronai P. in 2019 made some exercise recommendations for cardiac patients with chronic nonspecific low back pain indicating an individualized approach to developing exercise program with a constant monitoring patient for new or worsening symptoms [14]. Our patients had an individualized exercise program though they had a group session. Some authors studied the combined effect of carbon dioxide baths and physical exercise on EKG parameters and cardiac rhythm variability in postmyocardial infarction patients noticing less number and duration of episodes of ST -segment ischemic depressions and the trend to normalization of heart rhythm [15].

Our study has some limitations, like the relatively small sample size. Larger studies are needed to have a more specific insights on the beneficial effects of balneotherapy in conjunction with physical therapy based on hypertension stages.

CONCLUSIONS

Cardiovascular diseases are one of the most common forms of disease globally, which is why we believe it is important to apply balneotherapy and physical therapy to these patients. The present study started from the desire to find out whether the treatment with carbonated mineral water baths and mofettes associated with kinetotherapy, applied in the Medical Centre of the Parc Hotel Complex in Buziaş spa resort, influences the dynamics of the cardiovascular parameters. Considering the small group studied, we can admit that this preliminary result influences the dynamics of blood pressure, heart rate and SpO_2 values, supporting the necessity to perform balneotherapy and physical therapy together.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of „Victor Babes" University of Medicine and Pharmacy Timisoara, Romania (protocol nr. 28/10.01.2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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