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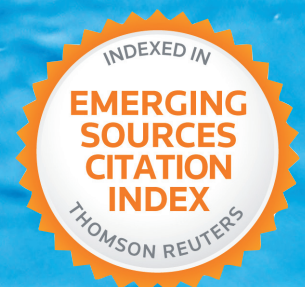
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PHYSICAL THERAPY IN CEREBRAL PALSY. CLINICAL ASPECTS. CASE REPORT

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ABSTRACT

Cerebral palsy is a non-progressive functional disorder affecting the developing central nervous system, predominantly motor neurons, whose onset occurs during pregnancy, delivery or in the perinatal period. The incidence of cerebral palsy ranges from 1.5 to 2.5 per 1,000 live births. Brain damage due to periventricular leukomalacia and intraventricular haemorrhage in newborns is the most common cause of cerebral palsy.

This paper presents the clinical picture of a girl with cerebral palsy. The child experienced perinatal hypoxia, which resulted in central nervous system damage and changes in the form of periventricular leukomalacia. Initially, she exhibited considerable axial hypotonia and upper and lower limb hypotonia. Rehabilitation was promptly initiated using a combination of multiple neurological methods, for example Vojta's method, NDT Bobath therapy and PNF. The rehabilitation produced the desired effects, with the child achieving better motor control with respect to trunk and head stabilisation. She began using orthopaedic aids and undergoing verticalisation at the age of two years. She started experimental stem cell treatment in 2016. Currently her therapy takes place five times a week. The child is able to walk a short distance when she is being held by her arms. She acquires new skills and learns fast and has a wide vocabulary. She is motivated and determined to continue her rehabilitation in order to achieve her dream of walking with a walker by herself. Systematic motor rehabilitation contributed to an improvement in the physical fitness and everyday functioning of the child.

KEY WORDS: cerebral palsy, physical therapy, rehabilitation

INTRODUCTION

The prevalence of cerebral palsy (CP) is estimated at 1.5 to 2.5 cases per 1,000 live births. There are approximately 50,000 physically disabled children in Poland and over a half of those individuals have CP.

Multiple factors are responsible for the development of CP. The most important ones include preterm birth, hypoxia and ischaemia of the brain in the foetus, extremely low birth weight, multiple pregnancy, infections during pregnancy and the mother being under 16 or over 40 years old. CP is heterogeneous both clinically and etiologically. It is a non-progressive functional disorder affecting the developing central nervous system, predominantly motor neurons, whose onset occurs during pregnancy, delivery or in the perinatal period. Children with CP show various motor abnormalities and multiple health, emotional and social problems [1-13].

DIAGNOSTIC WORK-UP IN CEREBRAL PALSY

Magnetic resonance imaging (MRI) of the head is a neuroimaging technique best suited to detect hypoxic-ischaemic changes occurring in the perinatal period. Identifying their location, size and further evolution helps establish the prognosis with respect to future development of the child. A transfontanellar ultrasound in full-term children with perinatal hypoxia may visualise the most severe brain tissue changes [6, 7].

Early assessment of central motor abnormalities in these children includes the following:

- Functional assessment with the use of:
 - General Movements (GM) assessment;
 - neurodevelopmental assessment (NDT);
 - Vojta's neurokinesiological diagnostics;
 - psychomotor development profile using Munich Functional Developmental Diagnostics (MFDD) tests;
 - psychoeducational and speech assessment [2-6].

The Munich Functional Developmental Diagnostics (MFDD) tests assess the "age" of developing motor functions, i.e. crawling, sitting down, walking, gripping, and the level of communication skills [4-6].

Neurodevelopmental assessment (NDT). This method's main tool is to evaluate the development of the antigravity mechanism in infants through assessment of the "quality" of postural and motor patterns as well as the respective postural tone distribution in the course of psychomotor development [4-6].

The General Movements (GM) assessment, or Prechtl's method, is one of the leading methods of assessment of the "quality" of postural and motor patterns.

The range of normal GMs is quite broad and includes the following:

- Foetal Movements, Preterm Movements: foetal or pre-term patterns occurring until the date of birth.

- Writhing Movements (WMs).
- Fidgety Movements (FM).
- In case of central nervous system (CNS) damage, general movements lose their complexity, become monotonous and are manifested as abnormal general movement patterns.

VOJTA'S DIAGNOSTICS

Vojta's diagnostics focuses on assessing postural patterns and psychomotor activity in children from birth to 1 year of age. Vojta created a diagnostic framework that helps determine the motor abilities of a child.

FUNCTIONAL SCALES USED IN CEREBRAL PALSY

The Gross Motor Function Classification System (GMFCS) is the first system that describes the severity of physical disability in children with CP. The GMFCS classifies the motor abilities and the severity of physical disability in children with CP into one of five levels. It currently includes descriptions of children's abilities on every level in four age groups: up to 2 years, 2 to 4 years, 4 to 6 years, and 6 to 12 years [3-4].

The Gross Motor Function Measure-66 (GMFM-66) is used solely to assess children with CP. It is based, among others, on the GMFM-88, which accurately describes the degree of difficulty in performing various tasks by children with CP. The GMFM-66 consists of 66 motor tests performed on five levels, i.e. lying and rolling, sitting, crawling and kneeling, standing, and walking, running and jumping [3-4].

The Manual Ability Classification System (MACS) is another tool used in CP children. The MACS analyses the ability to use one's hands to handle objects during daily activities.

The Communication Function Classification System (CFCFS) is a complementary system that helps determine the level of everyday communication performance.

The Functional Independence Measure for Children (WeeFIM) is used to describe and assess functional independence at home and among other children in patients before they reach school age and in those with developmental problems. This scale assesses children aged 6 months to 8 years, including healthy children and children with developmental problems, and individuals of any age who are mentally under the age of 7 years. This is an 18-item scale divided into 7 functional levels. It assesses such activities as self-care, bladder and bowel control, mobility, transferring, quality of communication, independence during meals and the way the child behaves in their environment [3-5].

Physical therapy and rehabilitation constitute the basis of treatment in this group of patients [14-24]. The following methods of rehabilitation are used:

- NDT Bobath therapy
- The NDT Bobath therapy is the most common rehabilitation method used in children with CP as well as with other dysfunctions.
- The NDT Bobath therapy allows for conducting early treatment of newborns and infants, and neurodevelopmental assessment not only enables early detection of central motor abnormalities, but also constitutes a func-

tional assessment tool used to plan further treatment and monitor the effects during rehabilitation. Realignment of body segments in relation to each other is the basic technique in this therapy and changes the other components of the motor control mechanism. According to this concept, this is called key point manipulation [14-24].

VOJTA'S METHOD

The approach developed by a Czechoslovakian neurologist called Vaclav Vojta is another method used in the rehabilitation of children with CP. Vojta's method consists in priming, that is stimulating coordination fields in the CNS based on temporal and spatial summation.

PETO METHOD

The Peto method combines therapeutic and psychoeducational rehabilitation with various forms of social adaptation. The main goal of this method is to appropriately prepare the disabled child for independent functioning [5-6].

PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF)

This method incorporates motor patterns called mass movement patterns based on functional patterns used during different activities of daily living, for example eating, walking and sitting. The patterns can be spiral or diagonal, with the synergy of the relevant muscle groups. A movement pattern consists of three components.

Orthopaedic aids play a key role in the process of rehabilitation in children with CP. Orthoses should be adjusted to the current functional treatment goal. They should never be used in isolation and should always constitute an element of an ongoing rehabilitation process [21-24].

CASE REPORT

The girl was born via a C-section in 2012 at 30 weeks of gestation with a birth weight of 1160 g. The whole course of the pregnancy was normal; however, at around 29 weeks the mother developed hypertension and proteinuria, which within several hours led to the most severe condition a pregnant woman can have, namely HELLP syndrome. In order to save the lives of the mother and the child, the decision was made to pursue delivery. In the first moments of her life, the child was resuscitated for ten minutes to restore her vital signs, after which she scored 1.3 and then 5 points in the Apgar test. Following the necessary care activities, nasal continuous positive airway pressure (nCPAP) was initiated. The child was transported to a hospital in Krakow on the third day after delivery. Her condition was very severe and she was intubated and underwent INSURE (INtubation-SURfactant-Extubation) surfactant administration. The condition of the child improved with every passing day. nCPAP respiratory support was initiated on the 8th day of her life and was performed until the 20th day of life. The child was tube-fed until the 26th day of life due to a weak sucking reflex and abnormal peristalsis.

During her hospital stay, the child underwent multiple examinations, including an ultrasound of the brain, with

the results as follows. On the 9th day an ultrasound showed immature brain tissue, not fully developed sulci, and a visible cavum septum pellucidum. Hyperechogenic periventricular areas were visible. The ventricular system was not dilated within the anterior horns and bodies and it was symmetrical; it was dilated within the posterior horns (R: 26 mm, L: 22 mm). The pericerebral spaces were not dilated and the midline was not displaced. The choroid plexuses and the posterior cranial fossa were normal. The blood flow in the anterior cerebral artery (ACA) and the middle cerebral artery (MCA) was normal.

After two months, a transfontanellar ultrasound showed well-differentiated brain tissue.

The girl was discharged from hospital after two months with a body mass of 2590 g. She started rehabilitation at an early intervention centre. However, at first the rehabilitation took place once a month and her parents received instructions about the therapy they should conduct with their child at home (Fig. 1).



Fig. 1. The child's ability to support herself on her arms at the age of 6 months



Fig. 2. The child's ability to support herself on her arms during therapy at the age of 12 months

In the first months of life, the child showed considerably reduced axial muscle tone, complete lack of control of the head and trunk, left-sided asymmetry, no midline crossing, very sparse upper and lower limb movements, a narrow range of general movements and an initial lack of fidgety movements. She performed general movements in a very chaotic manner and lacked the ability to support herself on her arms.

The parents started intensive rehabilitation of their child using Vojta's method, which was supervised by a therapist (Fig. 2).

The asymmetry started to slowly decrease. Working on trunk extensors improved central and head control, which was particularly visible in higher positions. In addition, the NDT Bobath therapy was introduced when the child was 1 year old.

The child's development was very disharmonious from the start. She acquired intellectual, social and cognitive skills in a normal manner while her motor development was at the level of a 3-month-old infant with impaired antigravity reactions.

At the age of 2 years the girl was fully dependent on her carer. When her carer held her up, she sat on her knees with very weak head and trunk control. She continued to show very weak head control and axial muscle tone in higher positions (Fig. 3).

The child used orthopaedic aids in the form of an ankle foot orthosis (AFO), which stabilised her ankle joint and shin, on both lower limbs. Daily verticalisation was introduced in a verticaliser, which was initially performed for approximately half an hour a day. In addition to her everyday therapy, once a year the child participated in intensive 2-week inpatient rehabilitation programmes.

Moreover, the child underwent rehabilitation in a Dunag suit, which is a soft proprioceptive orthosis device consisting of a vest, shorts and knee and foot pieces connected by individually placed rings and elastic elements (Fig. 4).

At the age of 3 years the child underwent an MRI of the head with contrast. The scan showed no focal lesions and no pathological contrast-enhanced areas in her brain. The ventricular system was dilated, particularly within the



Fig. 3. The child's "on-all-fours" position at the age of 24 months



Fig. 4. The child's therapy at the age of 3 years in a Dunag suit

bodies, posterior horns and trigones; it was not compressed or displaced. The pericerebral fluid spaces showed no evidence of dilation.

The parents were searching for options and methods that could support the treatment of CP in their child through improving her functioning. In 2016, after a series of examinations, the girl was qualified for an experimental stem cell treatment. Mesenchymal cells were obtained from the umbilical cord, specifically from Wharton's jelly, of an unrelated donor. The biological material was administered to the patient in intravenous injections. A single treatment cycle consisted of 5 intravenous administrations of the biological material performed at an interval of 2 months. Before the administration of stem cells, the child underwent gross motor function assessment with the GMFM in order to verify any potential improvements occurring during treatment.

GROSS MOTOR FUNCTION ASSESSMENT GMFM-88 AND GMFM-66

The GMFM is a standardised observational instrument designed and validated to measure change in gross motor function over time in children with cerebral palsy (Table 1).

$$\begin{aligned} \text{Total score} &= \frac{\%A + \%B + \%C + \%D + \%E}{\text{Number of dimensions}} \\ &= \frac{64.70 + 18.33 + 2.38}{5} = 17.08\% \end{aligned}$$

Another GMFM test was performed one year later, on 5 April 2017, to verify the progress made by the child. The assessment was conducted after the first cycle of stem cell therapy, which consisted of 5 intravenous injections administered at an interval of 2 months (Table 2).

$$\begin{aligned} \text{Total score} &= \frac{\%A + \%B + \%C + \%D + \%E}{\text{Number of dimensions}} \\ &= \frac{70.58 + 18.33 + 2.38}{5} = 18.25\% \end{aligned}$$

The child showed small improvements in functioning and gross motor skills in the first year after the initiation of the experimental treatment. A comparison of the GMFM results revealed the difference to be only 1.17%.

Another stem cell treatment cycle started one year after the end of treatment. After comprehensive assessment of psychomotor progress in the child and after a series of examinations, the decision was made to administer material with stem cells directly into the cerebrospinal fluid through lumbar puncture at the L4–L5 level.

Another GMFM test was performed on 14 March 2018, before the next phase of experimental treatment cycles (Table 3).

$$\begin{aligned} \text{Total score} &= \frac{\%A + \%B + \%C + \%D + \%E}{\text{Number of dimensions}} \\ &= \frac{84.31 + 28.33 + 9.52 + 4.16}{5} = 25.26\% \end{aligned}$$

Another GMFM test to verify the progress made by the child with respect to gross motor skills was performed on 25 June 2020 (Table 4).

$$\begin{aligned} \text{Total score} &= \frac{\%A + \%B + \%C + \%D + \%E}{\text{Number of dimensions}} \\ &= \frac{98.03 + 40 + 16.66 + 15.38 + 12.2}{5} = 36.45\% \end{aligned}$$

Table 1. GMFM total score

| DIMENSION | CALCULATION OF DIMENSION % SCORES | GOAL AREA |
|--------------------------|--|-----------|
| A. lying and rolling | $\frac{\text{Total dimension A}}{51} = \frac{33}{51} \times 100 = 64.70\%$ | A |
| B. sitting | $\frac{\text{Total dimension B}}{60} = \frac{11}{60} \times 100 = 18.33\%$ | B |
| C. crawling and kneeling | $\frac{\text{Total dimension C}}{42} = \frac{1}{42} \times 100 = 2.38\%$ | C |
| D. standing | $\frac{\text{Total dimension D}}{39} = \frac{0}{39} \times 100 = 0\%$ | |
| E. walking and running | $\frac{\text{Total dimension E}}{72} = \frac{0}{72} \times 100 = 0\%$ | |

*Scoring key: 0 = does not initiate, 1 = initiates, 2 = partially completes, 3 = completes

Table 2. GMFM total score

| DIMENSION | CALCULATION OF DIMENSION % SCORES | GOAL AREA |
|--------------------------|---|-----------|
| A. lying and rolling | $\text{Total dimension A} = \frac{36}{51} \times 100 = 70.58\%$ | A |
| B. sitting | $\text{Total dimension B} = \frac{11}{60} \times 100 = 18.33\%$ | B |
| C. crawling and kneeling | $\text{Total dimension C} = \frac{1}{42} \times 100 = 2.38\%$ | C |
| D. standing | $\text{Total dimension D} = \frac{0}{39} \times 100 = 0\%$ | |
| E. walking and running | $\text{Total dimension E} = \frac{0}{72} \times 100 = 0\%$ | |

Table 3. GMFM total score

| DIMENSION | CALCULATION OF DIMENSION % SCORES | GOAL AREA |
|--------------------------|---|-----------|
| A. lying and rolling | $\text{Total dimension A} = \frac{43}{51} \times 100 = 84.31\%$ | A |
| B. sitting | $\text{Total dimension B} = \frac{17}{60} \times 100 = 28.33\%$ | B |
| C. crawling and kneeling | $\text{Total dimension C} = \frac{4}{42} \times 100 = 9.52\%$ | C |
| D. standing | $\text{Total dimension D} = \frac{0}{39} \times 100 = 0\%$ | |
| E. walking and running | $\text{Total dimension E} = \frac{3}{72} \times 100 = 4.16\%$ | E |

Table 4. GMFM total score

| DIMENSION | CALCULATION OF DIMENSION % SCORES | GOAL AREA |
|--------------------------|---|-----------|
| A. lying and rolling | $\text{Total dimension A} = \frac{50}{51} \times 100 = 98.03\%$ | A |
| B. sitting | $\text{Total dimension B} = \frac{24}{60} \times 100 = 40\%$ | B |
| C. crawling and kneeling | $\text{Total dimension C} = \frac{7}{42} \times 100 = 16.66\%$ | C |
| D. standing | $\text{Total dimension D} = \frac{6}{39} \times 100 = 15.38\%$ | D |
| E. walking and running | $\text{Total dimension E} = \frac{9}{72} \times 100 = 12.2\%$ | E |

The above test was performed one year after the last stem cell injection into the cerebrospinal fluid.

The results of the tests show a considerable difference in gross motor skills development in the child. The GMFM result before the administration of mesenchymal cells into the cerebrospinal fluid was 25.25%. Two years later the total score was higher by 11 percentage points and was 36.45%.

Head and trunk control was improved in the child, particularly in higher positions, which translated into better fine motor skills. The child's ability to write and make her own arts and crafts projects, sometimes with someone's help, increasingly improved. She does not use her left upper limb a lot in her daily life. When she is placed on all fours, she is able to maintain that position for more than

a minute. She is able to walk a short distance when someone is holding her by the arms. She can get up from a sitting position into a standing position with assistance and can maintain a standing position for 3 seconds without the therapist's help; with support, she is able to maintain a standing position for 10 seconds. She corrects her sitting position by herself by increasing trunk control (Fig. 5).

The girl is currently diagnosed with CP in the form of spastic tetraparesis. Functionally, her condition is classified as level four on a 5-point scale in the GMFCS. She rolls over from front to back and from back to front and crawls. When placed on all fours, she can maintain the position for a short moment. She is able to transfer from the position on all fours to a high kneeling position with assistance if there is a high



Fig. 5. The child at the age of 7 years in a TheraTogs suit

cube or another therapeutic aid in front of her. She sits in an orthopaedic chair that stabilises the pelvis and trunk. When sitting on a bench, she is able to stand up with assistance. She can walk a short distance, but she needs help; she uses a wheelchair with the help of other people. She requires help in daily activities and depends on her carers in many aspects of life. She currently has no deformities or contractures.

Even though there are currently 25,000 children with cerebral palsy in Poland, no perfect definition of the CP dysfunction has been developed so far.

The child was born extremely prematurely with a low birth weight and perinatal damage in the form of perinatal leukomalacia, which resulted from cardiac arrest and resuscitation in order to restore the vital signs. Ultrasound imaging of the brain showed multiple leukomalacia lesions in both hemispheres. Initially, the child presented with considerable hypotonia not only in her upper and lower limbs but also with respect to her head and trunk. Early multidisciplinary rehabilitation and stimulation gradually produced the expected effects. The child has been using orthopaedic aids and undergoing verticalisation in a verticaliser every day since she was 2 years old. She undergoes rehabilitation five times a week and the methods and treatments used are combined in order to achieve the best therapeutic effects. In addition, the child participated in speech therapy, educational therapy and sensory integration sessions.

The child has undergone two cycles of stem cell administration since 2016, after which she showed considerable improvements in gross and fine motor skills, translating into better functioning. However, it is clear that her motivation and determination during rehabilitation have a huge impact on the progress she has made.

The girl is under routine care at a neurology clinic and orthopaedics clinic and her therapy is currently conducted five times a week. She cannot sit unassisted, requires an appropriate seat and walks a short distance when she is being held by her arms. She learns and acquires new skills fast and has a wide vocabulary. She is motivated and determined to continue her rehabilitation in order to achieve her dream of walking with a walker by herself.

CONCLUSIONS

1. Cerebral palsy is a very difficult clinical and social problem.
2. Cerebral palsy treatment is based on physical therapy and rehabilitation.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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EFFECTS OF PULMONARY REHABILITATION IN SUBTERRANEAN SALT CHAMBERS ON FUNCTIONAL STATUS, CHEST MOBILITY, AND ENDURANCE OF PATIENTS WITH POST-COVID SYNDROME

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ABSTRACT

Aim: The main objective of this retrospective study was to determine the effect of a pulmonary rehabilitation programme conducted in underground salt chambers on functional status, chest mobility, and endurance of patients with post-COVID syndrome. In addition, we attempted to determine whether the symptoms reported by specific patients depended on the period in which they suffered from COVID-19.

Materials and Methods: Based on the analysis of the 'Wieliczka' Salt Mine Health Resort patients' medical records, the effects of post-COVID rehabilitation programme, in effect from June 19th, 2021 till October 28th, 2022, i.e. during 19 consecutive 3-week treatment stays, were assessed. The programme involved 699 patients, of whom 591 completed the entire programme. For each patient, the Post-COVID Functional Status questionnaire was completed, chest mobility was measured using a tape measure, and endurance was evaluated using the 2-Minute Step Test.

Results: The most common symptoms reported in the Post-COVID Functional Status questionnaire were: chronic fatigue, post-exertional malaise, and dyspnoea on exertion. The mean chest mobility significantly increased from 4.07 ± 2.17 cm before to 5.95 ± 4.99 cm ($p < 0.001$) after completion of the programme. In a definite majority of patients ($n = 467$, i.e. 79%), an improvement of the result of 2-Minute Step Test was observed, usually accompanied by increased fatigue with concomitant reduction of dyspnoea on exertion. The period in which patients suffered from the infection had no effect on reporting of specific symptoms.

Conclusions: Subterraneotherapy combined with pulmonary rehabilitation improves functional status, chest mobility, and endurance in patients with post-COVID syndrome.

KEY WORDS: subterraneotherapy, chest expansion test, 2-minute Step Test, PCFS, COVID-19

INTRODUCTION

By the end of 2019, in the city of Wuhan, Hubei province, China, a new coronavirus type was isolated. It was a result of the interest of researchers who wanted to find out the cause of significantly increased incidence of pneumonia of unknown aetiology in that region. The formal name of the newly discovered virus was established by the International Committee on Taxonomy of Viruses on February 11th, 2020. From then on, the Wuhan virus was officially known as Severe Acute Respiratory Syndrome Coronavirus 2, abbreviated SARS-CoV-2. According to the WHO recommendations, the disease caused by the new virus was named Coronavirus Disease 2019, commonly known as COVID-19. The main symptoms of that infection were fever, cough, fatigue, and myalgia; infected patients usually developed pneumonia with a high risk of respiratory failure [1]. Numerous SARS-CoV-2 subtypes have been isolated so far, including Alfa, Beta, Gamma, Delta, Epsilon, Omicron, Eta, Iota, Kappa, Lambda, Mi, or Theta [2]. Of those, according to data accumulated

by the State Health Inspectorate and the National Institute of Public Health, in the whole observation period in Poland the most commonly registered cases of infection were those caused by the Omicron, Delta, and Alfa variants [3]. Since March 4th, 2020 (when the first case in Poland was confirmed), the total number of cases reached 6.4 million, nearly 119,000 of them fatal [4].

People all over the world struggle with various ailments developed as a result of past infection with SARS-CoV-2 [5]. If those ailments manifest themselves within 8 months of infection and persist for at least 12 weeks, they are classified as post-COVID syndrome. Its prevalence among all convalescents is estimated at ca. 10% [6]. Numerous studies concerning rehabilitation of patients following the COVID-19 infection may be found in the literature. The applied methods included balance exercise, chest physiotherapy (bronchial hygiene techniques), resistance training, including respiratory muscle training, aerobic training, health education,

and memory training. In most studies only hospitalised patients took part, and the follow-up period did not exceed 3 months. Rehabilitation usually resulted in improvement in terms of exercise capacity, pulmonary function, and quality of life. With respect to symptoms of the post-COVID syndrome, rehabilitation contributed to reduction of dyspnoea, anxiety, and fatigue. However, studies concerning non-hospitalised patients with longer follow-up periods are scarce [7].

One possible method of rehabilitation of patients following the COVID-19 infection, applied at the 'Wieliczka' Salt Mine Health Resort, is subterranean therapy, i.e. treatment with subterranean environment. In this method, the effect of physical, chemical, and biological factors present in a specific microclimate of unused salt mine workings, is used. The effectiveness of subterranean therapy has been confirmed in previous studies in patients with chronic obstructive lung disease [8], bronchial asthma [9], and diseases of the nose and paranasal sinuses [10]. Specific features of subterranean environment that may contribute to its healing properties include: high relative air humidity (60-75%), stable temperature (13-14.5°C) [11], unique composition of aerosol contained in the air (the concentration of minerals: 3-8 mg/m³) [12], microbiological purity of the air [13], stable atmospheric pressure (higher from that measured on the surface by ca. 16 hPa) [11, 14], and high air ionisation (1,200-4,700 air-ions/cm³) [15].

A combination of properties of the subterranean environment and physical exercise is the base of rehabilitation of patients with respiratory diseases conducted at the mine. In response to growing medical needs of the society, a rehabilitation programme dedicated to patients struggling with consequences of infection with SARS-CoV-2 was developed at our Health Resort. It was based on the American Thoracic Society/European Respiratory Society guidelines on pulmonary rehabilitation [16] and the experience of our staff gained from work with the first patients who suffered from COVID-19 infection. The programme included functional assessment of the patient (initial and final), respiratory training, strength and aerobic training, repose

in salt chambers, cognitive function training, effective relaxation training, and health education. In addition, the patients had unrestricted access to the advice of physicians (including specialists in respiratory diseases), a dietician, and physiotherapists (Table 1). The entire programme was conducted in the underground facilities of the Resort, at the 3rd level of the 'Wieliczka' Salt Mine (135 m b.s.l.), in the 'Wessel Lake' chamber (Fig. 1).

AIM

The main objective of this study was to evaluate the efficacy of a rehabilitation programme dedicated to patients with prior COVID-19 infection, conducted in subterranean environment at the 'Wieliczka' Salt Mine Health Resort, based on retrospective analysis of patients' records. In addition, we attempted to determine whether a specific period of time in which the patients suffered from infection (and therefore, indirectly, the dominant SARS-CoV-2 variant at that time) had any effect on the symptoms reported by specific patients or the final effect of treatment.

MATERIALS AND METHODS

Medical records of patients who participated in the post-COVID-19 rehabilitation programme conducted at the 'Wieliczka' Salt Mine Health Resort from June 19th, 2021, till October 28th, 2022, i.e. during 19 consecutive treatment stays, were analysed. The patients included in the rehabilitation programme discussed here were adults who reported COVID-19 infection in the previous year with subjective deterioration of health, or who were specifically referred for rehabilitation due to past infection with SARS-CoV-2, regardless of the time of infection. The final decision on the patient's inclusion into the post-COVID rehabilitation programme was made by a physician, based on the patient's history. In the analysis, the patients were classified depending on the time of COVID-19 infection (i.e. the month in which the patient was diagnosed) into one of three groups with three dominant SARS-CoV-2 variants: Alfa/other from March 4th, 2020, till July 31st, 2021; Delta from August 1st, 2021, till January 31st, 2022; and Omicron from February 1st, 2022, till October 28th, 2022 (termination of

Table 1. Post-COVID-19 rehabilitation programme

| Activity | Duration |
|---|--|
| Rehabilitation stay | Saturday and 15 consecutive working days |
| Single session | Up to 180 minutes a day |
| Respiratory training | 30 minutes once a day |
| Strength and aerobic training | 30 minutes once a day |
| Walk through salt mine workings (ca. 350 m) | 15 minutes twice a day |
| Relaxation training | 30 minutes a week |
| Passive repose in salt chambers | Up to 90 minutes a day |
| cognitive function training | 30 minutes a week |
| Presentation by a dietician | 30 minutes once in a stay |
| Individual health education | Unlimited |
| Individual medical advice | Unlimited |



Fig. 1. The 'Wessel Lake' chamber, a part of the 'Wieliczka' Salt Mine Health Resort (source: 'Wieliczka' Salt Mine)

the programme) [3]. Data were analysed using the Wilcoxon test, the Kruskal-Wallis test, and post-hoc tests. The level of significance was established at 5%. Calculations were performed using STATISTICA 13 software.

POST-COVID-19 FUNCTIONAL STATUS QUESTIONNAIRE

The intensity of post-COVID syndrome symptoms was evaluated using a paper form of the Post-COVID-19 Functional Status (PCFS) questionnaire [17]. The first part of the questionnaire referred to general assessment of functional limitation on a 5-grade ordinal scale (0-4), while in the second part the intensity of each of 31 specific symptoms was assessed using a scale from 0 to 10 points. Higher results represented higher intensity of symptoms. The questionnaires were completed with assistance of the duty nurse or physiotherapist on the first and last day of stay in underground salt chambers.

CHEST MOBILITY

Chest mobility was assessed by measurement of chest circumference following inhalation and exhalation. The measurement was performed by a physiotherapist with a minimum of three-year work experience, on the first and last day of the stay, and the results were noted to within 0.5 cm. Chest circumference was measured using a tape measure, with the patient standing with their arms loose at their sides, at the nipple level in men and under the breasts in women.

ENDURANCE TEST

The endurance test used in the programme was the 2-Minute Step Test (2-MST). The patients were asked to

step in place for two minutes. Only steps during which the patient raised the knee of their dominant limb to the mid-thigh level were counted. The test was performed at a specially prepared test stand. The indicating bar showing the patient how high they should raise their knees could be easily regulated (Fig. 2). According to the protocol, the physiotherapist performing the test instructed the patient to raise their knees as many times as possible in the specified time. In addition, the intensity of subjective dyspnoea and exertion was measured before and after the test using the Borg CR10 Scale. If a patient needed orthopaedic aids, those were allowed; however, each instance of such a situation was noted in order to reproduce the same conditions for the final test. During the test, no verbal encouragement was used; the patient was only informed when half the time of the test had elapsed.

RESULTS

Out of 699 patients who participated in the programme, 591 (84.55%) completed the entire three-week treatment stay. Information concerning the reason of interruption of the stay was not collected. The proportion of women was higher, and most patients suffered from the infection in a period when the dominant variant was Alfa/other. On average, the patients started their rehabilitation between 7 and 8 months after the onset of infection (diagnosis). The patients' age was 25 to 87 years, with the most common value being 68 years in 42 patients. Detailed characteristics of the analysed group are presented in Table 2.

The highest mean PCFS score (i.e. the highest symptom intensity) was reported for chronic fatigue, post-exertional



Fig. 2. The stand with an indicating bar used for the 2-Minute Step Test (source: own material)

malaise, dyspnoea on exertion, arthralgia, and memory disorders. The least commonly reported symptom was fever. It was also the only symptom analysed in the PCFS questionnaire with respect to which no significant improvement was reported by the patients (Table 3). Some patients graded the intensity of fever above zero; however, this subjective feeling was not reflected in any objective measurements noted in the patients' records. All the recorded results of body temperature measurement were normal.

Statistically significant improvement was observed with respect to chest mobility. No significant effect of the period in which patients suffered from the infection on the results of chest expansion test was observed. The results are summarised in Table 4.

In Table 5, the results of 2-Minute Step Test are presented. The mean improvement was 18.94 steps (20%), which is a statistically significant value. A statistically significant difference in final 2-MST results was observed between two groups of patients classified depending on the dominant virus subtype, i.e. between the Delta group and the Alfa/other group. No significant differences were found in any other comparison.

In a definite majority of patients who completed the rehabilitation stay, an improvement in 2-MST results was found ($n=467$; 79%); that improvement was usually associated with increased fatigue and concomitant reduction of dyspnoea on exertion (Fig. 3).

Of all patients, 124 (21%) achieved worse final than initial results of the 2-Minute Step Test. That was most commonly due to increased dyspnoea limiting the patient's exercise capacity (Fig. 4).

DISCUSSION

The COVID-19 epidemics remains a challenge not only in terms of treatment, but also pulmonary rehabilitation in

the broad sense. Along with recommendations concerning treatment and vaccination, materials and studies on rehabilitation started to appear. The first important document of this kind was a leaflet titled Support for rehabilitation: self-management after COVID-19-related illness issued by the WHO at the end of the year 2020 [18]. The publication contained simple directions on management of typical symptoms and exercises facilitating recovery. Until recently, it was not certain whether introduction of such recommendations alone is sufficient, or perhaps active rehabilitation would produce better results. A study conducted by Jimeno-Almazán et al. demonstrated that the active rehabilitation programme they applied was more effective in terms of reduced fatigue and dyspnoea as well as improved exercise capacity than implementation of the WHO recommendations alone [19]. In another study in which the efficacy of rehabilitation was assessed in a group of 58 patients, it was demonstrated that pulmonary rehabilitation was effective with respect to exercise capacity, PCFS score, dyspnoea, fatigue, and quality of life [20]. The observations made in our study were similar. The patients who participated in the rehabilitation programme achieved significant improvement with respect to the evaluated symptoms, reported lower dyspnoea, both at rest and on exertion, and less commonly complained of chronic fatigue.

In patients with respiratory diseases, the most common test used to assess exercise capacity is the 6-Minute Walk Test (6-MWT) [21]. In our programme of pulmonary rehabilitation in subterranean conditions the 2-Minute Step Test, which is often applied as a substitute of the 6-MWT, was used instead. The mean endurance improvement as measured using the 2-MST was 20% (from 94 to 113 steps) and was statistically significant. The mean improvement observed previously in elderly patients (>65 years) with respiratory diseases who participated in the standard programme of subterranean rehabilitation was 9% (from 88 to 96 steps) and was also significant [22]. In a study conducted by Jakubowska that enrolled patients treated at the post-COVID rehabilitation ward in the Popielów hospital, a significant improvement in exercise capacity, i.e. an increase of the 6-MWT distance by 25%, was observed [23].

In the study discussed here, an increase in chest mobility by 47% (from 4.07 to 5.95 cm on average) was noted; this change was statistically significant. Mętel et al. investigated the same parameter in patients participating in a standard rehabilitation stay in 'Wieliczka' Health Resort (mainly those with bronchial asthma and other chronic respiratory diseases) and also observed a significant increase by 17% (from 2.4 to 2.9 cm on average) [24]. In a study that enrolled patients hospitalised in Teheran due to COVID-19, the increase in chest mobility in the group that received the standard rehabilitation procedure (cough and airway clearance training with in-bed respiratory exercises) was 5% (from 5.02 to 5.27 cm on average) and was not significant. Training sessions were performed at 24-hour intervals on three consecutive days, and each session

Table 2. Detailed patient's characteristics (n=699)

| Variable | N(%) | Mean(SD) |
|----------------------------------|------------|--------------|
| Programme completed | 591(84.55) | |
| Programme interrupted | 108(15.45) | |
| Sex | | |
| Men | 285(40.77) | |
| Women | 414(59.23) | |
| Age (years); min=25, max=87 | | 60.31(11.28) |
| Men | | 62(10.91) |
| Women | | 59.09(11.38) |
| Rehabilitation start* (months) | | 7.41(3.92) |
| Concomitant diseases | | |
| Arterial hypertension | 286(22.79) | |
| Bronchial asthma | 167(13.31) | |
| None reported | 132(10.52) | |
| Cardiovascular diseases | 107(8.53) | |
| Diabetes mellitus | 95(7.57) | |
| Chronic rhinitis | 89(7.09) | |
| Hypothyroidism | 76(6.06) | |
| Chronic sinusitis | 50(3.98) | |
| Chronic obstructive lung disease | 36(2.87) | |
| Osteoarthritis | 35(2.79) | |
| Chronic laryngitis | 32(2.55) | |
| Bronchiectases | 16(1.27) | |
| Gastroesophageal reflux | 13(1.04) | |
| Sleep apnoea | 13(1.04) | |
| Lower limb varicose veins | 13(1.04) | |
| Chronic bronchitis | 12(0.96) | |
| Other | 83(6.61) | |
| Variant** | | |
| Alfa/other | 435(62.23) | |
| Delta | 144(20.60) | |
| Omicron | 60(8.58) | |

*the time from diagnosis to rehabilitation start

**the number of patients who suffered from infection at the time when a specific SARS-CoV-2 variant was dominant

lasted 20 minutes [25]. In a study that involved elderly patients in which the effect of pulmonary rehabilitation and the subterranean environment on dynamic balance and chest mobility was evaluated, a significant increase of chest mobility by 20% (from 4.5 cm to 5.4 cm) was observed [26].

The analysis of medical records demonstrated that the symptoms reported as most intense included chronic fatigue, post-exertional malaise, dyspnoea on exertion, arthralgia, and memory disorders. On average, the assessment took place between seven and eight months after the onset of infection. These results are similar to those presented in a vast meta-analysis (of 23 studies including 24,255 cases) performed by Fernández et al. Fatigue, dyspnoea, anosmia, myalgia, and arthralgia

were the most common symptoms reported by patients after 90 days following the infection [27]. In another meta-analysis by Zang et al., including 151 studies performed in 32 countries (in total, ca. 1.2 million cases), it was demonstrated that at least one consequence of COVID-19 affected nearly 50% of all convalescents within a year after the infection. The most commonly reported abnormalities included lung computed tomography findings, fatigue, depression, post-traumatic stress disorder, cognitive impairment, and memory disorders [28]. Aiyegbusi et al. stated that the 10 most common symptoms reported by patients who suffered from COVID-19 between January 1st, 2020, and February 8th, 2021, were (in decreasing order of frequency): fatigue, dyspnoea, myalgia, cough, headache, arthralgia, chest

Table 3. PCFS questionnaire results

| Group | | Programme completed (n = 591) | | | Alfa/other (n = 425) | | Delta (n = 123) | | Omicron (n = 43) | | p* |
|-------------------------|---------|-------------------------------|------|--------|----------------------|------|-----------------|------|------------------|------|------|
| | | Mean | SD | p | Mean | SD | Mean | SD | Mean | SD | |
| Main PCFS score | Initial | 1.14 | 0.72 | <0.001 | 1.13 | 0.72 | 1.19 | 0.74 | 1.00 | 0.69 | 0.37 |
| | Final | 0.72 | 0.63 | | 0.70 | 0.62 | 0.79 | 0.63 | 0.70 | 0.67 | 0.33 |
| Chronic fatigue | Initial | 3.00 | 2.30 | <0.001 | 3.10 | 2.24 | 2.86 | 2.48 | 2.40 | 2.27 | 0.09 |
| | Final | 2.03 | 1.87 | | 2.04 | 1.80 | 1.98 | 2.02 | 2.07 | 2.12 | 0.74 |
| Post-exertional malaise | Initial | 2.74 | 2.37 | <0.001 | 2.75 | 2.31 | 2.82 | 2.68 | 2.37 | 1.96 | 0.64 |
| | Final | 1.77 | 1.81 | | 1.74 | 1.76 | 1.89 | 2.04 | 1.77 | 1.49 | 0.86 |
| Fever | Initial | 0.06 | 0.45 | 0.112 | 0.06 | 0.46 | 0.06 | 0.41 | 0.07 | 0.46 | 0.98 |
| | Final | 0.03 | 0.27 | | 0.03 | 0.28 | 0.03 | 0.28 | 0.02 | 0.15 | 0.80 |
| Arthralgia | Initial | 2.21 | 2.41 | <0.001 | 2.16 | 2.38 | 2.27 | 2.55 | 2.37 | 2.34 | 0.74 |
| | Final | 1.62 | 2.04 | | 1.54 | 1.99 | 1.73 | 2.14 | 2.05 | 2.24 | 0.31 |
| Myalgia | Initial | 1.83 | 2.17 | <0.001 | 1.84 | 2.12 | 1.88 | 2.29 | 1.65 | 2.33 | 0.60 |
| | Final | 1.28 | 1.77 | | 1.24 | 1.70 | 1.36 | 1.93 | 1.44 | 2.04 | 0.93 |
| Dyspnoea at rest | Initial | 0.97 | 1.55 | <0.001 | 0.97 | 1.58 | 0.91 | 1.45 | 1.05 | 1.48 | 0.71 |
| | Final | 0.58 | 1.12 | | 0.56 | 1.09 | 0.58 | 1.18 | 0.81 | 1.20 | 0.19 |
| Dyspnoea on exertion | Initial | 2.65 | 2.24 | <0.001 | 2.61 | 2.24 | 2.86 | 2.36 | 2.35 | 1.94 | 0.49 |
| | Final | 1.78 | 1.82 | | 1.72 | 1.78 | 2.02 | 2.04 | 1.72 | 1.53 | 0.45 |
| Cough | Initial | 1.33 | 1.83 | <0.001 | 1.28 | 1.84 | 1.46 | 1.86 | 1.42 | 1.58 | 0.27 |
| | Final | 0.86 | 1.40 | | 0.81 | 1.38 | 1.06 | 1.53 | 0.77 | 1.13 | 0.29 |
| Sputum retention | Initial | 1.46 | 1.94 | <0.001 | 1.37 | 1.89 | 1.59 | 1.96 | 1.93 | 2.29 | 0.11 |
| | Final | 1.02 | 1.50 | | 0.98 | 1.47 | 1.11 | 1.50 | 1.14 | 1.77 | 0.48 |
| Chest tightness | Initial | 1.05 | 1.71 | <0.001 | 1.02 | 1.70 | 1.19 | 1.88 | 0.93 | 1.33 | 0.51 |
| | Final | 0.60 | 1.15 | | 0.58 | 1.14 | 0.67 | 1.21 | 0.62 | 1.03 | 0.34 |
| Chest pain | Initial | 0.86 | 1.60 | <0.001 | 0.85 | 1.57 | 0.99 | 1.83 | 0.58 | 1.05 | 0.90 |
| | Final | 0.46 | 1.02 | | 0.46 | 1.04 | 0.48 | 1.03 | 0.40 | 0.73 | 0.66 |
| Palpitations | Initial | 0.96 | 1.63 | <0.001 | 0.89 | 1.61 | 1.18 | 1.75 | 1.00 | 1.41 | 0.07 |
| | Final | 0.58 | 1.14 | | 0.52 | 1.09 | 0.72 | 1.31 | 0.77 | 1.04 | 0.06 |
| Quick heart beating | Initial | 1.16 | 1.77 | <0.001 | 1.14 | 1.78 | 1.29 | 1.84 | 0.98 | 1.42 | 0.48 |
| | Final | 0.73 | 1.26 | | 0.73 | 1.28 | 0.76 | 1.31 | 0.60 | 0.95 | 0.92 |
| Abdominal pain | Initial | 0.49 | 1.28 | <0.001 | 0.49 | 1.28 | 0.47 | 1.21 | 0.56 | 1.45 | 0.79 |
| | Final | 0.27 | 0.91 | | 0.27 | 0.90 | 0.24 | 0.80 | 0.37 | 1.23 | 0.73 |
| Nausea | Initial | 0.32 | 1.02 | <0.001 | 0.33 | 1.05 | 0.25 | 0.87 | 0.42 | 1.12 | 0.13 |
| | Final | 0.17 | 0.75 | | 0.18 | 0.79 | 0.12 | 0.58 | 0.23 | 0.78 | 0.45 |
| Diarrhoea | Initial | 0.26 | 0.87 | <0.001 | 0.27 | 0.88 | 0.25 | 0.77 | 0.26 | 1.03 | 0.78 |
| | Final | 0.14 | 0.60 | | 0.13 | 0.61 | 0.15 | 0.57 | 0.12 | 0.63 | 0.82 |
| Decreased appetite | Initial | 0.39 | 1.17 | <0.001 | 0.41 | 1.18 | 0.31 | 1.09 | 0.42 | 1.22 | 0.38 |
| | Final | 0.26 | 0.84 | | 0.27 | 0.86 | 0.19 | 0.68 | 0.35 | 1.04 | 0.48 |
| Impaired concentration | Initial | 1.9 | 2.09 | <0.001 | 1.88 | 2.12 | 2.07 | 2.11 | 1.58 | 1.76 | 0.37 |
| | Final | 1.40 | 1.79 | | 1.37 | 1.78 | 1.60 | 1.85 | 1.21 | 1.46 | 0.36 |
| Memory disorders | Initial | 2.20 | 2.16 | <0.001 | 2.10 | 2.14 | 2.60 | 2.35 | 2.09 | 1.73 | 0.11 |
| | Final | 1.68 | 1.92 | | 1.59 | 1.90 | 1.98 | 2.11 | 1.67 | 1.57 | 0.16 |
| Headache | Initial | 1.20 | 1.95 | <0.001 | 1.15 | 1.94 | 1.33 | 2.08 | 1.33 | 1.69 | 0.34 |
| | Final | 0.77 | 1.52 | | 0.73 | 1.51 | 0.87 | 1.63 | 0.88 | 1.20 | 0.13 |
| Vertigo | Initial | 1.10 | 1.82 | <0.001 | 1.06 | 1.81 | 1.27 | 1.97 | 1.02 | 1.46 | 0.48 |
| | Final | 0.74 | 1.48 | | 0.72 | 1.49 | 0.85 | 1.57 | 0.67 | 1.08 | 0.41 |

| | | | | | | | | | | | |
|--------------------------------|---------|------|------|--------|------|------|------|------|------|------|------|
| Sleep disorders | Initial | 1.88 | 2.31 | <0.001 | 1.88 | 2.28 | 1.93 | 2.50 | 1.81 | 2.03 | 0.97 |
| | Final | 1.27 | 1.82 | | 1.25 | 1.80 | 1.31 | 1.98 | 1.40 | 1.58 | 0.49 |
| Limb tingling | Initial | 1.69 | 2.22 | <0.001 | 1.62 | 2.15 | 1.87 | 2.55 | 1.88 | 1.87 | 0.36 |
| | Final | 1.19 | 1.86 | | 1.12 | 1.79 | 1.30 | 2.10 | 1.53 | 1.82 | 0.13 |
| Limb numbness | Initial | 1.64 | 2.25 | <0.001 | 1.59 | 2.18 | 1.80 | 2.57 | 1.72 | 1.88 | 0.60 |
| | Final | 1.13 | 1.85 | | 1.09 | 1.82 | 1.20 | 1.99 | 1.28 | 1.80 | 0.51 |
| Depression symptoms | Initial | 0.96 | 1.84 | <0.001 | 0.96 | 1.85 | 0.89 | 1.91 | 1.05 | 1.63 | 0.39 |
| | Final | 0.62 | 1.40 | | 0.61 | 1.38 | 0.56 | 1.45 | 0.84 | 1.41 | 0.15 |
| Anxiety symptoms | Initial | 0.72 | 1.55 | <0.001 | 0.75 | 1.59 | 0.66 | 1.57 | 0.53 | 1.12 | 0.67 |
| | Final | 0.47 | 1.16 | | 0.50 | 1.17 | 0.41 | 1.21 | 0.40 | 0.88 | 0.54 |
| Tinnitus (ringing) | Initial | 0.81 | 1.68 | <0.001 | 0.75 | 1.62 | 0.97 | 1.92 | 0.93 | 1.53 | 0.35 |
| | Final | 0.59 | 1.38 | | 0.56 | 1.33 | 0.67 | 1.55 | 0.63 | 1.33 | 0.75 |
| Tinnitus (other sensations) | Initial | 0.90 | 1.76 | <0.001 | 0.80 | 1.70 | 1.22 | 1.99 | 0.86 | 1.54 | 0.09 |
| | Final | 0.67 | 1.46 | | 0.62 | 1.42 | 0.85 | 1.64 | 0.70 | 1.34 | 0.25 |
| Lost or reduced sense of taste | Initial | 0.39 | 1.32 | <0.001 | 0.37 | 1.27 | 0.36 | 1.20 | 0.74 | 1.92 | 0.72 |
| | Final | 0.27 | 1.11 | | 0.25 | 1.09 | 0.23 | 0.80 | 0.63 | 1.83 | 0.06 |
| Lost or reduced sense of smell | Initial | 0.56 | 1.59 | <0.001 | 0.57 | 1.62 | 0.53 | 1.43 | 0.53 | 1.75 | 0.87 |
| | Final | 0.39 | 1.32 | | 0.40 | 1.38 | 0.31 | 0.92 | 0.49 | 1.64 | 0.84 |
| Other olfactory disorders | Initial | 0.33 | 1.17 | <0.001 | 0.39 | 1.27 | 0.21 | 0.99 | 0.12 | 0.50 | 0.17 |
| | Final | 0.19 | 0.83 | | 0.21 | 0.91 | 0.15 | 0.65 | 0.09 | 0.37 | 0.68 |

*calculated using the Kruskal-Wallis rank test to find out whether at least one of the investigated groups differed from the others

Table 4. Chest mobility

| Group | | Programme completed (n = 591) | | | Alfa/other (n = 425) | | Delta (n = 123) | | Omicron (n = 43) | | p* |
|---------------------|---------|-------------------------------|------|--------|----------------------|------|-----------------|------|------------------|------|------|
| | | Mean | SD | p | Mean | SD | Mean | SD | Mean | SD | |
| Chest mobility [cm] | Initial | 4.07 | 2.17 | <0.001 | 4.03 | 2.21 | 4.30 | 2.10 | 3.85 | 2.07 | 0.37 |
| | Final | 5.95 | 4.99 | | 5.68 | 2.45 | 6.89 | 9.8 | 5.90 | 2.69 | 0.06 |

*calculated using the Kruskal-Wallis rank test to find out whether at least one of the investigated groups differs from the others

Table 5. Endurance test (2-MST)

| Group | | Programme completed (n = 591) | | | Alfa/other (n = 425) | | Delta (n = 123) | | Omicron (n = 43) | | p* |
|--------------------|---------|-------------------------------|-------|--------|----------------------|-------|-----------------|-------|------------------|-------|------|
| | | Mean | SD | p | Mean | SD | Mean | SD | Mean | SD | |
| 2-Minute Step Test | Initial | 94.18 | 25.11 | <0.001 | 93.84 | 25.56 | 93.41 | 24.97 | 99.65 | 20.55 | 0.33 |
| | Final | 113.12 | 4.99 | | 114.89 | 23.82 | 107.03 | 23.50 | 112.95 | 23.88 | 0.01 |

*calculated using the Kruskal-Wallis rank test to find out whether at least one of the investigated groups differed from the others

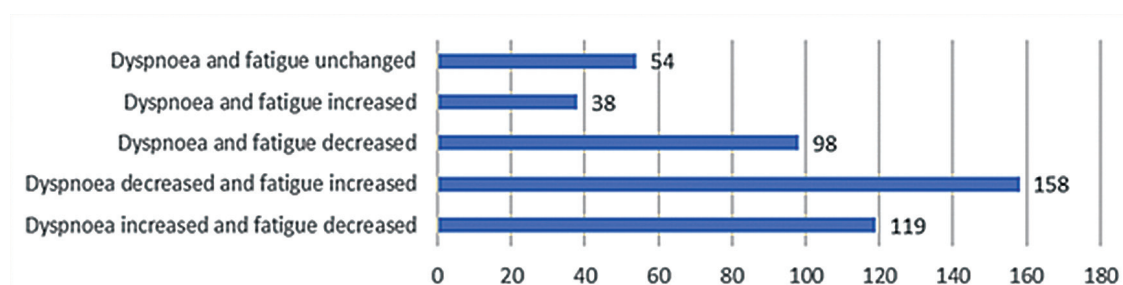


Fig. 3. Dyspnoea and fatigue in patients in whom an improvement of 2-MST results was observed (n=467)



Fig. 4. Dyspnoea and fatigue in patients in whom deterioration of 2-MST results was observed (n=124)

pain, olfactory disorders, diarrhoea, and dysgeusia [29]. Ponikowska et al. indicated fatigue, dyspnea and memory impairment/confusion as the most common symptoms of post-COVID syndrome in their study [30]. In an expert's opinion, the most common consequences of post -COVID-19 include: fatigue, headache, impaired concentration, hair loss, and dyspnoea [31].

It has not been definitely specified which forms of rehabilitation should be used in order to optimise the process of recovery in terms of benefits to patients as well as financial burden for the payer. However, it may be ventured to say that institutional rehabilitation is a justified mean. Until prospective controlled trials are performed, the question concerning a possible additional effect of subterranean conditions on the results of rehabilitation in post-COVID-19 patients will remain unanswered.

CONCLUSIONS

Subterraneotherapy combined with pulmonary rehabilitation improves functional status, chest mobility, and endurance in patients with post-COVID syndrome.

LIMITATIONS

It should be noted that limitations of the study discussed here include:

1. collection of patients' clinical data by different persons which could have affected correctness and repeatability of the results;
2. lack of analysis of symptoms that became more important with time, such as hair loss or hyperhidrosis, but were not included in the PCFS questionnaire;
3. lack of reference to severity of the disease, as no relevant data were collected.

Strong points of the study include a long period of data collection and a large number of analysed cases.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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THE IMPORTANCE OF FUNCTIONAL EXAMINATION OF PATIENTS AND ASSESSMENT OF PERIPHERAL HEMODYNAMICS IN THE REHABILITATION OF PATIENTS WITH OBLITERATING ATHEROSCLEROSIS OF THE VESSELS OF THE LOWER EXTREMITIES

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ABSTRACT

Aim: To evaluate the effectiveness of the treatment and clarify the medical and social criteria for the rehabilitation of patients with obliterating atherosclerosis of the vessels of the lower extremities.

Materials and Methods: A comprehensive clinical and instrumental examination of 54 patients who underwent various types of operations for obliterating atherosclerosis of the vessels of the lower extremities 3 years ago and 11 non-operated patients who made up the control group was conducted. All examined (men) aged from 45 to 60 years. The average duration of the disease was about 7 years. Operations were performed mainly in the II and III stages of the disease.

Results: A complex clinical and functional examination of the patients revealed: in most of them, after the operation, the general condition improved or the process stabilized, periodic lameness decreased, and the intensity of pain decreased. However, intermittent lameness still persisted in 93% of them, and pain in the lower limbs at rest occurred in 41%. Calf muscle spasms were noted in 70% of patients, frostbite of the feet persisted in 51%. The pulse on the peripheral arteries was determined in 36% of the examined.

Conclusions: The main criterion for the rehabilitation of obliterating atherosclerosis of the lower extremities patients is the degree of blood circulation compensation achieved as a result of the operation. The obtained data open wide opportunities for social and labor rehabilitation of patients with obliterating atherosclerosis of the lower extremities, which allows 53% of them to return to working capacity.

KEY WORDS: the obliterating atherosclerosis of the lower extremities, the rehabilitation, reconstructive-restorations reoplethysmography and reovasography

INTRODUCTION

Over the past decade, the incidence of occlusive lesions of the arteries of the lower extremities has increased by more than 10%, the number of patients is more than 200 million people worldwide [1-3]. Currently, this pathology affects up to 10% of the population; among people over 65 years of age, the proportion of such patients increases to 15–20% [4-6]. In 60% of cases, diseases of the arteries of the lower extremities (LAIL) are combined with lesions of the coronary, brachiocephalic, and renal arteries [2-3].

In the development of occlusive lesions of the aorta and main arteries, atherosclerosis belongs to up to 94%. Systemic atherosclerosis is regarded as one of the most common, serious, and life-threatening diseases [4].

The social significance of the problem is due to both the widespread and progressive course of the disease with an increase in symptoms of lower limb ischemia, and the insufficient effectiveness of ongoing conservative therapy,

including in patients undergoing surgical treatment, which affects the quality of life, working capacity, disability, and an increase in the number amputations and rather high lethality [5-6].

However, even after surgery, 85% of of therapeutic labor examination patients are recognized as disabled. Currently, the problem of social and labor rehabilitation of this category of patients is of particular importance [7].

AIM

The purpose of the study was to evaluate the effectiveness of the treatment and clarify the medical and social criteria for the rehabilitation of patients with obliterating atherosclerosis of the vessels of the lower extremities.

To prove that the leading criterion for the rehabilitation of patients with obliterating atherosclerosis of the lower extremities is the degree of blood circulation compensation achieved as a result of the operation, that the use of PSORPG

and RVG techniques, as well as tests conducted not only at rest, but also during exercise, in combination with clinical data, makes it possible to objectively assess the condition peripheral blood flow and the effectiveness of the operation in the long term.

MATERIALS AND METHODS

In the conditions of the surgical department of the Poltava regional hospital and the vascular department of the regional hospital, a comprehensive clinical and instrumental examination of 54 patients who underwent various types of operations 3 years ago with obliterating atherosclerosis of the lower extremities, and 11 unoperated, hemotopoietic control groups was carried out.

A comprehensive clinical and functional examination of the patients revealed the following: in most of them, after the operation, the general condition improved or the process stabilized, the intermittent lameness decreased, and the pain intensity decreased. However, intermittent lameness still persisted in 93% of them, and pain in the lower limbs at rest occurred in 41%. Calf muscle spasms were noted by 70% of patients, frostbite of the feet persisted in 51% of them. The pulse on the peripheral arteries was determined in 36% of the examined. The expression of samples of plantar ischemia was: Leignel-Lawastine 4-6s, Oppel 25-15s, Samuels 20-10s, Goldflam 15-20s. X-ray revealed osteoporosis of the feet.

In a certain number of patients, the lack of improvement in the condition at the time of the examination is explained not only by the progression of the main process, which occurs in severe degrees of arterial insufficiency with a pronounced pain syndrome, caused in 23% of observations by the phenomena of ischemic polyneuropathy, but also by the presence of concomitant diseases. The atherosclerotic process was widespread in 54% of patients. Ischemic heart disease was observed in 46% of those examined, atherosclerosis of cerebral vessels – in 61%, osteochondrosis of the lumbar spine was detected in 44%, and diabetes – in 7%. To assess the state of peripheral blood circulation, we used modern non-invasive research methods: polysegmental occlusive rheoplethysmography (PS ORPG) and rheovasography (RVG). Plethysmograms were recorded on a domestic plethysmograph, at rest (lying down) and with reactive hyperemia (RH). Volumetric blood flow velocity (VVBF) was calculated for each of the three segments of the lower leg (in the upper, middle, and lower third), and then the average the indicator of the (VVBF) of the entire monosegment “shin”.

We recorded the rheovasographic curves with the serial device RPG 2-02 with the “Elkar” recorder from both limbs simultaneously. The study was carried out at rest (lying down), during the orthostatic test (standing) and after the walking test until the onset of intermittent lameness (in the first 30 s after the forced stop of the patient). On the basis of the obtained data, the (VVBF) and the rheographic index (RI) were calculated.

RESULTS

The analysis of the results of the conducted studies revealed that the leading factor characterizing the degree of

restoration of blood circulation after surgery is the degree of chronic arterial insufficiency (CAI). Considering the indicators characterizing the state of peripheral hemodynamics at different degrees of (CAI) at rest and after exercise, we found a number of regularities.

Carrying out tests, loads, allows you to objectively characterize the improvement of peripheral blood circulation achieved as a result of the surgical treatment. This improvement is especially clearly observed when conducting polysegmental occlusive rheoplethysmography (PSORPG) with a test on the reovasography (RVG).

In this study, it was found that the indicator of VVBF in all degrees of (CAI) in the operated patients is higher on average by 20% than in patients of the control group. However, it should be noted that when evaluating the indicators characterizing the use of tests and loads, their changes are more significant in patients with I and II degrees of (CAI). The clinically determined sharp decrease in blood flow in the III degree of (CAI) causes the fact that in operated patients, as well as in non-operated patients with this degree of insufficiency, minimal changes in hemodynamic indicators during exercise were noted (Fig. 1).

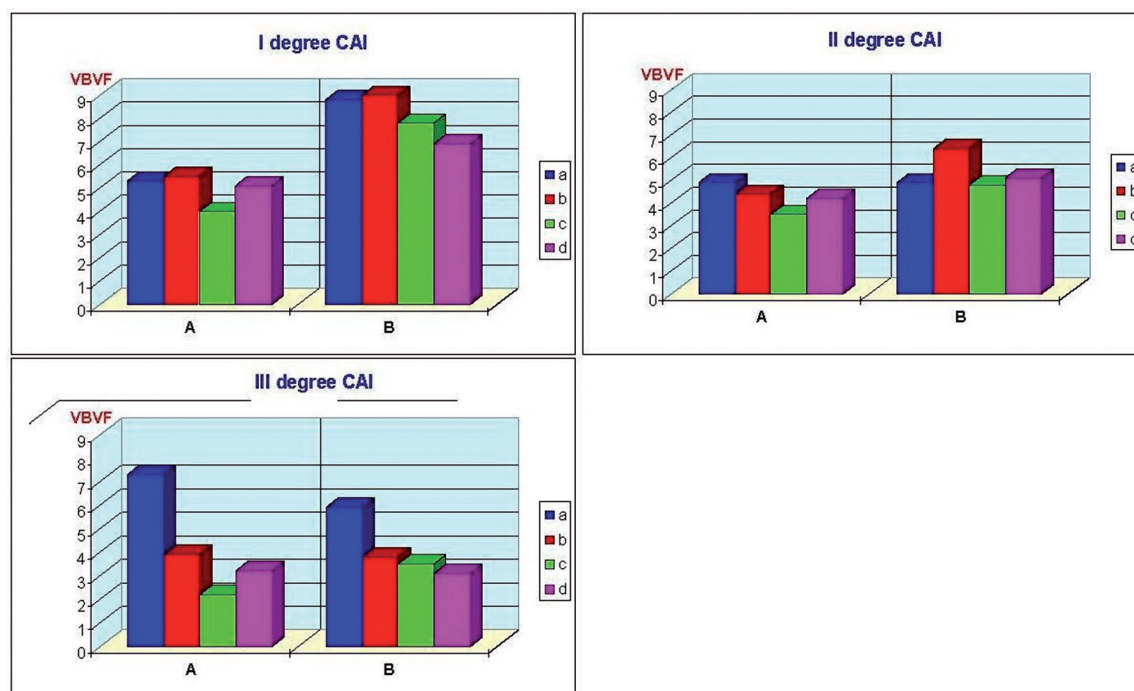
When loads of different intensity are applied, at all degrees of (CAI), the indicators of peripheral hemodynamics, characterizing reactions in response to loads of different severity, are more differentiated in operated than in non-operated patients. At the same time, only in operated patients the indicators characterizing the application of these loads have significant differences from the indicators of the state of rest ($p < 0.01$) and exceed the initial ones by 10-30%, while in the control group they tend to decrease.

The test with walking until the onset of lameness, which we used when conducting (RVG) (Figs. 2, 3), which moves, as clearly as the orthostatic test, reflects the reaction of the vascular bed to the physiological workload. Practically all indicators of (VVBF) and (RI), calculated on the basis carrying out this test in operated patients, at all degrees of (CAI) significantly differ from the corresponding indicators of rest ($p < 0.01$), and in the control group, no significant difference between these indicators was noted.

On the basis of the data obtained by us, clinical and functional criteria for assessing the degree of (CAI) in patients undergoing surgery for obliterating atherosclerosis of the lower extremities are proposed.

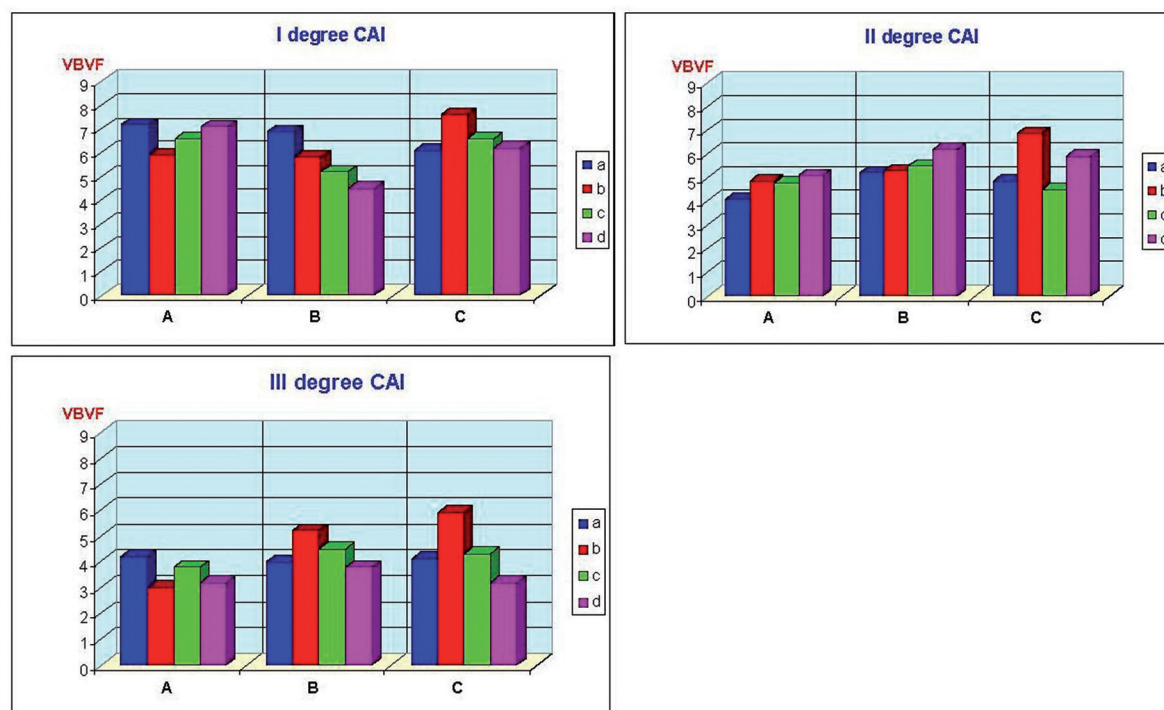
I degree of (CAI): clinically characterized by a significant improvement in the general condition of patients, the walking distance before the onset of intermittent lameness is 150 m. Pulsation of the arteries of the feet is constant or intermittent. A test on (RVG) during (PSORPG) reveals a 58% increase in (VVBF) – the maximum compared to resting (VVBF) ($p < 0.01$). In non-operated patients, this increase is only 36%. When carrying out (RVG) with loads, the reactions of peripheral hemodynamics are almost similar to the reactions of healthy people and patients of the control group with stage I obliterating atherosclerosis of the lower extremities (Fig. 2).

In response to the orthostatic test, the (VVBF) and (RI) decrease, and after the walking test, these indicators



a) - in patients who underwent sympathectomy; b) - in patients who underwent combined operations; c) - in patients who underwent operations on blood vessels; d) - in patients of the control group.
A) - rest; B) - reactive hyperemia.

Fig. 1. Changes in the parameters of (VBF), ml (100 cm³·min) according to the data of occlusive rheoplethysmography in patients undergoing surgery for obliterating atherosclerosis



A) — lying down; B) — standing; C) — after loading. The rest of the designations are as in Fig. 1.

Fig. 2. Changes in the parameters of the (VBF), ml (100 cm³·min) according to the data of reovasography in patients after various types of surgical interventions for obliterating atherosclerosis of the lower extremities

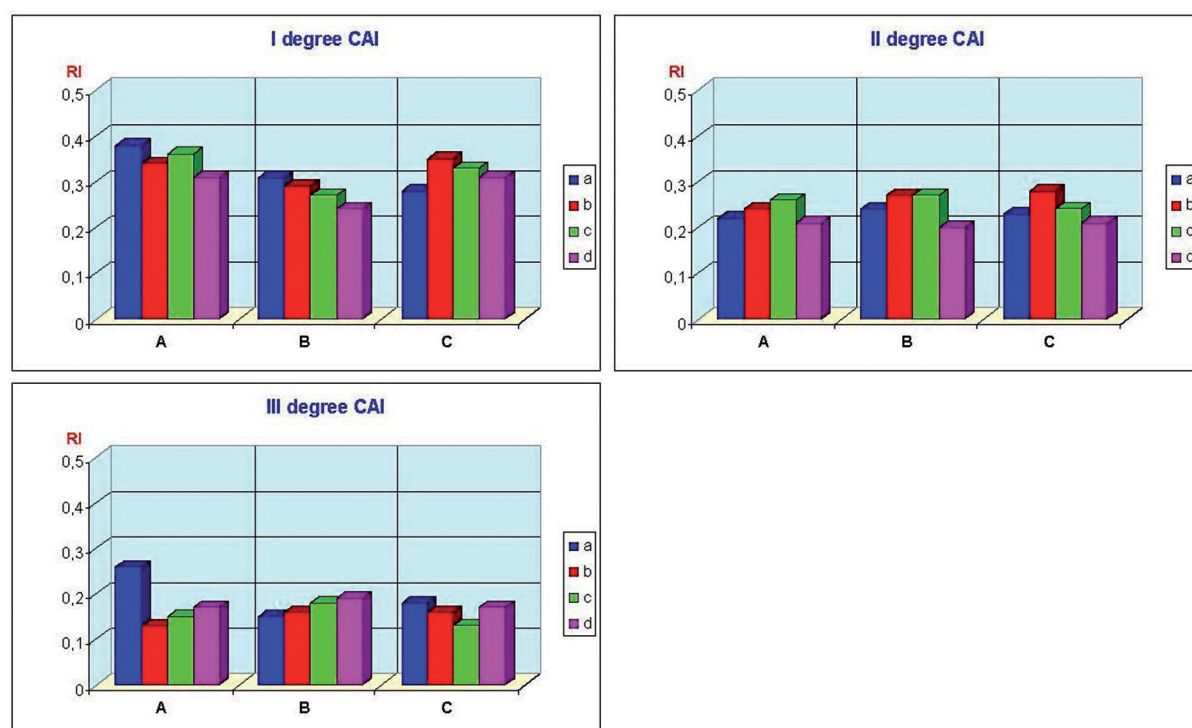


Fig. 3. Changes in (RI) indicators according to rheovasography data in patients after various types of surgical interventions for obliterating atherosclerosis of the lower extremities

increase. At the same time, the relative changes of (VBF) and (RI) in response to a walking test before the onset of intermittent lameness are higher than in non-operated patients. Adequate responses to loads of varying severity are explained, apparently, by the almost complete restoration of blood flow in both the main and collateral vessels, which leads to a significant improvement in the blood supply of the operated limb and allows the application of the first degree of (CAI) as a compensation of blood circulation.

II degree of (CAI): is also characterized by some improvement in the general condition of patients after surgery, but their free walking distance is reduced to 100 m. There is no pulsation in the arteries of the feet, and often also in the popliteal arteries. When conducting (PSORPG) with a sample on (RG), an increase in (VBF) was found compared to the initial one by 34% ($p < 0.01$). This increase is almost half as much as in the first degree of (CAI), but at the same time it is 2.5 times greater than in the control group, where it is 14% ($p > 0.05$). Rheovasography revealed an increase in (VBF) and (RI) in response to both of the loads we used, with a higher load causing increased blood flow in the lower extremities to a greater extent. Relatively high indicators of (RI) and a significant increase in (VBF) during (RG), together with the clinically detected improvement of blood circulation, indicate the predominant restoration of main blood flow after surgery. Additional inflow through collaterals is, apparently, insignificant and does not lead to a complete restoration of blood flow in the limb, which allows us to define the II degree of (CAI) as a subcompensation of blood circulation (Fig. 3).

At the III degree of (CAI): despite the surgery, there is pain in the lower limbs at rest, intermittent lameness with a free walking distance of about 50 m. There is a lack of pulse not only in the arteries of the feet, but also in other arteries, in combination with pronounced tissue trophic disorders and severe osteoporosis stop. However, even with this degree of (CAI) in operated patients, there is a tendency to an increase in (VBF), when performing a test with (RG), on average by 23% ($p > 0.05$), while in the control group there is a tendency to decrease it with (RVG), the blood flow indicators also increase, but the differential response to loads of different severity disappears, and in response to any load, the maximum possible blood filling of the limb occurs, obviously. Numerical values of rheographic indicators practically do not differ from those of the control group ($p > 0.05$). Significant differences remain only in relation to the (VBF) when conducting a test with walking before the onset of intermittent lameness, which, along with the unlikely increase in (VBF) in operated patients with (RVG) and low (RI) values, indicates that postoperative changes occur mainly due to collateral blood flow. The above makes it possible to determine the III degree of (CAI) as circulatory decompensation.

Examining changes in peripheral hemodynamic parameters in response to load after various types of operations, we noted that in people who underwent combined operations, these parameters increase by 1.5 times compared to the resting state especially in I and II degrees of (CAI).

In patients who are operated only on vessels (when restoring the patency of main arteries), they increase 1.5-2 times to the initial levels at all degrees of (CAI). Operations

on the sympathetic nerve trunks only partially improve or stabilize the condition of the patients, but in most of them it is possible to preserve the limb. The indicators of VVBF and RI in response to the load do not change or decrease. It should be noted here that when analyzing hemodynamic changes after various types of operations, the PSORPG technique makes it possible to objectively assess the arterial inflow reserve in the operated limb.

DISCUSSION

The ultimate goal of rehabilitation of disabled people with lesions of the lower arteries limbs is the restoration of working capacity and return to work improvement of limb function, prevention of progression of atherosclerosis and prevention of its complications. Medical rehabilitation leads to reduction and suspension of manifestations of ischemia of limb tissues due to removal vasospasm, normalization of their permeability, analgesic, trophic, anti-inflammatory effects, improvement of rheological properties of blood and microcirculation [1, 2].

It should be emphasized that patients with chronic obliterating diseases of the arteries of the lower extremities should be treated throughout their lives, taking into account the nosological form and stage of the disease. Treatment should be complex with the use of pharmacotherapy, surgical methods, physiotherapy, exercise therapy, diet, sanatorium-resort factors [4].

The analysis of the results of the conducted studies revealed that the leading factor characterizing the degree of restoration of blood circulation after surgery is the degree of chronic arterial insufficiency (CAI). Considering the indicators characterizing the state of peripheral hemodynamics at different degrees of (CAI) at rest and after exercise, we found a number of regularities [5, 6].

Carrying out tests, loads, allows you to give an objective description of the improvement of peripheral blood circulation achieved as a result of the surgical treatment. This improvement is especially clearly observed during (PSORPG) with a sample on (RVG). In this study, it was found that the index of volume velocity blood flow (VVBF) at all degrees of (CAI) in operated patients is on average 20% higher than in patients of the control group. However, it should be noted that when evaluating indicators characterizing the

use of tests and loads, their changes are more significant in patients with I and II degrees of (CAI).

The clinically determined sharp decrease in blood flow at the III degree of (CAI) causes the fact that in operated patients, as well as in non-operated patients with this degree of insufficiency, minimal changes in hemodynamic indicators during exercise were noted.

Examining the changes in peripheral hemodynamic parameters in response to load after various types of operations, we noted that in people who underwent combined operations, these parameters increase by 1.5 times compared to the resting state especially in I and II degrees of (CAI). In patients who are operated only on vessels (when restoring the patency of main arteries), they increase 1.5-2 times to the initial levels at all degrees of (CAI).

Operations on the sympathetic nerve trunks only partially improve or stabilize the condition of the patients, but in most of them it is possible to preserve the limb. Indicators of obliterating atherosclerosis of the lower extremities and RI do not change or decrease in response to exercise. It should be noted here that when analyzing hemodynamic changes after various types of operations, the (PSORPG) technique makes it possible to objectively assess the arterial inflow reserve in the operated limb.

The obtained data open wide opportunities for social and labor rehabilitation of patients with obliterating atherosclerosis of the lower extremities, which allows to return to working capacity of 53% of them.

CONCLUSIONS

The main criterion for the rehabilitation of obliterating atherosclerosis of the lower extremities patients is the degree of blood circulation compensation achieved as a result of the operation. The complex application of (PSORPG) and (RVG) techniques, performed not only at rest, but also during exercise, in combination with clinical data, makes it possible to objectively assess the state of peripheral blood flow and the effectiveness of the operation performed much later. The obtained data open wide opportunities for social and labor rehabilitation of patients with obliterating atherosclerosis of the lower extremities, which allows 53% of them to return to working capacity.

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CONFLICT OF INTEREST

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A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review,
F – Final approval of the article

THE EFFECT OF TREATMENT WITH MAGNETIC STIMULATION ON THE CONCENTRATION OF INTERLEUKIN-6, MORPHOLOGICAL PARAMETERS OF BLOOD AND CRP IN COVID-19 PATIENTS: PRELIMINARY RESULTS

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ABSTRACT

Aim: The purpose of this study was to evaluate the efficacy of low-frequency magnetic field in the hybrid treatment of COVID-19 patients, i.e., including magnetic stimulation in the standard treatment.

Materials and Methods: In the study groups, the patients were subjected to magnetic field - magnetic stimulation with the use of apparatus Viofor JPS System. In laboratory tests, the following levels were assessed in the patients: interleukin 6 (IL-6), leukocytes (WBC), monocytes (MONO), platelets (PLT) and CRP.

Results: In patients hospitalized for COVID-19 who received magnetic stimulation treatments with the use of the Viofor JPS System device, a statistically significant reduction in proinflammatory IL-6 levels was achieved (28.72 vs. 6.05 pg/ml, $p=0.008$). In the study group (with magnetic stimulation) we also observed a higher number of monocytes (MONO) with a more stable level of leukocytes (WBC) compared to the control group (without magnetic stimulation).

Conclusions: It is probable that the application of low-frequency magnetic field in the hybrid treatment of COVID-19 patients may reduce pro-inflammatory factors (IL-6). The low frequency magnetic fields are capable of restoring body homeostasis in terms of parameters evaluated in laboratory tests (WBC, MONO, PLT, CRP) which requires further research.

KEY WORDS: IL-6, cytokine storm, magnetic stimulation, physical therapy, immune cells, pro-inflammatory cytokines

INTRODUCTION

Magnetic stimulation is a treatment method of pulsed non-invasive low frequency magnetic field LF MF with low induction values (30-70 μ T). Magnetic fields with induction above 100 μ T are referred to as Extremely Low Frequency-Electromagnetic Field (ELF-EMF) [1].

In the Viofor JPS device, the magnetic field is pulsed with a complex pulse shape and signal structure generating a multi-vertical frequency spectrum in the range between 0.08 Hz and 195 Hz. The fundamental pulse frequencies range from 180 Hz to 195 Hz, pulse packet frequencies – from 12.5 Hz to 29 Hz, packet group frequencies – from 2.8 Hz to 7.6 Hz, and series frequencies – from 0.08 Hz to 0.3 Hz. The above pulse frequency parameters and the basic pulse waveform, which is similar to a ball shape, with a deflection in the ascending part from a linear waveform are responsible for the occurrence of biophysical effects including ion cyclotron resonance, magnetomechanical and electrodynamic effects [1-3].

International literature and the Rehabilitation Society recommend early rehabilitation of patients in the course

of COVID-19 (from the beginning of hospitalization), including early application of physical therapy. Magnetic field accelerates and increases the effectiveness of medications, improves oxygen utilization and penetration of substances through biological membranes; therefore, it is assumed to accelerate the healing process and shorten the hospitalization time by strengthening immune mechanisms in COVID-19 patients and restoring homeostasis in inflamed systems [4, 5].

While most environmental EMFs cause oxidative stress, the LF-MFs used in therapy appear to have antioxidant and neuroprotective effects [5].

Macrophages are responsible for the elimination of infectious agents and other cell debris. The recruitment of monocytes / macrophages to inflammatory sites and neoplastic tissues and their activation are of paramount importance for the effectiveness of the immune response, in part because migration is closely related to leukocyte function. Resting macrophages have a low level of phagocytic activity and only become fully active through pathogen binding or local cytokine release. Upon activation, macrophages show

an elevated level of phagocytic activity and an increased production of reactive oxygen species (ROS), which enables the killing of phagosomal microorganisms. The first step in a defense response is phagocytosis of the infectious agent, which is then transferred to the phagosome, where it is killed by ROS and reactive nitric oxide species [4].

The effect of LF-MF on free radicals is widely discussed as a probable straightforward mechanism of LF-MF action on living organisms. A study on mouse macrophages after a 45-minute exposure to a 50 Hz, 1.0 mT electromagnetic field showed significant tracer uptake in macrophages, suggesting that electromagnetic fields stimulate phagocytic activity.

In addition, nitric oxide NO, which is formed during application, enhances the ability of monocytes to respond more effectively to chemotactic agents and is considered one of the main effector molecules involved in macrophage-mediated cytotoxicity. It has also been reported that the anti-inflammatory effect is partially caused by the stabilizing effect of LF-MF on cell membranes, restoring intracellular Ca²⁺ levels in plasma lymphocytes. Some researchers have suggested that LF-MF may interact with cells through mechanisms that involve extracellular calcium channels [4].

The immunocorrective mechanism of magnetic stimulation with the Viofor JPS system was demonstrated *in vitro* in relation to immune cells isolated from blood [6].

Vergallo C et al. investigated the effect of magnetic field on the production of different cytokines from human peripheral blood mononuclear cells (PMBC), i.e. lymphocytes and macrophages (studied *in vitro*). Some cultures were activated with lipopolysaccharide (LPS) at time point – 3 hours and they were left alone (positive control) or exposed to magnetic field continuously from 0 to 6, 18 or 24 hours. A concentration analysis showed significantly reduced production of the pro-inflammatory cytokines IL-6, IL-8 and TNF- α . Production of the anti-inflammatory cytokine IL-10 from macrophages and lymphocytes was increased compared with the negative control. Results of the above studies support the hypotheses that magnetic field exposure inhibits the release of the pro-inflammatory cytokines IL-6, IL-8 and TNF- α and enhances the production of the anti-inflammatory cytokine IL-10 and may be an effective method for treating immune deficiency-related conditions [7-10].

AIM

The purpose of this study was to evaluate the efficacy of low-frequency magnetic field in the hybrid treatment of COVID-19 patients, i.e., including magnetic stimulation in the standard treatment. The authors evaluated among other things, the immunocorrective therapeutic effect of magnetic stimulation, improving the defensive functions of the immune system and thus supporting the immune function by, among other things, suppressing the “cytokine storm”.

Based on the cited literature, it was hypothesized that magnetic stimulation may benefit COVID-19 therapy due to its effect on lowering pro-inflammatory cytokines and its regulatory role in leukocyte activity.

MATERIALS AND METHODS

The study was conducted on 23 patients aged 39 to 80 years (mean 65; SD=10.53), of both sexes (15 women and 8 men) affected by COVID-19. The patients were in moderately severe general condition, circulatory efficiently, conscious and stable. Patients did not require intensive care, but required passive oxygen therapy. Among the subjects, 5 people were treated for arterial hypertension and 4 were treated due to diabetes. The study subjects were recruited at the Covid Unit of the Military Medical Academy University Teaching Hospital – Central Veterans' Hospital in Lodz. The study group (13 patients) included patients hospitalized due to PCR-confirmed SARS-Cov-2 infection, who were treated with magnetic stimulation in addition to a standard therapy. The control group (10 patients) included patients receiving a comprehensive treatment without magnetic stimulation.

The study was approved by the Bioethics Committee RNN/339/20/KE, dated on 12 January, 2021. ClinicalTrials.gov Identifier: NCT05163613 was completed 1 April 2022 by the National Library of Medicine.

Standard therapy used in all patients consisted of the use of pharmacological agents necessary to treat the viral infection (antiviral drugs, antibiotics, dexamethasone) and the inclusion of proper care, education, occupational therapy, self-service learning, breathing exercises and motor mobilization. The drugs were administered according to the established protocol.

Inclusion criteria:

- patients hospitalized for PCR-confirmed SARS-Cov-2 infection;
- age criterion (18-80 years);
- patients who do not require intensive care (ventilator therapy).

Exclusion criteria:

- the presence of absolute contraindications to the use of magnetic fields;
- lack of logical contact with the patient;
- lack of consent of the patient.

In the study groups, the patients were subjected to magnetic field – magnetic stimulation with the use of apparatus Viofor JPS System. 14 treatments were performed, 7 times a week. Treatment parameters: 12 minutes M2P2 program, with increasing intensity from 1 to 8. We applied magnetic field with a frequency of 180-190 Hz, pulse packet frequencies between 12.5 and 29 Hz, packet groups 2.8-7.6 Hz, series 0.08-0.3 Hz, with magnetic induction B=3.2 μ T (on average) and B=40 μ T at a pulse peak.

In laboratory tests, the following levels were assessed in the patients: interleukin 6 (IL-6), leukocytes (WBC), monocytes (MONO), platelets (PLT) and CRP. The patients' blood was taken twice: on admission to the department and after a series of treatments with magnetic stimulation. Approximately 6 ml of blood was collected at one time (3 tubes).

After application of low-frequency magnetic field in the hybrid treatment of COVID-19 patients, we expected: a decrease in the level of proinflammatory factors (IL-6),

restoration of homeostasis in the body with regards to the range of parameters evaluated in laboratory tests (WBC, MONO, PLT and CRP).

Hybrid treatment means including an application with magnetic stimulation with the Viofor JPS device to pharmacological treatment and proper care.

Low-frequency magnetic field was used on the whole body of patient by using mat on which applicated person was lying down.

Blood was drawn on admission to the hospital, these were standard laboratory parameters used to assess the patient's condition. The next collection took place after the completion of the series of magnetic stimulation treatments.

Blood tests were done by the same laboratory. The treatments of magnetic stimulation were performed by two people due to shift work. They were physiotherapy specialists.

For independent data (comparisons between the study and control groups), the Mann-Whitney U-test was used. The Wilcoxon test was used in order to test the significance of differences in dependent data (comparison of the pre-test to the post-test). To reduce the risk of type I error (considering that a statistically insignificant difference is significant), caused by multiple comparisons between the groups, the Holm-Bonferroni sequential correction was applied.

The statistica version 13.3 from 2020 was used for data analysis.

RESULTS

In the study group, the monocyte level before therapy was 0.5 K/ μ l; SD=0.09, after treatment 1.0 K/ μ l; SD=0.30;

$p=0.084$. In the control group, the monocyte level before therapy was 0.7 K/ μ l; SD=0.10, after treatment 0.7 K/ μ l; SD=0.34; $p=0.799$ (Fig. 1). The platelet level in the study group before therapy was 246 K/ μ l; SD=21.63, after treatment 271.9 K/ μ l; SD=25.33; $p=0.654$. In the control group, the platelet level before therapy was 193.6 K/ μ l; SD=24.66, after treatment 270.6 K/ μ l; SD=28.88; $p=0.187$ (Fig. 2).

In the study group, the CRP value before therapy was 84.8 mg/l; SD=16.72, after treatment 8.1 mg/l; SD=3.08; $p=0.007$. In the control group, the CRP value before therapy was 98.4 mg/l; SD= 19.07, after treatment 16.0 mg/l; SD=3.51, $p=0.015$ (Fig. 3).

There was a statistically significant reduction in the level of pro-inflammatory IL-6 in both the study and control groups compared to the results before therapy (Fig 4). There was no statistically significant difference between the groups, nevertheless, in the study group, interleukin-6 levels reached physiological levels. A higher number of monocytes (MONO) with a more stable level of leukocytes (WBC) was also observed in the study group (with magnetic stimulation) compared to the control group. Platelet counts (PLT) increased in both study groups, reaching a lower increase in the test group. In both the study and control groups, the values of the evaluated parameters (WBC, MONO, PLT) after the treatment cycle, were within the reference range of the applicable laboratory standards (Figures 1, 2, 5).

Both the study and control groups showed a statistically significant reduction in CRP values after therapy (Fig. 3) (study group: 84.8 vs. 8.1 mg/dL, $p=0.007$; control group: 98.4

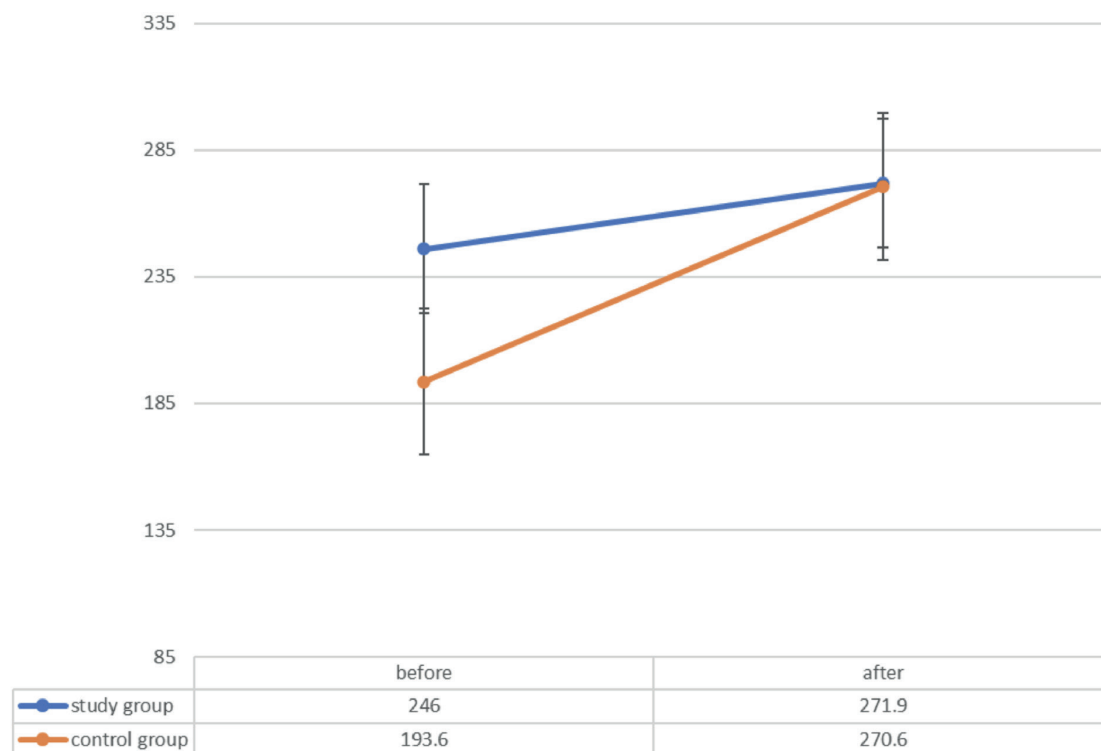


Fig. 1. The level of platelets (PLT) in the research and control groups before and after magnetic stimulation, [norm: 150-400 K/ μ l]

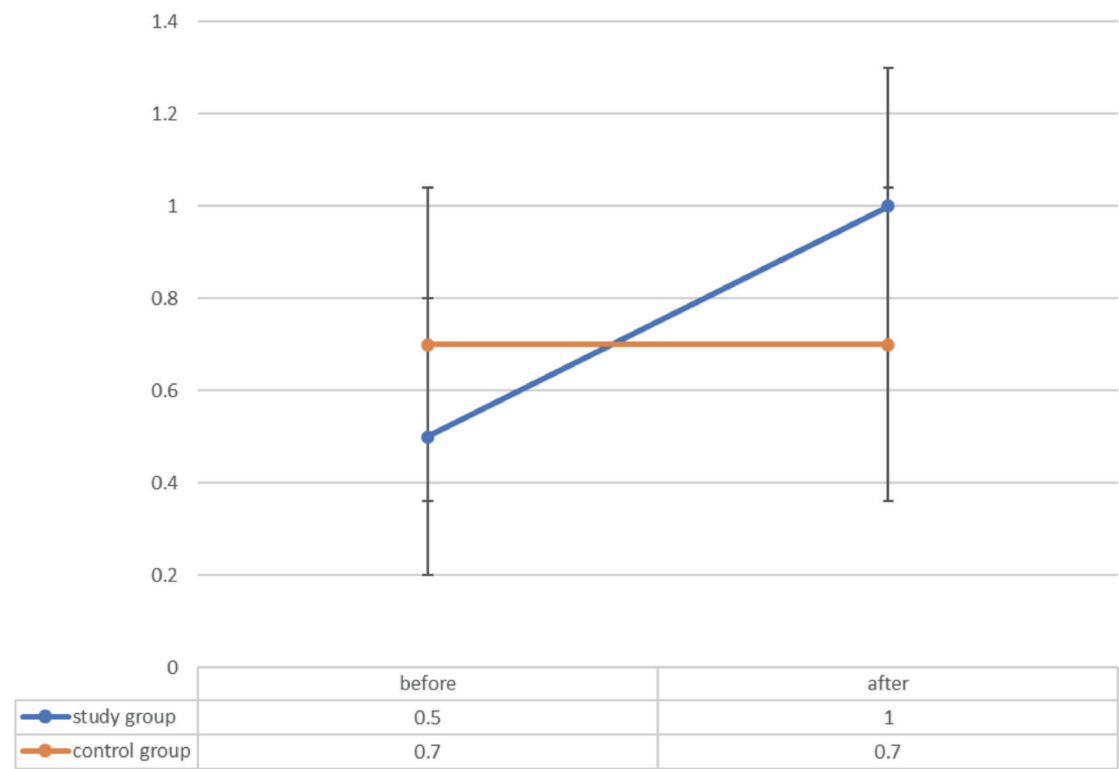


Fig. 2. Number of monocytes (MONO) in the research and control groups before and after magnetic stimulation, [norm: 0.30-0.80 K/ μ l]

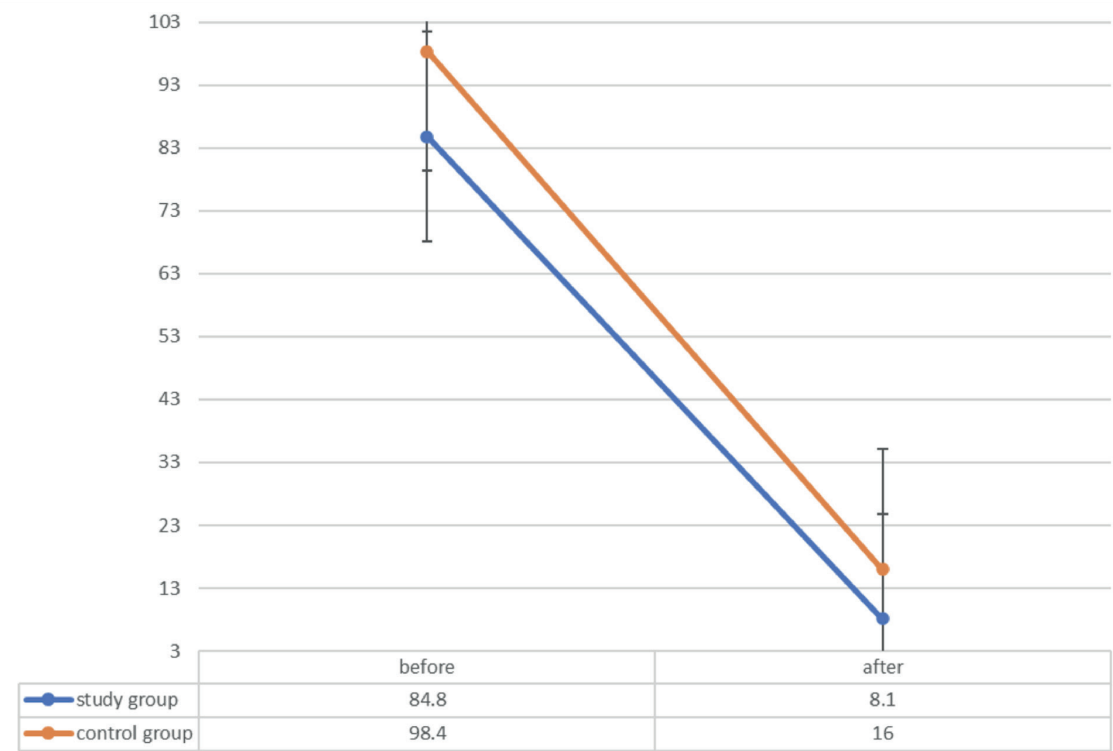


Fig. 3. CRP values in the study and control group before and after magnetic stimulation, [norm: 0,05-5.00 mg/l]

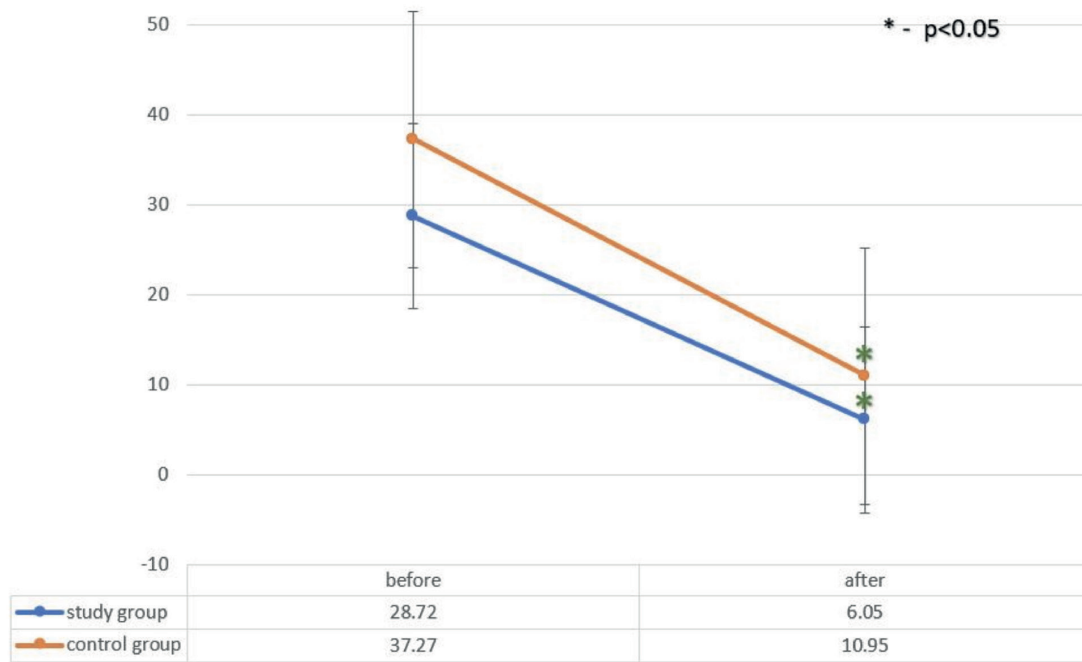


Fig. 4. The level of IL-6 in the study group and in the control group before and after the therapy, [norm: 2-6 pg/ml]

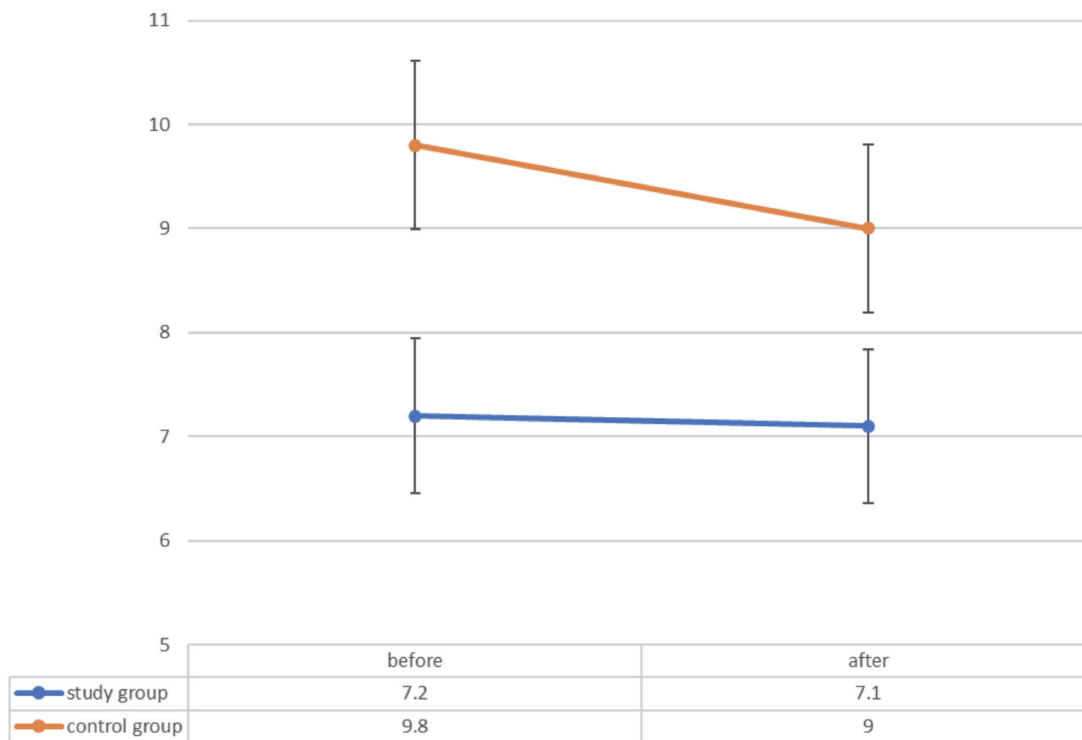


Fig. 5. The leukocyte level (WBC) in the study and control group before and after magnetic stimulation, [norm: 4.0-10.0 K/ μ l]

vs. 16 mg/dL, $p=0.015$). Only in the magnetic stimulation treated group was the CRP value close to 5 mg/l, indicating normalization of the results.

No adverse effects were observed in the study.

DISCUSSION

It is suggested that the effects of low induction magnetic fields are exerted on altered functional states, in terms of hypo- or over-reactivity, but not on normal functional states. There is still no consensus on the exact biological effect of electromagnetic fields on the physical mechanisms that may be behind their interaction with biological systems. As already explained, the biological effects of electromagnetic fields depend on the frequency, amplitude, time and duration of exposure, but are also related to the intrinsic susceptibility and reactivity of different cell types. This prompts confirmation of the observations related to the effects of electromagnetic fields on biological systems, and which concerns the presence of a “window effect”, indicating that biological effects only occur at certain combinations of frequency and field strength. There is increasing evidence of the potential role of electromagnetic fields in the biological modulation of autoimmunity, immune function and oxidative stress [4].

The magnetic field, as a physical agent in the form of magnetic stimulation of the Viofor JPS System, exerts an immunocorrective therapeutic effect, improving the defensive functions of the immune system and thus supporting the immune function. Treatment of patients with COVID-19 exacerbations involves among others the use of antibodies against interleukin-6, whose activity increases rapidly during the so-called cytokine storm. There are scientific reports on the effect of magnetic field on the IL-6 activity [11-15].

Studies on the application of magnetic stimulation in the acute course of COVID-19 were conducted, among others, by Vergallo C. The researcher, while evaluating hematological parameters in severely ill patients with COVID-19, observed leukocytosis, lymphocytopenia, and abnormal release of circulating cytokines, referred to as the cytokine storm syndrome (CSS, also known as cytokine release syndrome or CRS). In his study, he showed that the production of these cytokines is modulated by 24-hour magnetic field exposure which is induced by IL-10 and suppressed by IL-6. The researcher concluded that even if the lymphocyte count in COVID-19 patients is very low, magnetic field exposure can be a method to restore the physiological balance of lymphocytes, thus providing an effective treatment for patients [16]. Our results correspond to the reports of Vergallo C. Patients hospitalized due to COVID-19 who received magnetic stimulation treatments with the use of Viofor JPS System apparatus, demonstrated a statistically significant decrease in the concentration of proinflammatory IL-6.

Magnetic stimulation induces in the body electromotive forces selected in such a way as to maintain homeostasis, and in the case of its disruption – accelerate the return to normal. In the study group (with magnetic stimulation), we

also observed a higher number of monocytes (MONO) at a more stable level of leukocytes (WBC) compared to the control group (without magnetic stimulation). Both the study and control groups showed a statistically significant decrease in CRP levels. Only in the magnetic stimulated group, the CRP value was below 10 mg/l, which meant the absence of active inflammation [17-19].

The Viofor method opens up a wide range of possibilities in the treatment and prevention of COVID-19 patients. From the point of view of efficacy, it can be used in some cases, also as an alternative to pharmacological treatment, both acute and chronic. It is a non-invasive therapy and may be particularly beneficial in patients with comorbidities (cardiovascular, post-stroke, pneumonia). The beneficial immunocorrective changes in the immune system after Viofor JPS treatments, contribute significantly to the clinical improvement of patients with COVID-19 and may prevent dangerous complications [20-22].

The magnetic fields used in physiotherapy are safe and usually do not have any side effects except for slight changes in subjective well-being. The limiting magnitude of the magnetic field for pigs is 1.66 kT, which is 31 times the magnitude of the human heart that was administered for MRI. For comparison the magnetic fields in magnetic stimulation are measured in microteslas, generally not acting detrimentally [23].

Controlling inflammatory mediators appears to be important for cell homeostasis and health. For example, a deficiency in TGF- β activity promotes neurodegeneration and the development of Alzheimer's disease, while an increase in TGF- β may act as an anti-inflammatory cytokine and has a potential neuroprotective effect. cytokines, chemokines, and adhesion molecules. In contrast, its natural inhibitor, IL-18 binding protein (IL-1BP), acts as a negative feedback mechanism in both cases and reduces the effects of inflammation [24].

In a study by Reale M. et al. cultures of SH-SY5Y human nerve cells were exposed to ELF-EMF 50 Hz, 1.0 mT exposure, and their cellular morphology and proliferation rate were compared to that of control cells that were not exposed to a magnetic field. No differences in cell morphology and viability were seen at any time during the evaluation. Importantly, a significant increase in TGF β and IL-18BP expression was observed after 24 hours. exposure to ELF-EMF, while the expression of IL-18 and MCP-1 were not statistically significantly changed [24].

In the above study, these parameters were not tested, but their changes indicate the anti-inflammatory effect of the field and the safety of its use.

The research is a pilot study. Unfortunately, the conditions of the epidemic (many changes in the organization of isolation and therapy) did not make it possible to gather a larger group. Undoubtedly, it would be worthwhile, if possible, to increase the study group and the observation time after the end of the application of magnetic stimulation. Nevertheless, the shown trends of improvement in laboratory indicators point to the potential action of magnetic stimulation, as a possible beneficial effect.

CONCLUSIONS

1. The application of low-frequency magnetic field in the hybrid treatment of COVID-19 patients may reduces pro-inflammatory factors (IL-6).
2. A statistically significant decrease in the concentration of pro-inflammatory factors was noted in both the study and control group with greater tendency to normalize in the study group.
3. Both in the study group and the control group, a statistically significant decrease in the CRP level was

noted – the improvement was greater in the study group.

4. Only in the study group with magnetic stimulation was the CRP value close to 5 mg/l, indicating normalization of the results.

In the study group (with magnetic stimulation) a number of monocytes (MONO) was also observed with a more stable level of leukocytes (WBC) compared to the control group (without magnetic stimulation – which is a favorable phenomenon.

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CONFLICT OF INTEREST

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THE ASSESSMENT OF ACUPRESSURE EFFECTIVENESS AND SAFETY IN THE COMPREHENSIVE TREATMENT AND REHABILITATION OF PATIENTS WITH PEPTIC ULCERS

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ABSTRACT

Aim: The paper evaluates effectiveness and safety of acupressure (AP) in the comprehensive treatment and rehabilitation of patients with uncomplicated peptic ulcer disease (PUD).

Materials and Methods: The study retrospectively assessed the effectiveness of treating 24 PUD patients, who received AP session following the author's protocol based on Houston F.M. recommendations. The statistical analysis of the results employed the algorithm for qualitative data analysis applying the MedCalc 2023 software package. We analyzed the frequency of clinical syndrome manifestations before and after treatment, calculating the interval estimate of this measure (95% confidence interval (CI)). The study formulated null and alternative statistical hypotheses applying the McNemar test to check the null hypothesis for paired samples. When evaluating the risk of AP side effects, we determined 95% CI for proportion, considering binomial distribution of the feature ("presence-absence of complications").

Results: After completing the treatment course and observing the absence of endoscopic signs of peptic gastropathy, we detected statistically significant changes in the frequency of all clinical syndrome manifestations (p -value < 0.0001 , based on the McNemar test). AP rapidly and effectively alleviated the main clinical manifestations in patients with PUD. The tolerability of acupressure was good, without side effects. The study determined with 95% probability, that the risk of adverse effects did not exceed 15%.

Conclusions: AP is easy to use, non-invasive adjunctive therapy and alternative medical practice during the rehabilitation stage for PUD patients. It proves to be effective, safe, and inexpensive non-pharmacological method of treatment and rehabilitation, aligning with the alternative statistical hypothesis.

KEY WORDS: complementary and alternative medicine, acupressure, peptic ulcer disease, rehabilitation

INTRODUCTION

Peptic ulcer disease of the stomach and duodenum remains a topical issue in gastroenterology in many countries worldwide. Its high prevalence across all age groups of the population, including working-age individuals, the elderly, children, and adolescents, highlights the medical and social importance of this problem [1]. In the United States, PUD affects approximately 4.6 million people annually, and in Western countries, the prevalence of this condition ranges from 6% to 15%. In Ukraine, the proportion of PUD cases in the overall gastrointestinal disorders reaches 13.3% [1, 2].

Complementary and alternative medicine (CAM) is becoming increasingly popular and the fastest-growing methods of treatment worldwide [3]. Acupressure is one of the well-known CAM medical practices originated more than 3000 years ago in China. Acupressure (*from Latin acus – point + pressura – pressure*) is a variation of acupuncture (*needle puncture*) without needles, accurately described by F.M. Houston [4]. As an integral part of ancient Eastern medicine, known as finger "zhēn" in China and "shiatsu" in

Japan, acupressure (AP) has proven its effectiveness over the centuries and remains significant to this day [4-6].

AP works with the same points and meridians as acupuncture. Practitioners can activate acupuncture points with their fingers or various handheld devices for therapeutic massage [3]. Applying pressure to these effective point, one can produce effect similar to those of acupuncture [7], which in many cases is no less effective than traditional needle acupuncture [5]. Meridians are channels within the human body that assist in maintaining Qi (life energy) and, thus, promoting the stability of health state [3]. Both finger acupressure and acupuncture are based on the same fundamental principle of activating acupuncture points through meridians, which correct Qi imbalance [3]. The only difference between two approaches is that acupressure stimulates the biologically active points (BAP) through finger pressure, rather than applying thin needles. Compared to needle acupuncture, finger acupressure is technically simpler [6], as it does not require special equipment or instruments [4, 5, 8-11], and it is non-invasive, painless, and eliminates the risk of bleeding or infection associated with needle insertion [3].

Therefore, acupressure stands as one of the promising non-pharmacological therapeutic technique for improving patients' well-being and quality of life, as well as being an effective medical rehabilitation technique.

AP can be applied at all stages of rehabilitation and treatment and is widely used in various medical fields. In pediatrics, AP stands as one of the primary methods of reflexotherapy. Clearly, AP has numerous advantages, including its non-invasive, safe, accessible, and effective nature. It is employed both independently and in combination with acupuncture, physiotherapeutic procedures, therapeutic exercises, and conventional medication. The well-considered selection of AP points and successful integration of AP as adjunctive therapy with medication, make it possible to minimize the need for drugs, avoiding polypharmacy [9-11]. It should be noted that AP can also be applied for emergency assistance [3-9]. Applying pressure to specific AP points enables the provision of first aid during shock, revives unconscious or collapsed patients, alleviates or eliminates pain, stops bleeding, and more [5, 6, 10, 11].

AIM

The paper evaluates the effectiveness and safety of implementing AP in the comprehensive treatment and rehabilitation of patients with uncomplicated peptic ulcer disease of the stomach and duodenum. It aimed at analyzing AP effect on the clinical course, tolerability and side effects in these patients. The primary endpoint during the treatment and rehabilitation period was the complete absence or significant alleviation of symptoms at the end of the treatment, leading to improved well-being and enhanced quality of life [10, 11].

MATERIALS AND METHODS

The study is based on a retrospective analysis of examination and treatment results of 24 outpatients with uncomplicated PUD associated with *H. pylori* infection: 4 patients with gastric ulcers and 20 with duodenal ulcers. It included 10 (41.7%) male patients and 14 (58.3%) female. The inclusion criteria for the study involved adults aged between 22 and 60 years, presenting clinical manifestations of abdominal and/or dyspeptic, as well as asthenoneurotic syndromes, with varying degrees of severity.

The study excluded individuals with "anxiety" symptoms, severe comorbid pathologies, adolescents, individuals over 60 years old, cancer patients, pregnant women, and patients with alcohol or drug abuse. Persons who had undergone surgical interventions (including stomach resection, cholecystectomy, etc.) were also not included in the study. AP was not administered to patients after meals and in the presence of fever or acute inflammatory processes, skin inflammation, scars, or rashes.

The diagnosis verification was based on general clinical data, findings of physical examinations, fibroesophagogastroduodenoscopy (FEGD), pH-metry, presence of *H. pylori* infection, and, if necessary, histopathological examination, as well as abdominal ultrasound, etc. FEGD findings (prior to AP application)

detected that all patients presented with ulcerative defect and inflammatory-dystrophic changes in the gastroduodenal mucosa.

When achieving the objective specified, all patients received AP session following the protocol developed by the authors and based on Houston F.M. recommendations. The developed AP protocol encompassed both local (abdominal) and distant acupressure points (located on the trunk, chest, head and hands) associated with the stomach and duodenum [4]. The procedure for AP administering was documented in detail in the authors' patent in Ukraine [11]. The treatment duration ranged from 12 to 20 days, comprising 6-8 acupressure sessions, considering the severity of the clinical symptoms.

In 16 (66.7%) patients, we used AP as adjunctive therapy alongside the conventional 10 or 14-day session of triple-component anti-*Helicobacter pylori* therapy. Typically, *H. pylori* infection causes 90% of duodenal ulcers and 70%-90% of gastric ulcers [12]. However, 8 (33.3%) patients did not receive anti-*Helicobacter pylori* therapy, since they had already undergone it previously as part of a comprehensive anti-ulcer treatment, without experiencing significant therapeutic improvement afterward. These patients presented with various degrees of clinical symptoms and syndromes, indicating the need for further rehabilitation applying AP as adjunctive therapy to facilitate optimal recovery.

We assessed AP effectiveness based on the criteria which included speed of pain relief, speed of resolution of major clinical manifestations regarding dyspeptic and asthenoneurotic syndromes, disappearance of endoscopic signs of ulcerative changes in the mucosa considering the follow-up FEGD findings after adjunctive or alternative therapy.

When performing statistical analysis of the observational findings obtained, we followed the algorithm for qualitative data analysis, description and presentation of dichotomous qualitative variables [13-15], applying the MedCalc Statistical Software version 22.009 (MedCalc Software Ltd, Ostend, Belgium, 2023) [16].

The assessment of AP efficacy in PUD patients comprised identification of existing symptoms before and after AP application. The analysis included the occurrence frequency of various qualitative indicators (clinical syndromes before and after treatment, side effects risk caused by AP application), with the variable attribute having values "yes/no", "presence/absence of side effects" and etc. Qualitative variables analyzed in medical research with only two possible values, are referred to as binary or dichotomous variables [13, 14].

The study provided the absolute value and the feature percentage in the structure of entire totality (point estimate of the feature frequency), when describing binary qualitative variables, along with the calculation of the interval estimate – 95% confidence interval (95% CI) [13, 14].

The evaluation of the AP effect on the frequency change in major clinical syndromes against the background of disappearance of endoscopic signs of ulcerative gastropathy was performed with the non-parametric McNemar test for two paired (dependent) observation groups, with patients

acting as their own control or a “before and after” type research [13-16].

We conducted the assessment of the side effects risk caused by AP based on determining 95% CI level for the proportion, considering the binomial distribution of the feature (“presence-absence of complications”) [15].

The application of statistical analysis allowed confirming or rejecting the decision adopted and formulating statistical hypotheses. We have formulated the null hypothesis H_0 [13, 14], suggesting that the proposed treatment and rehabilitation method for PUD patients, involving AP sessions, is not effective and safe. Accordingly, the alternative hypothesis H_a [13, 14] has asserted that the proposed treatment and rehabilitation approach for PUD patients, including AP sessions is effective and safe, and it is accepted in case of rejecting the null hypothesis. To test the null hypothesis, we employed the McNemar criterion (for related groups to analyze the research results based on paired observations – “before and after”) [13, 14, 16].

Based on the results of the examination, the Committee on Ethical Issues and Biomedical Ethics of Poltava State Medical University believes that the work meets the requirements of the Helsinki Declaration on Human Rights.

RESULTS

The clinical presentation of all 24 (100%) patients with peptic ulcers included varying degrees of abdominal pain syndrome, depending on the ulcer location and the active phase duration of the pathological process, which were dominant. The majority of patients experienced abdominal pain accompanied by dyspeptic disorders such as heartburn, belching, nausea, vomiting, bloating, appetite disturbances, constipation, etc., as well as asthenoneurotic symptoms, including fatigue, irritability, increased excitability and anxiety, reduced work capacity, emotional instability and even aggression, adynamia, passivity, drowsiness, apathy, depression, and sensitivity to weather changes, etc.

The frequency of manifestations of the major clinical syndromes was assessed before and after AP application. Before AP administration, 19 patients ($79.17 \pm 8.29\%$; 95% CI 47.66-123.63%) presented with dyspeptic syndrome manifestations, and 18 patients ($75.0 \pm 8.84\%$; 95% CI 44.45-118.53%) experienced asthenoneurotic syndrome. After

treatment with AP application, pain and asthenoneurotic syndromes persisted in 4 patients ($16.67 \pm 7.61\%$; 95% CI 4.54-42.67%), while 3 patients ($12.5 \pm 6.75\%$; 95% CI 2.58-36.53%) experienced residual symptoms of dyspeptic syndrome.

While determining the AP effect on changes in the frequency of the major clinical syndromes, we used the McNemar test for two related (dependent) observation groups (case of paired observations) with the calculation of the exact probability value for the binomial distribution. The data of calculations are presented in Table 1.

All patients tolerated AP well. No adverse effects were observed in any of the patients when applying AP. Calculations based on a normal distribution of the sample indicate that both the assessment of side effects risk and 95% CI equal zero [15]. However, this contradicts common sense. Therefore, we performed additional calculations of 95% CI for the proportion based on the binomial distribution [15], which provided a more accurate assessment of the side effects risk associated with AP.

For this purpose, one should start with locating the point which corresponds to the sample proportion p (in this case, zero) on the horizontal axis. Then, draw a perpendicular line from this point, intersecting with a pair of curves corresponding to the sample size. The vertical coordinates of these intersection points represent the boundaries of 95% CI. In our study with a sample size $n = 24$, the lower CI boundary is 0, and the upper CI boundary is approximately 0.15. Therefore, with 95% confidence, we can conclude that the risk of experiencing side effects caused by AP does not exceed 15%.

DISCUSSION

Over the past few decades, CAM has attracted the interest of healthcare professionals and patients worldwide owing to its simplicity of application, effectiveness, economic aspects and various other reasons [3]. It refers to the use of treatment and rehabilitation methods that typically fall outside the realm of traditional medical model. Complementary and alternative medicine (also referred to as “non-orthodox,” “unconventional,” “holistic,” and “integrative” medicine) comprises a heterogeneous array of interventions, from acupuncture to spinal manipulation and from herbal medicine to homeopathy [17].

Table 1. Changes in the frequency of manifestations of abdominal, dyspeptic and asthenoneurotic syndromes in patients with peptic ulcer disease during treatment and the main criteria for comparison

| Stages of observation | Abdominal syndrome | | Dyspeptic syndrome | | Asthenoneurotic syndrome | | totally |
|-------------------------|--------------------------|---------|--------------------------|---------|--------------------------|---------|---------|
| | present | absent | present | absent | present | absent | |
| Before treatment, n (%) | 24 (100) | 0 (0) | 19 (79) | 5 (21) | 18(75) | 6 (25) | 24 |
| After treatment, n (%) | 4 (17) | 20 (83) | 3 (12) | 21 (88) | 4 (17) | 20 (83) | 24 |
| McNemar criterion, % | – 83, 33 | | – 66, 67 | | – 58, 33 | | |
| 95% CI | From –98, 2 to –68, 4 | | From –85, 5 to –47, 8 | | From –78, 1 to –38, 6 | | |
| Significance (p) | < 0, 0001 | | < 0, 0001 | | < 0, 0001 | | |

AP is a form of acupuncture that involves applying constant pressure instead of inserting needles. It stands as one of the oldest treatment methods, mentioned in ancient Eastern texts alongside descriptions of zhen-jiu therapy (acupuncture and moxibustion) and herbal medicine [18].

Modern studies confirm the use of AP in providing painless treatment for a wide range of conditions, spanning from immune disorders to emotional disturbances. It serves as adjunctive treatment method which effectively alleviates various types of pain while concurrently managing multiple symptoms in different patients. The non-invasive and needle-free nature of AP makes it more acceptable to individuals, contributing to its widespread appeal [3].

AP method is based on applying pressure with the fingertips on specific acupoints or reflex zones involving widely accepted techniques energetically related to various internal organs and systems. It has been determined that AP transmits pleasant impulses to the brain at a speed four times faster than pain stimuli [3].

There are over 360 acupuncture points located along 14 meridian channels which encompass the body in interconnected matrix [19]. Moreover, each acupuncture point is recognized to have a specific therapeutic effect; however, combinations of acupuncture points are often stimulated to produce a therapeutic effect [19].

It is commonly known that AP effectiveness relies on the ability to find and target the correct AP points, skillfully combine them, and select appropriate techniques and methods for stimulation. The careful selection and activation of specific acupuncture points, along with the appropriate pressure applied, play the important role in the success of treatment [3]. It is evident that the intensity of pressure should be regulated appropriately: high-intensity pressure can potentially harm any part of the body, while insufficient pressure may be ineffective in alleviating pain [3]. Murphy et al. (2019) reported four minor side effects associated with AP application, all of which were related to excessive pressure applied to acupuncture points [20].

In all cases, determining the appropriate stimulation dosage for BAP depends on the patient's clinical condition and reactivity. Assessing the patient's reactivity can be challenging, requiring the experience and intuition of practitioner. Moreover, the time of day and seasonal factors should also be considered. The same person may exhibit higher reactivity in the morning than in the evening, while in winter individuals tend to be less sensitive to stimulation. It is important to bear in mind that excessive duration or intensity of AP can trigger a negative response from the body, potentially leading to deterioration of the patient's overall condition.

The vasomotor response of the skin can be used for appropriate dosing, namely, the appearance of hyperemia in the area of AP application [18]. The presence of red spot on the skin indicates correctly performed acupressure and its sufficient duration. Therefore, the approach to each patient should be tailored to their individual characteristics, since the intensity and force of the massage stimulation are crucial factors in achieving the desired effect.

The correctly applied pressure to the body active points ("life points") causes a phenomenon of predictable sensations and specific sequence of effects on the body, similar to inserting acupuncture needles [18]. During acupressure, the patient experiences a combination of specific sensations (pain, warmth or coolness, feeling of electrical current, etc.), which radiate in particular directions. Our practical experience supplemented this list of sensations: "dropping" the stomach or internal organs, warmth dispersing like rays of the setting sun. According to ancient medical practitioners, the absence of these expected sensations may indicate a lack of therapeutic effect [18]. It is worth noting that not all patients experience these sensations. In 5-10% of cases, they are absent, which can complicate the intervention, since it becomes challenging to monitor the therapeutic process. However, the emergence of predictable sensations serves as a significant psychological factor for physician, while also having a positive psychotherapeutic effect on patient. The presence of these sensations indicates that the point is detected correctly and works, which is a key factor in achieving a rapid and positive therapeutic effect when applying AP. Furthermore, the first AP session holds great significance, since it allows the practitioner to assess the patient's response to BAP stimulation, thereby predicting the effectiveness of intervention in advance. Practical experience with AP reveals that in some patients, even in the absence of expected sensations, a positive therapeutic effect can still be achieved. The treatment outcomes mainly depend on the accurate selection of points, the method of stimulation employed and the appropriate dosage of pressure applied.

Usually, even after the first AP session, most patients primary experienced relief from abdominal pain and reduction in dyspeptic syndrome manifestations. Simple finger pressure on specific AP points, following AP protocol, not only alleviates pain within the first 15-30 minutes of the intervention but also greatly improves the patient's overall well-being. Consolidation of treatment results and patient's recovery include repeated intervention sessions daily for the next 2-3 days, followed by intervals of 2, and eventually 3-4 days.

The results obtained regarding the rapid pain relief align with the literature data, since pain is widely recognized as a primary indication for treatment, and AP ranks among the most commonly employed methods for pain reduction [3, 21-24]. According to the literary sources, the rapid and significant effect of AP application is observed in painful conditions [3-11, 18, 20-24]. Notably, applying continuous pressure for around one minute on specific hyperalgesic points helps to effectively reduce both local and widespread pain [3]. Furthermore, employing acupressure on acupuncture points can alleviate or completely eliminate abdominal pain of various nature [8].

After completing the two-week treatment course, clinical manifestations of abdominal and asthenovegetative syndromes completely disappeared in 83% of patients (20 out of 24), while symptoms of dyspeptic syndrome – in 87.5% (21 out of 24) correspondingly. Only 4 patients experienced occasional

painful sensations, mild discomfort in the epigastric region, or heaviness in the stomach. The treatment was assessed as highly effective, with 83% of patients experiencing very positive outcomes (complete absence of symptoms), and the remaining 17% reported good results (significant reduction in symptoms). The patients' condition showed significant improvement, confirmed by the absence of ulcerative defects based on the follow-up EGD data after 3-4 weeks of treatment. Moreover, the eradication control data demonstrated the successful elimination of *H. pylori* within 1-1.5 months. These positive outcomes contributed to a stable and long-term remission of the disease.

When assessing the treatment effect on changes in the frequency of syndrome manifestations, we employed the non-parametric McNemar test for paired samples (pre- and post-treatment study) [13, 14, 16]. After completing AP treatment in patients with uncomplicated ulcer disease, we observed statistically significant changes in the frequency of all three clinical syndromes (two-sided p-values < 0.0001 according to the McNemar test). This provides evidence of a substantial difference between these two proportions [14, 16].

The statistical analysis conducted indicates AP effectiveness, which allows for a rapid and productive alleviation of the major clinical manifestations in patients with uncomplicated gastric and duodenal peptic ulcers. Therefore, the null hypothesis,

suggesting no clinical effect of AP application, is rejected and the alternative hypothesis is accepted [13, 14]: the proposed rehabilitation and treatment approach for patients with peptic ulcers, including AP sessions, is effective.

The tolerability of AP in all patients was excellent. No side effects of acupressure were observed in the patients. With 95% confidence level, we can assert that the risk of developing side effects from AP application does not exceed 15%, which is consistent with the safety data presented in the literature [3-6, 19, 21]. Only some authors have reported minimal side effects associated with the use of excessive pressure [20].

CONCLUSIONS

AP serves as easy to use, non-invasive adjunctive therapy and alternative medical practice in the rehabilitation of patients with uncomplicated gastric and duodenal peptic ulcers.

AP can be a cost-effective non-pharmacological approach to rehabilitation and treatment of peptic ulcers due to its efficacy, safety and low risk of side effects.

The findings of the study presented contribute to the knowledge base concerning medical practices for the treatment and rehabilitation of uncomplicated gastric and duodenal peptic ulcers.

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THE ASSESSMENT OF THE EFFECT OF THE WHOLE-BODY CRYOTHERAPY ON THE FUNCTIONAL STATUS OF PATIENTS WITH LUMBAR SPINE OSTEOARTHRITIS

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ABSTRACT

Aim: To assess the effect of the whole-body cryotherapy on everyday functioning and the severity of pain of patients diagnosed with lumbar spine osteoarthritis.

Materials and Methods: The study included 100 patients with osteoarthritis who underwent a course of a series of 10 treatments of the whole-body cryotherapy in cryogenic chamber. The Visual Analogue Scale and the Revised Oswestry Low Back Pain Disability Scale were used to assess the effectiveness of the therapy. The mobility of the spine was examined using the Thomayer test and the Schober one.

Results: A significant statistical improvement was demonstrated in the reduction of pain ($p < 0.0001$) and daily functioning ($p < 0.0001$). The biggest change was observed in the case of personal care, sleeping and traveling activities. There was no significant change in walking ($p = 0.6323$), sitting ($p = 0.0827$) and lifting heavy objects ($p = 0.0761$).

Conclusions: The use of the whole-body cryotherapy significantly improves daily functional efficiency and reduces pain of patients with lumbar spine osteoarthritis. In addition, the range of mobility is improved

KEY WORDS: cryotherapy, osteoarthritis, low back pain

INTRODUCTION

Osteoarthritis is one of the main health problems within the musculoskeletal system. It causes a significant reduction in functional activity and it is the second most common cause of disability according to the World Health Organisation estimate [1].

The joints of the lumbar spine are the most common location of it. Among other things, this is caused by overloads resulting from a sedentary lifestyle and poor physical activity. These phenomena have recently been exacerbated by the global epidemiological situation [2]. Predictors of this disease also include genetic factors and obesity [3, 4].

This disease is characterized by the formation of osteophytes and the remodelling of the subchondral layer of bones. The place most exposed to changes is the L₄-S₁ segment [3].

The irreversible degenerative process in the lumbar spine develops gradually and reduced mobility and pain associated with it limit functioning in many areas of life.

The treatment of patients with lumbar spine pain is a significant medical problem. Due to the high social and economic costs, the quick and comprehensive therapeutic intervention is necessary [5]. Many ways of treating

lumbar spine osteoarthritis are described in the literature. Rehabilitation is an integral and multidirectional method of treatment [6-8].

One of the physical stimuli commonly used is cryogenic temperature. The whole-body cryotherapy consists in cooling the patient's entire body, causing reversible adaptive reactions of the organism [3]. The treatment is performed in a specially adapted cryochamber. The therapy consists of cyclic exposure to temperatures between -170°C and -110°C for 1 to 4 minutes [9, 10].

AIM

The aim of the study was to assess the effect of the whole-body cryotherapy on everyday functioning and the severity of pain of patients diagnosed with lumbar spine osteoarthritis.

MATERIALS AND METHODS

The study was conducted on a group of 100 patients (73 women and 27 men) in the Centre of Prevention and Rehabilitation NZOZ CREATOR Sp. z o. o. in Lodz.

The average age in the study group was 56.9 ± 12.5 years, half of the patients were no more than 59.5 years old (IQR: 48.5-67 years).

Most of the patients were overweight (41% of the subjects), every third patient (33%) had a normal weight, and 26% were obese. The average Body Mass Index was 27.3 ± 5.1 kg/m²; in half of the patients, the body mass index did not exceed 26.8 kg/m² (IQR: 24.1–30.1 kg/m²).

The mean duration of the disease was 12.0 ± 8.2 years, in half of the patients it did not exceed 10 years (IQR: 5.5–15 years).

The consent of the Bioethics Committee at the Medical University of Lodz no. RNN/167/21/EC of June 8, 2021 was obtained to conduct the study. All participants were informed of the purpose of the study and its progress and gave their deliberate acquiescence to participate in it.

The qualification for the whole-body cryotherapy included a medical examination. Each time before the start of the procedure, all patients were measured by heart rate and blood pressure.

A cycle of 10 whole-body cryotherapy treatments was carried out using a cryogenic chamber of the Wrocław type in the temperature range from -130°C to -120°C . After the procedure, the participants were directed to 30-minute kinesitherapy in the form of general rehabilitation exercises and with the use of devices as steppers and cycloergometers.

An original questionnaire consisting of pain assessment on the Visual Analogue Scale and the Revised Oswestry Low Back Pain Disability Scale was prepared to analyse the performance of daily activities. However, the assessment of spinal mobility was made using the Thomayer test and the Schober one.

STATISTICAL ANALYSIS

The quantitative variables are described by means and standard deviation (in the case of normality of distribution) or positional measures: median (Me) and interquartile range (IQR) and minimum and maximum (Min-Max) – in the absence of normality or ordinal variables. The normality of the variables was verified using the Shapiro-Wolf normality test. For non-measurable variables, the number of observations with a given feature variant (N) and the corresponding percentage (%) are given.

To compare patients before and after a series of procedures due to the lack of normality of the distribution of the compared variables, the Wilcoxon pair order test was used. In addition, the effect size was assessed using Cohen's d value as a measure. The effect is considered small when $d \in [0.20-0.50]$, medium when $d \in [0.50-0.80]$ and large when $d \geq 0.80$.

For qualitative variables, the McNemar-Bowker test was used to compare pre- and post-therapy results.

Results at $p < 0.05$ were considered statistically significant. The calculations were performed using the PQStat v. 1.8.6 statistical package.

RESULTS

Table 1 shows the Visual Analogue Scale pain severity assessment before and after a series of treatments. After therapy, a statistically significant ($p < 0.0001$) reduction in pain was found. Half of the respondents before the therapy rated the ailments at most 5 points (IQR: 4–7 points) and after therapy – for a maximum of 3 points (IQR: 1–5 points). The obtained effect should be assessed as large.

Figure 1 (A–F) presents the results for selected subscales of the Revised Oswestry Low Back Pain Disability Scale Questionnaire – Polish version before and after a series of treatments.

Analysing the results presented in Figure 1, it can be observed that after statistically significant therapy ($p = 0.0042$) the functioning in the field of care improved – before the treatments, the majority of respondents (38%) felt slight pain or increased pain (25%), and after a series of treatments the percentage of patients experiencing only slight pain increased to 52% and the percentage of patients who do not have to change anything in terms of care increased noticeably, to avoid pain (30%).

However, there was no statistically significant ($p = 0.6323$) improvement in walking functioning. Both before and after therapy, most patients reported that the pain prevented them from walking longer than 1500 m (45% before and 42% after a series of treatments, respectively).

There was also no statistically significant ($p = 0.0827$) improvement in functioning

in the sitting comfort. It should be noted, however, that after the therapy, the percentage of people who can sit in their favourite chair for as long as they want (an increase from 22% to 35%) and who can sit in any chair without pain (an increase from 7% to 13%) has increased.

After therapy, a statistically significant ($p = 0.0002$) improvement in functioning was observed in terms of standing – before the treatments, the majority of respondents (34%) reported that they could not stand for more than an hour without increasing pain, and after a series of treatments in most cases (39%) they reported feeling slight pain when standing but not rising.

As a result of the treatment cycle, there was also a statistically significant ($p = 0.0040$) improvement in sleeping functioning – before the treatments, 38% of respondents reported that they feel pain while lying in bed but it does not hinder sleeping, and 32% that they sleep only 3/4 of the night due to pain. After a series of treatments, more than half (52%) of patients reported feeling pain while

Table 1. Pain assessment according to the VAS scale before and after therapy

| Unit | Pain assessment according to the Visual Analogue Scale | | Level p | Effect value |
|----------|--|---------------|---------|--------------|
| | Before therapy | After therapy | | |
| Me (IQR) | 5 (4–7) | 3 (1–5) | <0,0001 | 3,0860 |
| Min-Max | 1–10 | 0–7 | | |

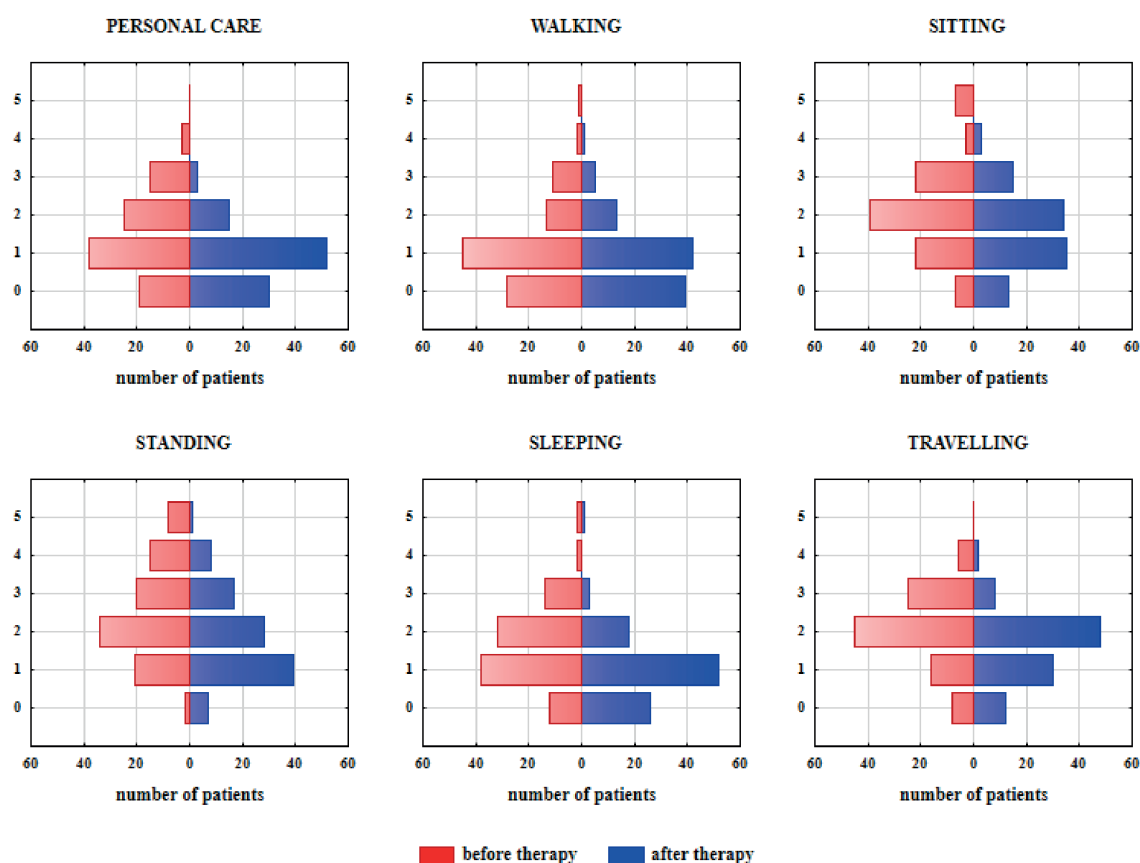


Fig. 1. Assessment of the ability to perform daily activities before and after therapy: A) Personal care, B) Walking, C) Sitting, D) Standing, E) Sleeping, F) Travelling

sleeping, but this pain did not interfere with sleep, and 26% said that they did not feel pain when lying in bed.

In addition, there was a statistically significant ($p=0.0020$) improvement in travel performance. Before the treatments, the majority of respondents felt additional pain while traveling, which did not force them to look for other ways to travel (45%) or one that forced them to look for other forms of travel (25%). After a series of treatments, the percentage of people who felt pain during the trip, but this pain did not increase significantly (increase from 16% to 30%).

Analysis of the remaining subscales showed statistically significant improvements in pain intensity ($p=0.0001$) and social functioning ($p=0.0019$). Before the treatments, the majority of respondents (40%) said that they had to avoid more demanding activities, and after a series of treatments, the most frequently indicated response (47% of patients) was that despite the pain they felt that their social life proceeds normally.

However, there was no statistically significant ($p=0.0761$) improvement in functioning in terms of lifting heavy objects, but you can see an increase in the percentage of patients who can lift heavy objects despite the pain (29% before therapy vs. 42% after therapy).

Table 2 presents a cumulative assessment of the state of functioning in the performance of daily activities before and after a series of treatments.

As can be noticed, after the therapy, a statistically significant ($p<0.0001$) improvement in the ability to function in everyday life was found. Before the therapy, half of the subjects obtained a score not higher than 20 points (IQR: 13-25 points) and after the therapy – no higher than 12 points (IQR: 8.5-18 points). The obtained effect should be assessed as large.

In addition, Table 3 compares the degree of disability assessed on the basis of the results of the Revised Oswestry Low Back Pain Disability Scale before and after a series of treatments. As can be seen, after a series of treatments, a statistically significant ($p<0.0001$) decrease in the degree of disability in the studied group was found. Before the therapy, the majority of patients (43%) had a moderate degree of disability, and after the therapy, more than half (53%) of the respondents disability can be described as minor.

Table 4 shows the results of the Thomayer test in the study group before and after a series of treatments. As can be seen, after the therapy, there was a statistically significant ($p<0.0001$) improvement in results. Before the procedures, half of the patients had a test result not exceeding 5 cm (IQR: 0-14 cm), and after a series of treatments – 1 cm (IQR: 0-9.75 cm). The obtained effect should be assessed as large.

Table 5 shows the results of Schober's test before and after a series of treatments. As can be seen, after the therapy, there was a statistically significant ($p<0.0001$) improvement

Table 2. Assessment of daily performance according to the Revised Oswestry Low Back Pain Disability Scale before and after therapy

| Unit | Total number of points in the questionnaire | | Level p | Effect value |
|----------|---|---------------|---------|--------------|
| | Before therapy | After therapy | | |
| Me (IQR) | 20 (13-25) | 12 (8,5-18) | <0,0001 | 2,8178 |
| Min-Max | 1-43 | 1-29 | | |

Table 3. Assessment of the degree of disability based on the Revised Oswestry Low Back Pain Disability Scale before and after therapy

| Disability | Before therapy | | After therapy | | Level p |
|------------|----------------|------|---------------|------|---------|
| | N | % | N | % | |
| lack | 2 | 2,0 | 8 | 8,0 | <0,0001 |
| low | 29 | 29,0 | 53 | 53,0 | |
| average | 43 | 43,0 | 32 | 32,0 | |
| serious | 24 | 24,0 | 7 | 7,0 | |
| total | 2 | 2,0 | 0 | 0,0 | |

Table 4. Thomayer test results before and after therapy

| Unit | Thomayer test results | | level p | Effect value |
|----------|-----------------------|---------------|---------|--------------|
| | Before therapy | After therapy | | |
| Me (IQR) | 5 (0-14) | 1 (0-9,75) | <0,0001 | 1,5103 |
| Min-Max | 0-37 | 0-36 | | |

Table 5. Schober test results before and after therapy

| Unit | Schober test results | | level p | Effect value |
|----------|----------------------|---------------|---------|--------------|
| | Before therapy | After therapy | | |
| Me (IQR) | 14,5 (14-15) | 15 (14,5-15) | <0,0001 | 1,6843 |
| Min-Max | 9-16 | 9-17 | | |

in results. Before the procedures, 50% of the patients did not have a test result exceeding 14.5 cm (IQR: 14-15 cm), and after a series of treatments – 15 cm (IQR: 14.5-15 cm). The obtained effect should be assessed as large.

DISCUSSION

Lumbar spine osteoarthritis entails long-lasting and burdensome effects, which are undoubtedly pain and limitation of efficiency during everyday activities.

The use of a stimulus in the form of cold causes analgesic, anti-edematous and myorelaxing effects in tissues [11, 12]. These are very beneficial changes from the point of view of patients struggling with osteoarthritis of the spinal joints.

In the study, an analgesic effect was observed through a statistically significant change in the intensity of pain according to the Revised Oswestry Low Back Pain Disability Scale and Visual Analogue Scale. This effect has also been confirmed in many other publications [13-16]. The analgesic effect of low temperatures was independent of

the age of the patients [16]. However, there are studies that deny the high statistical value of this parameter in the studied population [17]. In turn, Śliwiński et al. [18] report no significant change in the intensity of pain only in the group of women surveyed.

In the studies cited above, it can be observed that the whole-body cryotherapy reduces the perception of pain due to degeneration in the spine, but the size of this effect may be individually variable.

Even partial abolition of everyday pain can positively affect the range of motion of the degeneratively altered spine section. The obtained own results showed this type of relation. In studies, a significant improvement in the range of lumbar spine flexion was observed. Similar results were obtained by Szpruch and Kikowski [15] and Stanek et al. [19] in case of ankylosing spondylitis.

The increased range of motion within the spine will be reflected in the daily functioning of the patient. The analysis of the collected data showed that after a series of treatments in the cryochamber, the number of points

decreased significantly in the Revised Oswestry Low Back Pain Disability Scale Questionnaire. The greatest effect was observed for parameters such as personal care activities, travelling and sleeping. An improvement in the quality of falling asleep was also noted by Stanek et al. [20] both of patients suffering from lumbar spine pain and of healthy people. This may be due to an increased release of beta-endorphins, resulting in a state of relaxation and improved mood [21]. This mechanism is successfully used in adjuvant therapy of depressive disorders [22, 23].

In the study, activities such as walking, sitting, standing or lifting heavy objects improved only slightly, the results obtained were not statistically significant. On the other hand, activities such as prolonged staying in a sitting position and lifting, for example related to work, are strong predictors of future spinal pain [24].

As an element of prevention, the cryochamber treatment has been used in biological regeneration. Its stimulating effect on the body to regenerate prevents overload injuries and allows patients to return to the state of homeostasis faster [25].

The mechanisms of action of extremely low temperatures on the body are still not fully understood. However, both scientific reports and own results indicate the need for a holistic approach to the patient's problem during therapeutic intervention in form of the whole-body cryotherapy due to the possibility of improving the patient's quality of life on many levels.

CONCLUSIONS

The use of the whole-body cryotherapy significantly improves daily functional efficiency and reduces pain of patients with lumbar spine osteoarthritis. In addition, the range of mobility is improved.

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COMPLEX REHABILITATION OF ISCHEMIC HEART DISEASE PATIENTS AFTER CORONARY BYPASS OPERATION WITH THE USE OF BIOLOGICALLY ACTIVE ADDITIVES

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ABSTRACT

Aim: The purpose of the work was to study the possibility of using Dihydroquercetin in rehabilitation programs for patients with coronary artery disease after Coronary artery bypass grafting (CABG) surgery in order to increase the effectiveness of rehabilitation, which has notable scientific and practical significance.

Materials and Methods: The methodological basis of the research is based on systemic, historical, terminological, and informational approaches.

Results: The results of the study showed the high clinical effectiveness of Dihydroquercetin in the complex medical rehabilitation of patients with coronary artery disease who underwent the operation. The pill intake did not affect indicators of carbohydrate and lipid metabolism, which indicates its metabolic neutrality. None of the patients had any worsening of the condition, increased frequency of angina attacks, or episodes of painless ischemia. All patients indicated good tolerability of the drug, and improvement in general well-being (reduction or disappearance of shortness of breath, decrease in pain intensity, increase in activity, improvement in sleep). The implementation of the optimized rehabilitation program also contributed to the improvement of the psycho-emotional state of the patients.

Conclusions: Complex medical rehabilitation of patients with coronary heart disease after Coronary artery bypass grafting surgery according to a program with the inclusion of Dihydroquercetin helps to improve the rheological properties of blood, strengthen the active vasomotor mechanisms of MC regulation, improve indicators of central and peripheral hemodynamics, blood oxygenation, increase in exercise tolerance, improve psycho-emotional the condition, which ultimately ensure an increase in the rehabilitation effect.

KEY WORDS: ischemic heart disease, dihydroquercetin, biologically active supplements

INTRODUCTION

The state of health of the population is one of the most important factors in the economic development and well-being of the country. This social trend is supported by legislative documents that regulate the development and implementation in the coming years of new technologies for expanding the range and production of healthy food products with certain quality characteristics. Chronic deficiency of essential trace elements in the diet of a modern person against the background of disturbances in the structure of nutrition, hypo dynamism, adverse environmental factors, and other adverse effects of civilization is associated with the occurrence of general diseases and leads to a decrease in the duration of working capacity and unjustified socio-economic losses. Available domestic and international experience shows that the problem of

optimizing nutrition, including the diet special products containing biologically active additives (BAA), with a targeted systemic effect, convincingly indicates a successful solution to health problems. Therefore, the development of scientific principles, recipes, and technologies, supported by studies of quality indicators and an evidence base of effectiveness, is relevant and timely.

Dietary supplements (naturopathic remedies) are, as a rule, concentrates identical to natural biologically active substances, obtained as a result of processing plant and animal raw materials. Biologically active substances include dihydroquercetin, also known as "taxifolin" in Europe, which refers to natural antioxidants, or bioflavonoids. Dihydroquercetin is widely used in the production of biologically active supplements due to its excellent antioxidant and capillary protective properties.

Dihydroquercetin is often combined with vitamins, mineral complexes, and extracts of medicinal plants, creating vitamin drinks and cocktails for improving well-being in nutrition and rehabilitation practices.

Despite significant achievements in the field of pharmacotherapy of patients with coronary heart disease (CHD), surgical treatment of this category of patients, in particular, direct myocardial revascularization surgery - coronary artery bypass grafting (CABG), in some cases is the most effective [1-3]. As a result of the operation, coronary blood flow is restored, which eliminates or reduces myocardial hypoxia [4-6]. However, surgical treatment does not eliminate the main causes of the disease, it can be considered only as one of the stages in the complex treatment of CAD. In addition, severe surgical trauma, such as CABG surgery, naturally causes complex and diverse body reactions [2, 6, 7]. Being protective and adaptive in nature, they can acquire a pathological character and manifest themselves in various complications both immediately after the intervention and in the later rehabilitation period.

Overcoming the consequences of surgical intervention, prevention, and treatment of early and late postoperative complications largely determine the effectiveness of the entire complex of rehabilitation measures [1-5]. The analysis of data from the literature [1, 2, 7] and the results of our own research [3, 4, 6] made it possible to reveal a number of regularities of the clinical course and pathogenetic changes accompanying the postoperative period in patients with coronary artery disease, which is characterized by the following main syndrome complexes: cardiac, post-sternotomy, respiratory, hemorheological with impaired microcirculation, psychopathological, hypodynamic, metabolic, post-phlebotomy. Of great importance is the hyperthrombotic syndrome, which is characterized by pronounced changes in blood coagulation and anticoagulation, hematocrit parameters, fluidity limit, blood viscosity, and an increase in the functional activity of platelets [2, 4, 8]. A significant increase in the level of fibrinogen, as well as a significant increase in the content of soluble fibrinogen and fibrinogen-fibrin degradation products, indicates an increase in blood coagulation potential in patients with coronary heart disease. Violation of the rheological properties of blood leads to a decrease in oxygen supply to tissues [3].

In addition, patients with coronary heart disease after CABG surgery in the postoperative period show signs of disseminated intravascular coagulation syndrome, the development of which also contributes to the disruption of blood microcirculation (MC), in connection with which the search for new means that contribute to its improvement is urgent. Such means include the bioflavonoid Dihydroquercetin, which is obtained from the wood of Daurian larch and Siberian larch. Dihydroquercetin has a stimulating effect on tissue blood flow, stabilizes the barrier function of microvessels, reduces the permeability of capillary walls, and thus contributes to the reduction of stagnant phenomena in the microcirculatory channel.

AIM

The purpose of the work was to study the possibility of using Dihydroquercetin in rehabilitation programs for patients with coronary artery disease after CABG surgery in order to increase the effectiveness of rehabilitation, which has great scientific and practical significance.

MATERIALS AND METHODS

The material of the study was the results of observation, examination and rehabilitation of 30 patients with coronary heart disease who underwent CABG surgery and arrived at the Department of rehabilitation of Public non-commercial enterprise Ivano-Frankivsk regional cardiology dispensary of the Ivano-Frankivsk regional council on the 12th–17th day (on average - 15.2 days) after surgical treatment. The age of the patients ranged from 32 to 68 years (on average - 47.6 ± 3.2 years). The age group of 41–50 years was the most numerous.

The study was carried out in compliance with the basic provisions of the "Rules of ethical principles of scientific medical research with human participation", approved by the Declaration of Helsinki (1964-2013), ICH GCP (1996), EEC Directive No. 609 (dated 24.11.1986), Orders of the Ministry of Health of Ukraine No. 690 (dated 23.09.2009), No. 944 (dated 14.12.2009), No. 616 (dated 03.08.2012). All the participants were informed about the goals, organization, methods of examination and signed an informed consent to participate in the completely anonymous study.

The methodological basis of the research is based on systemic, historical, terminological and informational approaches. The systemic approach made it possible to simultaneously present physical rehabilitation/physical therapy for cardiovascular system disorders as a complex and integral object with the coordinated functioning of all parts and a set of sequential actions, most of which are performed together by a doctor of rehabilitation medicine, a physical therapist, and a patient. The use of the terminological approach was determined by the theoretical nature of the research. There was a need to describe, clarify and define the concept of biologically active supplements that can be effectively used in the rehabilitation of patients with cardiovascular system dysfunctions. Based on the information approach and the principle of informativeness, physical rehabilitation/physical therapy for cardiovascular disorders was investigated as an information system with combined management, which transforms the input medical information about the patient into the output information about the restoration of the functions of the cardiovascular system, activity and health.

To achieve the goal, the following general scientific research methods were used: general logical - abstraction, concretization, analysis, synthesis, induction, comparison, analogy; empirical knowledge - observation (qualitative); of theoretical knowledge - definition of scientific concepts, idealization, mental modeling.

RESULTS

We studied the possibility of optimizing the medical rehabilitation of patients with coronary artery disease

after CABG surgery by improving MC with the help of Dihydroquercetin. The average number of shunts per 1 patient was 2.3 ± 0.8 . During the study of the anamnesis, it was established that 19 (63.3%) patients underwent myocardial infarction before the operation. According to the NYHA classification, upon admission, 3 (10%) patients were assigned to I functional class (FC), 10 (33.3%) to II, 15 (50%) to III, and 2 (6.6%) to IV. The vast majority of patients are employees of highly emotional mental work (Table 1).

Among concomitant diseases, the most common were hypertension - in 16 (39.5%) patients, obesity - in 8 (26.6%), peptic ulcer - in 5 (16.6%), chronic bronchitis - in 6 (20%), chronic gastroduodenitis in 7 (23.3%), type 2 diabetes mellitus in 3 (10%). Most patients systematically smoked 20 to 40 cigarettes per day. Of the early postoperative complications affecting the course of rehabilitation, heart rhythm disturbances, complications from postoperative wounds, reactive pericarditis, and hydrothorax were noted. At the rehabilitation stage, patients most often complained of shortness of breath during normal physical exertion,

general weakness, pain along the course of the postoperative sternum scar, sleep disturbances. Improvement of MC after CABG surgery by improving MC with the help of Dihydroquercetin and indicators of FEB contributed to the positive dynamics of indicators of acid-base homeostasis (ABH) and gas composition of blood (Table 2).

As is evident from the data in Table II, patients of the main group had a more significant improvement in blood oxygenation than in controls, which was confirmed by a significant increase in PB2 and a decrease in blood PCO₂. The positive dynamics of MC indicators, improvement of blood oxygenation ensured an increase in the contractility of the myocardium, its propulsive force, a decrease in the average pressure in the pulmonary artery (AvPPA), which as a result contributed to a significant increase in exercise tolerance (ET) in the majority of patients of the main group (Table 3).

The results of the study showed the high clinical effectiveness of Dihydroquercetin in the complex medical rehabilitation of patients with coronary artery disease who underwent CABG. The drug did not affect indicators

Table 1. Dynamics of MC indicators in the rehabilitation process ($M \pm m$)

| Index, points | Control group (n=10) | | Main group (n=20) | |
|---------------|----------------------|-----------------|-------------------|-------------------|
| | before treatment | after treatment | before treatment | after treatment |
| KI | $7,7 \pm 0,3$ | $17,2 \pm 0,21$ | $8,3 \pm 0,37$ | $6,9 \pm 0,39^*$ |
| KII | $0,89 \pm 0,20$ | $0,88 \pm 0,23$ | $0,89 \pm 0,35$ | $0,80 \pm 0,36$ |
| KIII | $5,80 \pm 0,42$ | $5,64 \pm 0,45$ | $5,78 \pm 0,40$ | $4,85 \pm 0,35^*$ |
| KIV | $0,99 \pm 0,17$ | $0,92 \pm 0,21$ | $0,98 \pm 0,20$ | $0,95 \pm 0,35$ |

Note: * - the indicated indicators may probably differ from the indicators before treatment $p < 0,05$

Table 2. Dynamics of ABH indicators and blood gas composition in the rehabilitation process ($M \pm m$)

| Index | Control group (n=10) | | Main group (n=20) | |
|---|----------------------|-----------------|-------------------|-------------------|
| | before treatment | after treatment | before treatment | after treatment |
| pH | $7,40 \pm 0,03$ | $7,39 \pm 0,02$ | $7,38 \pm 0,03$ | $7,38 \pm 0,02$ |
| PCO ₂ , mm Hg | $41,4 \pm 1,34$ | $39,4 \pm 1,44$ | $41,4 \pm 1,44$ | $38,3 \pm 1,33$ |
| PO ₂ , mm Hg | $70,8 \pm 1,60$ | $75,2 \pm 1,40$ | $71,0 \pm 1,73$ | $83,6 \pm 1,81^*$ |
| Total plasma CO ₂ , mmol/liter | $23,84 \pm 1,6$ | $23,79 \pm 1,4$ | $23,95 \pm 1,6$ | $23,93 \pm 1,3$ |
| AB, mmol/liter | $22,4 \pm 0,9$ | $23,0 \pm 1,1$ | $23,0 \pm 1,6$ | $22,9 \pm 1,4$ |
| BE, mmol/liter | $-2,3 \pm 0,4$ | $-2,4 \pm 0,3$ | $-2,4 \pm 0,4$ | $-2,5 \pm 0,3$ |
| SB, mmol/liter | $23,1 \pm 0,6$ | $23,5 \pm 0,4$ | $23,6 \pm 0,6$ | $23,4 \pm 0,5$ |

Note: * - indicators may differ from the indicators before treatment $p < 0,05$

Table 3. Changes in indicators of hemodynamics and ET during rehabilitation ($M \pm m$)

| Index | Control group (n=10) | | Main group (n=20) | |
|-------------------------------------|----------------------|-------------------|-------------------|---------------------|
| | before treatment | after treatment | before treatment | after treatment |
| Cardiac index, liter/m ² | $2,78 \pm 0,22$ | $2,80 \pm 0,25$ | $2,71 \pm 0,12$ | $2,66 \pm 0,15$ |
| Emission fraction, % | $52,0 \pm 1,5$ | $54,4 \pm 1,42$ | $50,8 \pm 1,4$ | $56,2 \pm 1,5^*$ |
| Bandwidth repeater, units | $1126,3 \pm 40,4$ | $1156,7 \pm 39,8$ | $1092,4 \pm 40,1$ | $1001,2 \pm 39,6$ |
| AvPPA, mm Hg | $23,9 \pm 5,2$ | $18,7 \pm 5,4$ | $24,0 \pm 3,9$ | $17,1 \pm 3,4^*$ |
| ET, W | $77,4 \pm 5,1$ | $86,3 \pm 4,4$ | $70,7 \pm 4,3$ | $94,3 \pm 4,2^{**}$ |

Notes: * - indicators may differ from the indicators before treatment at $p < 0,05$; ** - indicator may differ from the initial one at $p < 0,001$

of carbohydrate and lipid metabolism, which indicates its metabolic neutrality. None of the patients had any worsening of the condition and increased frequency of angina attacks and episodes of painless ischemia. All patients indicated good tolerability of the drug, and improvement in general well-being (reduction or disappearance of shortness of breath, decrease in pain intensity, increase in activity, improvement in sleep). The implementation of the optimized rehabilitation program also contributed to the improvement of the psycho-emotional state of the patients. Their mood improved, and the index of reactive anxiety (RA) decreased statistically significantly - from 48.2 ± 4.1 to 34.4 ± 3.0 points ($p < 0.01$); in patients of the control group, the RA indicator decreased from 46.4 ± 5.1 to 39.5 ± 4.4 points ($p > 0.05$). Statistically unreliable reduction of indicators according to the scales of the neurotic triad (from 60.1 ± 1.34 to 57.1 ± 1.37 T-score for the 1st; from 59.7 ± 1.22 to 56 , for the 2nd 5 ± 1.27 T-score, on the 3rd - from 61.4 ± 1.32 to 58.5 ± 1.35 T-score; $p > 0.05$) in patients of the main group indicates the preservation of psychological maladaptation in part of operated patients, which requires appropriate correction. The development of microcirculatory disorders in coronary heart disease, including after CABG surgery, is caused mainly by changes in the rheological properties of blood due to impaired deformability of erythrocytes, increased aggregation of them, and platelets, increased hemostatic and decreased fibrinolytic potential of the blood, latent syndrome of disseminated dynamics of microvessels, which leads to increase in the volume of the microcirculatory bed, centralization of blood flow and inefficiency of MC [4-6, 9]. Stagnation, deposition of blood in capillaries, and venules contributes to a decrease in the venous return of blood to the heart and, in connection with this, to a decrease in cardiac output and a violation of tissue oxygenation. In turn, violations of the rheological properties of blood, associated with the aggregation of erythrocytes and accompanied by a decrease in the number of the latter, further disrupt the supply of tissues with oxygen. The main cause of tissue hypoxia is the development of a mechanical microcirculatory block.

It can be assumed that pronounced violations of pulmonary ventilation in patients cause hypoxia and metabolic disorders in tissues. This leads to the appearance of a number of vasoactive substances that contribute to the development of microvascular disorders and intravascular aggregation, which, in turn, supports and increases tissue metabolism disorders. Violations of FEB, ABH, gas composition of blood and MC, hypercoagulation, and reduction of the contractility of the myocardium leading to a decrease in the reserve capabilities of the cardiorespiratory system, which is clinically manifested by a decrease in ET, respiratory and heart failure [4, 5, 6, 9]. The positive dynamics of most of the indicators of the cardiorespiratory system during the rehabilitation program with the inclusion of Dihydroquercetin indicates improvement of MC, normalization of ABH and gas composition of blood, an increase of ET, elimination, and reduction of manifestations of respiratory and heart failure in most patients.

DISCUSSION

The results of the study suggest that Dihydroquercetin indirectly affects central and peripheral hemodynamics, improves indicators of intracardiac hemodynamics, and improves FEB and blood gas composition. The drug also eliminates spasms of arteries, including coronary arteries [4]. With a pronounced atherosclerotic lesion of the coronary arteries, even minimal changes in the normal tone of the smooth muscles in the areas of narrowing can increase ischemia or contribute to its reduction. Reduction of ischemia may be a consequence of relaxation of the normal tone of the smooth muscles of the stenosed areas of the coronary arteries. In addition, taking Dihydroquercetin prevents and relieves spasms in both normal and coronary arteries affected by the atherosclerotic process and thus contributes to the elimination of microangiopathy [1, 4-10].

The mechanism of inhibition of free radical reactions, including lipid peroxidation (LPO), in the presence of Dihydroquercetin (DHQ) can be different. It is proved that Dihydroquercetin can interact with lipid radicals and reactive oxygen species, such as hydroxyl and superoxide radicals, as well as chelate transition metal ions.

It is effective in rheumatism, septic endocarditis, and vegetative dystonia. It inhibits the development of dystrophic and sclerotic processes in the eyes and increases visual acuity. Inhibits inflammatory processes, and has a decongestant effect. Favorably affects the skin, normalizes the synthesis of collagen, and elastin in the skin (eliminates acne and pustular rash, helps maintain elasticity, skin). With prolonged use, it prevents the exacerbation of chronic respiratory diseases and the occurrence of acute respiratory viral infections. Helps to maintain the functions of the immune system, and has an antitoxic effect. It has gastroprotective activity: it stimulates the processes of regeneration of the gastric mucosa, prevents the development, and/or promotes the healing of gastric and duodenal ulcers. It has a hepatoprotective (antitoxic) effect, has radioprotective activity, and reduces the adverse effects of chemotherapy and radiotherapy on the body.

Dihydroquercetin is a reference antioxidant. Its antiradical activity is manifested at a concentration of approximately 0.0001-0.00001% in the complete absence of mutagenic activity for humans. The value of DHQ in pharmacology is invaluable. It has powerful anti-inflammatory and anti-allergic properties, strengthens and restores connective tissue, helps lower cholesterol levels, enhances the effect of many beneficial substances (vitamin C, etc.); strengthens blood vessels and capillaries, improves blood microcirculation, prevents the formation of blood clots, reduces inflammation in the prostate, strengthens the immune system. Also, DHQ protects the stomach and liver from harmful effects, and activates the processes of regeneration of the gastric mucosa. It has a pronounced prevention of the main diseases of aging: cancer, cardiovascular diseases, brain diseases, etc. It increases the resistance of body tissues to the damaging effects of excess blood sugar, reduces the likelihood of diabetes, and also facilitates the course of

developed forms. It has a positive effect on the nervous system and activates the nervous processes. The regulatory effect of this substance on several reactions of the body's immune system, on the course of inflammatory processes, characterizes it as an anti-allergic and anti-inflammatory agent that can reduce the damaging effects of a variety of adverse environmental factors from industrial pollution and infectious agents to household allergens. Thus, the presence of even small amounts of Dihydroquercetin in the daily diet will ensure the prevention of entire classes of diseases, such as tumor, hereditary, and metabolic, and will also give a rejuvenating and therapeutic effect. DHQ has low intrinsic toxicity, which makes it available for

consumption in almost unlimited doses. This property DHQ is especially valuable for people suffering from allergies.

CONCLUSIONS

Thus, complex medical rehabilitation of patients with coronary heart disease after CABG surgery according to a program with the inclusion of Dihydroquercetin helps to improve the rheological properties of blood, strengthen the active vasomotor mechanisms of MC regulation, improve indicators of central and peripheral hemodynamics, blood oxygenation, increase ET, improve psycho-emotional the condition of patients, which ultimately ensures an increase in the rehabilitation effect.

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CONFLICT OF INTEREST

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EFFICIENCY OF LOW-INTENSITY LASER IRRADIATION IN THE MANAGEMENT OF PATIENTS WITH ORAL MUCOSAL DISEASES ASSOCIATED WITH RHEUMATOID ARTHRITIS BY RESULTS OF DOPPLER ULTRASOUND

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ABSTRACT

Aim: To evaluate the therapeutic effectiveness of low-intensity laser irradiation in the treatment of patients with oral mucosal diseases in association with rheumatoid arthritis, according to parameters of Doppler ultrasonography of blood flow of lingual arteries.

Materials and Methods: An examination of 25 patients with geographic tongue and concomitant rheumatoid arthritis and 12 practically healthy persons of the control group was carried out. In the main group (13 patients) the complex treatment of glossitis was carried out with non-contact laser irradiation of the affected tongue areas. Patients in the comparison group (12 persons) underwent standard treatment. Treatment effectiveness of patients in both groups was determined by the parameters of Doppler blood flow study of lingual arteries.

Results: In the main group of patients, after diode laser therapy, a significant decrease in linear blood flow parameters (V_{max} by 19.7%, $TAMAX$ by 19.6%), an identical increase in volume velocity (Q by 21%) and an improvement in vascular tone and peripheral resistance (Pourcelot index by 12.5%, Gosling index by 13.1%) were observed. At the same time, a slight increase in the linear and volume velocity characteristics of blood circulation in lingual arteries during treatment of patients in the comparison group was not statistically significant ($p > 0.05$) and with a high degree of probability differed from the control group.

Conclusions: The use of low-intensity laser irradiation in the management of patients with oral mucosal diseases associated with rheumatoid arthritis contributes to the normalization of hemodynamics and the functional state in the vascular bed of the tongue.

KEY WORDS: oral mucosa, glossitis, rheumatoid arthritis, diode laser, Doppler ultrasound

INTRODUCTION

In recent years, many studies have been devoted to the search for effective methods of treatment of concomitant pathology. Due to the complexity and duration of treatment, oral mucosal diseases (OMD) in association with autoimmune illnesses are of great interest to doctors [1].

Despite the achievements of modern dentistry, the treatment of patients with glossitis in association with rheumatoid arthritis (RA) causes many difficulties. In view of concomitant autoimmune pathology and the use of strong pharmacotherapy for its containment, the treatment of OMD requires gentle and at the same time effective methods. One of the *problem-solving* approaches is the use of low-intensity laser radiation.

The diode laser is becoming increasingly popular in various fields of dentistry [2-4], because it is multifunctional, ergonomic and convenient for operations on soft tissues of the oral cavity. According to scientific research [5-7], low-intensity laser radiation stimulates biochemical processes in the body, promotes metabolic and reparative processes, activates microcirculation, normalizes vascular permeability, reduces the content of inflammatory mediators in the

affected areas and blocks the inflammatory process. All the above listed encourages its use for the treatment of patients with combined OMD and RA.

In the basis of the development of OMD, a disturbance of the local functional state of the vascular system occupies a prominent place [8, 9]. In addition, many studies indicate endothelial dysfunction and hemodynamic changes of internal organs in RA [10, 11]. Considering the fact that an important role in improving the treatment of OMD is played by the use of methods of adequate control over the effectiveness of treatment measures, the study of the nature of local hemodynamics in the oral cavity is a priority direction, which will allow to establish pathogenic processes of the development of associated diseases and to develop ways of influencing them for correction purposes.

AIM

To evaluate the therapeutic effectiveness of low-intensity laser irradiation in the treatment of patients with oral mucosal diseases in association with rheumatoid arthritis, according to parameters of Doppler ultrasonography of blood flow of lingual arteries.

MATERIALS AND METHODS

To achieve the aim of the study, an examination of 25 patients with lesions of oral mucosa, among them benign migratory glossitis (K14.1 BMG, geographic tongue) and concomitant RA aged 32 to 65 years was carried out. 12 practically healthy persons of the same age made up the control group.

Echographic study of arteria profunda linguae in patients was performed in triplex scanning mode: a combination of the image in B-mode, the color-flow imaging and spectral analysis of the blood flow with the use of the ultrasound scanner "MyLab 50 Xvision" of the company Esaote Biomedica SpA (Italy), equipped with a 7.5 MHz linear array transducer.

When performing the spectral analysis, qualitative parameters were evaluated: the shape of the Doppler curve, the presence of a "spectral window", the glow intensity of different zones of the Doppler spectrum. Assessment of quantitative parameters of the Doppler frequency shift was performed according to the indices of maximum systolic blood flow velocity (V_{max}) and time-averaged maximum blood flow velocity (TAMAX). Resistive index (RI, **Pourcelot index**), pulsatility index (PI, Gosling index), systolic-diastolic ratio (S/D) and volume velocity of blood flow (Q) were determined by standard methods.

To compare the treatment effectiveness of patients with the help a complex of prophylactic and therapeutic measures developed by us and the standard therapy, all patients with a concomitant lesion of OMD and RA were divided into two groups: the main (13 patients) and comparison (12 patients). Patients of both groups were treated with systemic therapy of the combined pathology with the use of disease-modifying antirheumatic drugs, glucocorticoids for oral use and nonsteroidal anti-inflammatory and antirheumatic drugs in accordance with the "Unified clinical protocol of primary, secondary (specialized), tertiary (highly specialized) medical care and medical rehabilitation" approved by the Ministry of Health of Ukraine" (Order No. 263 dated April 11, 2014).

In the stage of clinical-laboratory remission of autoimmune disorders of the joints, patients of the main group were treated with complex treatment of glossitis, developed by us [12] with non-contact constant laser irradiation of the affected tongue areas with the Picasso diode laser of the company "AMD Lasers" (USA) with a wavelength of 810 nm, a power range of 0.5 W/cm² when using non-activated 400 microns fiber and "Program 4" with the mode "Therapy". Exposure – 2 minutes per field, number – 5 procedures. Patients of the comparison group were treated with standard therapy, in accordance with the protocol adopted in Ukraine (Order of the Ministry of Health of Ukraine No. 566 dated November 23, 2004). The treatment effectiveness assessment of patients in the main and comparison groups was carried out on the basis of determining the quantitative and qualitative parameters of blood flow in one month after performed therapeutic complex.

The statistical analysis of the obtained data was performed with the use of parametric and non-parametric methods of variation statistics with the determination of Student's criteria in the computer programs "Statistica 5.5" (licensed number AXXR910A374605FA) and Microsoft® Excel 2003. Differences

between research groups were considered statistically significant at $p < 0.05$. In the case of confirming the normal distribution law, when comparing quantitative indicators between groups, we used parametric methods – Student's t-test for independent variables, and to identify differences occurring in the dynamics of preventive and therapeutic measures, Student's t-test for dependent variables.

The study complies with the requirements of the Declaration of Helsinki, the research protocol was approved by the Biomedical Ethics Committee of National Pirogov Memorial Medical University, Vinnytsya; voluntary informed consent of the patients was received.

RESULTS

Clinical examination of patients with BMG in association with RA revealed that the majority of patients (22 from 25 patients – $88.0 \pm 6.5\%$) complained of appearance the changes and lesions of oral mucosa. At the same time, the main complaints were dryness of oral mucosa, pain in the tongue, burning, bad breath and taste disorder. Lingual examination of patients showed prints of the teeth on the lateral borders of the tongue, on the dorsum and the lateral borders of the tongue – clearly island-shaped red smooth areas of desquamation and atrophy of the filiform papillae, surrounded by well-demarcated scalloped white borders of non-desquamated zone of hyperkeratosis, slightly raised above lingual mucosa (Fig. 1).

The obtained preliminary results [13] encouraged to study the possibility of using quantitative and qualitative parameters of blood flow for assessment of treatment effectiveness of patients with OMD associated with RA.

The effect of complex therapy in patients with tongue diseases in association with RA, there was a noticeable positive dynamic of the clinical condition and echographic indices of hemodynamics of the tongue.

Thus, after the third diode laser procedure, all patients of the main group noted the absence of dryness in the oral cavity, pain and burning sensation in the tongue. A follow-up patients' examination of this group 1 month later did not reveal further dynamics of clinical manifestations of the disease: the tongue was clear, without slough, patches or lesions, and the swelling of the tongue was reduced significantly (Fig. 2).

Despite the performed therapy, positive dynamics in patients of the comparison group was revealed only in 8 from 12 patients ($66.7 \pm 13.6\%$). At the same time, 2 patients of this group had taste disorder, and 4 patients ($33.3 \pm 13.6\%$) had swelling of the tongue and lesions, concentrated at the tip and lateral borders of the tongue (erythematous areas due to atrophy of the filiform papillae, partially surrounded by zone of hyperkeratosis).

The parameters of Doppler ultrasonography of regional blood flow in patients with BMG and RA of the main and comparison groups after treatment are shown in Table 1. According to the given table data, average statistical results of all parameters of hemodynamics arteria profunda linguae before treatment of patients of the main and comparison groups were identical with an unreliable difference in their

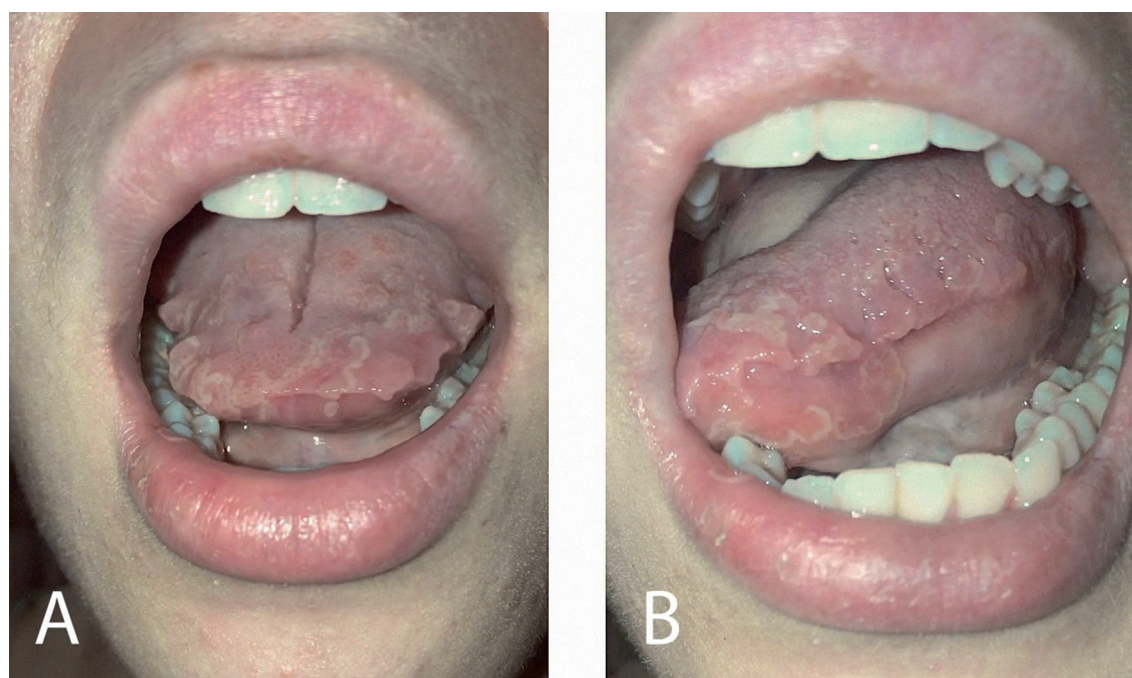


Fig. 1. Patient K. Diagnosis: benign migratory glossitis in association with rheumatoid arthritis. Dorsal aspect of the tongue (A) and lateral aspect (B) before treatment



Fig. 2. Patient K. Diagnosis: benign migratory glossitis associated with rheumatoid arthritis. Dorsal aspect of the tongue (A) and lateral aspect (B) after treatment

values. However, after the complex treatment of the main group of patients with the use of laser irradiation of the affected areas of the tongue, a probable improvement of most of the quantitative parameters of the echographic study of the deep lingual artery was determined. At the same time, a significant ($p < 0.01$) decrease in linear velocity indices (V_{\max} by 19.7%, TAMAX by 19.6% compared to the

initial level) indicated the normalization of local blood flow, that correlated with the elimination of inflammatory process in the tongue tissues.

As a result of the treatment of this group of patients, a significant improvement in the tone and peripheral resistance of blood vessels and their elastic properties was observed (according to the Pourcelot's index and

Table 1. Parameters of the Doppler ultrasonography of lingual arteries in patients with benign migratory glossitis in association with rheumatoid arthritis during treatment

| Parameters of ultrasound diagnostics of lingual artery | Control group (n=12) | Main group (n=13) | | Comparison group (n=12) | |
|--|----------------------|-------------------|---|-------------------------|-----------------|
| | | Before treatment | After treatment | Before treatment | After treatment |
| V max, m/c | 0.41 ± 0.05 | 0.62 ± 0.04 | 0.48 ± 0.02 $p > 0.05; p_1 < 0.01; p_2 < 0.05; p_3 > 0.05; p_4 < 0.05$ | 0.64 ± 0.04 | 0.54 ± 0.03 |
| RI | 0.73 ± 0.02 | 0.89 ± 0.03 | 0.78 ± 0.02 $p > 0.05; p_1 < 0.01; p_2 > 0.05; p_3 > 0.05; p_4 < 0.05$ | 0.87 ± 0.04 | 0.82 ± 0.04 |
| PI | 1.82 ± 0.03 | 2.25 ± 0.13 | 1.92 ± 0.06 $p > 0.05; p_1 < 0.05; p_2 > 0.05; p_3 > 0.05; p_4 > 0.05$ | 2.09 ± 0.14 | 1.96 ± 0.09 |
| TAMAX, m/c | 0.32 ± 0.02 | 0.46 ± 0.03 | 0.37 ± 0.01 $p > 0.05; p_1 < 0.01; p_2 > 0.05; p_3 < 0.05; p_4 < 0.05$ | 0.43 ± 0.04 | 0.39 ± 0.02 |
| S/D | 3.49 ± 0.12 | 3.1 ± 0.12 | 3.3 ± 0.05 $p > 0.05; p_1 > 0.05; p_2 > 0.05; p_3 > 0.05; p_4 < 0.05$ | 3.07 ± 0.15 | 3.15 ± 0.12 |
| Q, ml/min | 23.1 ± 1.6 | 20.2 ± 1.7 | 24.3 ± 1.2 $p > 0.05; p_1 < 0.05; p_2 > 0.05; p_3 > 0.05; p_4 < 0.05$ | 17.9 ± 2.2 | 18.2 ± 1.5 |

Note: p – the significance of the difference between the indices values of the main and comparison groups before treatment; p_1 – the significance of the difference in the parameters of the main group before and after treatment; p_2 – the significance of the difference in the parameters of the comparison group before and after treatment; p_3 – the significance of the difference in the parameters of the main group after treatment with the control group; p_4 – the significance of the difference in the parameters of the comparison group after treatment with the control group.

Gosling's index). A significant ($p < 0.05$) increase in the volume velocity of blood flow by 21% and its approach to the normative parameters of the control group is of particular importance. This indicates a significant improvement of microcirculation in arteria profunda lingua system. At the same time, a slight increase in the linear and volume velocity characteristics of the blood circulation in arteria profunda lingua system during treatment of patients in the comparison group was not *statistically significant* ($p > 0.05$) and with a high degree of probability (95-99.9%) differed from the control group. Despite a significant decrease in the linear velocity of blood flow after treatment of this group of patients ($p_2 < 0.05$), the average statistical values were higher than the normative parameters and differed from them with 95% significance. Therefore, the obtained results of the treatment of the comparison group can be considered low effective.

DISCUSSION

Literature data on the pathogenesis of RA indicate changes in the functional state of the vascular system [10]. In addition, long-term use of nonsteroidal anti-inflammatory drugs and glucocorticoids in RA leads to structural changes in blood vessels (reduced elasticity and increased resiliency) [14]. Atrophic processes in the lamina propria of tongue mucosa in glossitis and sclerotic processes in peripheral vessels in autoimmune lesions [11] contribute to the deepening of local blood circulation disorders in the tongue tissues during development of BMG.

From the point of view on the role of peripheral blood circulation in the pathogenesis of BMG [9, 13], the Doppler

blood flow study of lingual arteries in patients with associated pathology was carried out, which allows monitoring the effectiveness of therapeutic measures.

The normalization of the main parameters of the state of blood circulation (Vmax, TAMAX, Q) was facilitated by complex treatment using means and methods of pathogenic action on the local hemodynamics of tongue arteries. A significant improvement in regional blood flow is also associated with the normalization of tone and peripheral vascular resistance under the influence of the diode laser.

Non-contact laser irradiation of the affected areas of the tongue contributed to the expansion of blood vessels and increasing blood flow. A significant decrease in the resistive index of tongue vessels can be explained by the improvement of blood transport due to the normalization of venous outflow when using low-intensity irradiation, as indicated by the authors [6].

CONCLUSIONS

Doppler ultrasonography of regional blood flow is an informative method of treatment effectiveness assessment in patients with tongue diseases in association with RA.

The analysis of indices of the functional study of regional blood flow in the early term of follow-up examination shows that the complex therapy of patients with glossitis associated with RA, using low-intensity laser radiation, significantly increases the treatment effectiveness in comparison with standard method, which determines the recommendations on the expediency of its wide implementation in practice.

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CONFLICT OF INTEREST

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F – Final approval of the article

Ω-3 POLYUNSATURATED FATTY ACIDS AND MAGNETOTHERAPY COMBINED IMPACT ON FREE RADICAL PROCESSES IN PATIENTS WITH STABLE EXERTIONAL ANGINA

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ABSTRACT

Aim: To research the comparative effectiveness of a protocol-based drug complex for angina pectoris and combination therapy using ω-3 polyunsaturated fatty acids and magnetotherapy on the lipid peroxidation and antioxidant system activity dynamics.

Materials and Methods: The clinical examination included 97 patients who were randomized into three group of observation depending the variants of treatment. 50 practically healthy persons were involved into the control group. Lipid peroxidation end-products and antioxidant enzymes activities were determined in blood of the examined patients.

Results: Our results revealed the expressed efficacy of the original method of patients with stable exertional angina pectoris physiotherapeutic treatment. The scheme, which we prove to be effective for patients with stable exertional angina pectoris includes, combined used of ω-3 PUFAs and magnetotherapy. Our data allowed to indicate that the therapeutic benefits of our original physiotherapy complex developed faster and were expressed in more effective lipid peroxidation prevention and inhibition of the blood antioxidant system activity compared to those parameters in case of other used therapeutic complexes.

Conclusions: We determined an antioxidant efficacy of ω-3 PUFAs and magnetotherapy combined use patients with stable exertional angina pectoris. Continuing a series of similar courses of physiotherapy treatment in these patients with the expressed antioxidant effect, we are confident in its effectiveness, safety, and the absence of side effects, which justifies the expediency of its widespread use in physiotherapy clinics.

KEY WORDS: stable exertional angina, magnetotherapy, lipid peroxidation, antioxidant system, physiotherapeutic treatment

INTRODUCTION

The pathogenetic importance of lipid peroxidation (LP) intensification in the atherosclerotic process, which is the basis of coronary heart disease (CHD) and, in particular, exertional angina, is generally recognized [1]. The well-known is the relationship between the intensity of oxidative processes and both cardiac hypertrophy development and remodeling of the heart [2, 3].

The concept about the pathogenetic importance of LP in patients with CHD is unequivocal and boils down to peroxidative processes enhancement [4-6]. The ideas about the antioxidant system (AOS) are contradictory: some authors report a compensatory increase in AOS enzymes [7, 8], and some report a weakening of antioxidant protection [9].

Concerning the angina pectoris protocol therapy impact on LP and AOS, the issue has been studied insufficiently, and there are even isolated opinions about the negative influence, expressed in antioxidants level decrease and low density lipopolysaccharides resistance to oxidation decrease [10]. In this regard, the search for dosage forms that can effectively influence this link of CHD pathogenesis is relevant. Attention is drawn to ω-3 polyunsaturated fatty acids (ω-3 PUFAs), since

their competitive ability to partially replace ω-6 PUFAs in cell membranes, which are prooxidants, theoretically contributes to positive changes in LP and AOS functional activities.

It should be taken into account that patients with CHD, according to protocol therapy, have more than a sufficient set of drugs, which increases not only the cost of treatment, but also the possibility of side effects development. We believe that physiotherapy is especially relevant for this contingent of patients, especially magnetotherapy (MT), known for its positive effects on the cardiovascular system (analgesic, hypotensive, hypocoagulant) [11].

AIM

The aim of the present work was to research the comparative effectiveness of a protocol-based drug complex for angina pectoris and combination therapy using ω-3 PUFAs and magnetotherapy on the lipid peroxidation and antioxidant system activity dynamics.

MATERIALS AND METHODS

The clinical examination included 97 patients (52 men and 45 women) aged from 41 till 80 years (the average

age 63.39 ± 0.88 years). 50 practically healthy persons were involved into the control group for LP and AOS system indexes verification. The examined patients were hospitalized at the cardiology clinic of the Military Medical Clinical Center of the Southern Region (Odesa).

We used the following criteria of patients' inclusion into the clinical investigation: the patient's informed agree to the study and the presence of the exertional angina pectoris of the I-III functional classes. Exclusion criteria were the following: unstable angina pectoris, myocardial infarction during the last month, cardiac arrhythmias, heart failure stage of the IIB-III stages and severe somatic pathology (tumors, sepsis, etc.).

All patients were randomized into 3 groups. Group 1 consisted of 32 patients. The following protocol treatment was prescribed to patients with angina pectoris: nitrates, β -blockers, ACE inhibitors, antiplatelet drugs, statins (atorvastatin at a daily dose of 20 mg).

Group 2 consisted of 32 patients. Additionally to the protocol treatment these patients were prescribed with Vitrum Cardio Omega-3 (daily dosage of 2000 mg), divided into 2 doses. The daily dose of atorvastatin was reduced to 10 mg.

Group 3 consisted of 33 patients. Vitrum Cardio Omega-3 and a course of MT were added to the protocol treatment (atorvastatin 10 mg/day) according to the following method: two inductors were simultaneously placed on the heart area (alternating magnetic field, 14 mT) and the liver area (sinusoidal magnetic field, 20 mT). The course of treatment consisted of 10 daily procedures with 20 min exposure starting from 5-7 days from the drug therapy beginning. This MT technique was chosen due to fact that these two types of magnetic fields revealed number of cardiotropic properties, and their simultaneous use could provide a greater effect with less inductance [12].

The period of observation was 61.7 ± 2.0 days. The LP and AOS indicators level - malonic dialdehyde (MDA, $\mu\text{mol/l}$), diene conjugates (DC), activities of glutathione reductase (GTR), superoxide dismutase (SOD), SH- & SS-groups and thiol-disulfide ratio (TDR) - were determined in all patients' blood before and after the treatment.

The results are presented as $M \pm m$, where M is the arithmetic mean, m is the error of the mean. Assuming that the obtained distribution was normal, further statistical calculation was performed using One Way Analysis of Variance (ANOVA-test). The minimum statistical probability was determined at $p < 0.05$.

RESULTS

The results of patients' treatment under the influence of the used medical complexes are summarized in Table 1.

The LP intensification was registered in patients with stable angina pectoris, which was expressed in peroxidation products of MDA and DC significant increase in by 4 and 3 times, respectively ($p < 0.001$), while the AOS activity was suppressed in the form of a tendency of SOD activity to be decreased ($p > 0.05$) and a significant decrease in GTR activity ($p < 0.05$). The LP enhancement against the background of AOS depletion was also evidenced by the

starting indicators of the thioldisulfide system, which was expressed in a significant decrease in SH-groups ($p < 0.05$) and a significant increase in SS-groups ($p < 0.05$) which led to a TDR decrease and showed the shift of the redox potential towards oxidation. The absence of a compensatory increase in AOS parameters and the resulting decrease in the activity of its enzymatic and non-enzymatic link is due, in our opinion, to the duration of angina pectoris in patients of the studied groups (on average, about 10 years).

After the treatment using the protocol complex, none of the studied LP and AOS indexes underwent changes, although the overall trend was positive ($p > 0.05$).

The greatest antioxidant effect was demonstrated by the complex with the use of ω -3 PUFAs and a course of MT simultaneously additionally to the protocol therapy. Thus, after treatment, the LP end-products underwent positive changes (MDA, $p < 0.01$ and DC $p < 0.01$), while in the group using only ω -3 PUFAs, these indexes changed less ($p < 0.05$ in both cases), and in the group with the protocol complex of therapy, they did not change at all ($p > 0.05$).

This indicates an intrinsic antioxidant effect of both ω -3 PUFA and MT, but it should be emphasized that the effect of ω -3 PUFA on the concentration of radicals was somewhat greater than that of MT, which is confirmed by the presence of an intergroup difference in MD and DC at the level of approximation to reliability and a pronounced trend ($p_{1,2} = 0.06$ and $p_{1,2} = 0.15$, respectively) against the background of the absence of such a significant difference in groups 2-3 ($p = 0.41$ and $p = 0.25$, respectively).

A significant intergroup difference between the 3rd group and the 1st group (MDA $p_{1,3} = 0.02$ and DC $p_{1,3} = 0.03$) led to the conclusion about its maximum antioxidant effect, which is confirmed by a decrease in the group with "omega" of the levels of MDA by 26.3% and DC - by 25.6%, and with the addition of MT - by 34.4% and 40.5%, respectively.

The level of LP end-products still did not reach their reference values, then the AOS indexes practically returned to normal. So, despite the absence of intergroup difference in the parameters of the enzymatic link after treatment (with the exception of GTR in the group using combination therapy, where $p_{1,3} = 0.12$ is a level approaching a pronounced trend), the concentrations of "depleted" SOD and GTR in the 1st group did not change after treatment, in the 2nd group there was a tendency to increase ($p = 0.55$ and $p = 0.29$, respectively), and with the addition of MT they normalized, and the difference before and after therapy was in SOD in the form of a noticeable trend ($p = 0.15$), and according to GTR it was significant ($p < 0.05$).

DISCUSSION

The data obtained showed that the expressed efficacy of the original method of patients with stable exertional angina pectoris physiotherapeutic treatment. The scheme which we prove to be effective for patients with stable exertional angina pectoris includes combined used of ω -3 PUFAs and magnetotherapy.

It should be noted that the therapeutic benefits of our original physiotherapy complex developed faster and were expressed

Table 1. The comparative dynamic of lipid peroxidation and antioxidant system indexes in the investigated patients

| INDEXES | | Control | Group 1 | Group 2 | Group 3 | P, vs groups |
|--------------------|--------|------------|--------------|-------------|-------------|---|
| MDA, μmole/l | Before | 1.26±0.10 | 5.26±0.39*** | 5.39±0.40* | 5.32±0.39* | P ₁₋₂ =0.06 P ₂₋₃ =0.41 P ₁₋₃ =0.02 |
| | After | - | 5.05±0.37 | 3.97±0.53# | 3.49±0.27## | |
| DC, μmole/l | Before | 0.25±0.01 | 0.79±0.06*** | 0.78±0.07* | 0.79±0.06* | P ₁₋₂ =0.15 P ₂₋₃ =0.25 P ₁₋₃ =0.03 |
| | After | - | 0.72±0.08# | 0.58±0.07# | 0.47±0.05## | |
| SOD, rel. units | Before | 0.18±0.04 | 0.16±0.01 | 0.15±0.01 | 0.16±0.01 | P ₁₋₂ =0.51 P ₂₋₃ =0.45 P ₁₋₃ =0.34 |
| | After | - | 0.16±0.01 | 0.17±0.01 | 0.18±0.01 | |
| GTR, nmole/s·ml | Before | 84.22±2.98 | 71.22±3.19* | 72.22±3.79* | 72.53±3.24* | P ₁₋₂ =0.34 P ₂₋₃ =0.30 P ₁₋₃ =0.12 |
| | After | - | 71.06±3.08 | 75.75±3.87# | 80.94±3.47# | |
| SH-groups, μmole/l | Before | 9.23±0.03 | 7.54±0.57* | 7.37±0.58* | 7.27±0.62* | P ₁₋₂ =0.06 P ₂₋₃ =0.40 P ₁₋₃ =0.02 |
| | After | - | 8.09±0.35# | 9.09±0.38## | 9.53±0.41## | |
| SS-groups, μmole/l | Before | 3.54±0.08 | 5.42±0.57* | 5.87±0.67* | 5.78±0.55* | P ₁₋₂ =0.09 P ₂₋₃ =0.54 P ₁₋₃ =0.054 |
| | After | - | 4.95±0.51 | 4.00±0.35## | 3.66±0.27## | |
| TDR | Before | 2.61 | 1.94±0.28 | 1.94±0.27 | 1.69±0.24 | P ₁₋₂ =0.19 P ₂₋₃ =0.14 P ₁₋₃ =0.02 |
| | After | - | 2.17±0.23# | 2.54±0.16# | 2.96±0.20## | |

Notes: * – $p < 0.05$ and *** – $p < 0.001$ – significant differences in the studied parameters compared to those in the control observations

– $p < 0.05$ and ## – $p < 0.01$ – significant differences in the studied parameters compared to those before the treatment (ANOVA + Newman-Keuls test used in all calculations)

in more effective lipid peroxidation prevention and inhibition of the blood antioxidant system activity compared to those parameters in case of other used therapeutic complexes.

Our data indicate the absence of a positive effect on the processes of peroxidation of the standard drug complex with the inclusion of atorvastatin at a dose of 20 mg/day.

Analyzing the data obtained it should be mentioned that the effect on the enzymatic unit of AOS was somewhat greater for MT than for ω-3 PUFAs. The effect of combination therapy on the dynamics of indicators of the non-enzymatic link of AOS was also optimal, in which normalization of reduced SH-groups was noted even slightly more than normal against the background of slightly increased oxidized SS-groups ($p=0.04$ and $p=0.04$), while in the 1st group after treatment, their significant changes were not observed.

The absence of an intergroup difference in groups 2-3 and its significant difference between groups 1-3 also testifies to their own influence on the glutathione-dependent link of both MT and ω-3 PUFA. Considering that the thiol disulfide system is the most sensitive and quickly reacting AOS link, the presented evidence indicates that after treatment, not only its balance initially disturbed towards oxidation is restored, but also some compensatory reactions of the AOS are outlined, aimed at significantly reduced, but still persisting, processes intensification of LPO. This is also evidenced by normalization and even a slight increase in comparison with the TDO norm (2.96 ± 0.20 at a rate of 2.61), initially reduced in these patients by almost 1.5 times.

From the point of view of data analysis, the effective use of magnetic therapy in patients with exertional

angina is interesting and promising. On the one hand, our initial premise was the shown cardiotropic effects of magnetotherapy. But it should be noted that its effect on lipid peroxidation, according to researchers, is also not unequivocal. In the literature, there are data both on the corrective effect of MT on LP, in particular, on an increase in the levels of antioxidant enzymes [13], and on the stimulation of free radical oxidation processes [14, 15].

Therefore, the data obtained indicate an expressed antioxidant effect of the presented combination therapy, while there is a slightly greater effect of ω-3 PUFA on the normalization of peroxidation processes, and MT on the restoration of inhibited AOS processes, as well as their equivalent effect on the normalization of the disturbed balance of the non-enzymatic link of the antioxidant protection. Continuing a series of similar courses of physiotherapy treatment in these patients, we are confident in its effectiveness, safety, and the absence of side effects, which justifies the expediency of its widespread use in physiotherapy clinics.

CONCLUSIONS

We revealed the expressed efficacy of the original method of patients with stable exertional angina pectoris physiotherapeutic treatment.

The scheme, which we prove to be effective for patients with stable exertional angina pectoris includes, combined used of ω-3 PUFAs and magnetotherapy.

The therapeutic benefits of our original physiotherapy complex developed faster and were expressed in more

effective lipid peroxidation prevention and inhibition of the blood antioxidant system activity compared to those parameters in case of other used therapeutic complexes.

The effective use of magnetic therapy in patients with exertional angina is interesting and promising.

Continuing a series of similar courses of physiotherapy treatment in these patients with the expressed antioxidant effect, we are confident in its effectiveness, safety, and the absence of side effects, which justifies the expediency of its widespread use in physiotherapy clinics.

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APPLICATION PHYSIOTHERAPY AND BALNEOCLIMATOLOGY IN GYNAECOLOGY

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ABSTRACT

Aim: The aim of this paper is to present alternative and supportive methods/ways of treatment of female genital inflammations by means of physiotherapy and balneoclimatology. Physiotherapy and balneoclimatology can be a very good complement to the treatment of women, as very friendly treatments for the female body.

Materials and Methods: Two independent reviewers searched medical and public databases, e.g. PubMed, Google Scholar, MEDLINE, using search terms and MeSH. The inclusion criterion was to be an article published in a peer-reviewed journal with no restriction on the publication year range. There were no restrictions on the language of publication or the type of research. In this article, the authors consider aspects of the use of physiotherapy and balneoclimatology for inflammation in gynaecology. Failure to meet the inclusion criterion was treated as exclusion from the analysis. A review of journal databases was carried out between September and October 2022.

Conclusion: Physiotherapy and balneoclimatology are essential in treating inflammations in gynaecology as supplementary/supportive treatments. Interdisciplinary treatment performed by gynaecologists, obstetricians and physiotherapists can improve female health, which is crucial in terms of their quality of life.

KEY WORDS: physiotherapy, physical therapy, balneoclimatology, inflammation, women

INTRODUCTION

Genital inflammations are the most common gynaecological disorders. Women usually visit a gynaecologist because of the symptoms of inflammations, such as vaginal discharge, swelling, changes in the vulvar skin, vulvar pruritus, pain in the genitalia, or lower abdominal pain [1]. While genital inflammations and infections do occur in both girls and women, there is some specificity in locations with regard to age. Girls before sexual initiation often face vulvovaginal inflammations, while women of reproductive age most frequently experience adnexitis acquired through the ascending route [2].

Hypoestrogenism (typical for what is called hormonal quiescence) is a factor predisposing to genital inflammation. The fragile vaginal epithelium is susceptible to damage, and its close proximity to the urethral opening and the anus favours infections. Other factors that can cause inflammations are a lack of fatty tissue in the labia and pubic hair, small labia, and insufficient hygiene of intimate areas. Stagnation of smegma (a secretion of sebaceous and sweat glands) located between the labia and under the foreskin can be the nutrient for bacteria and fungi [3].

The most common symptoms of genital inflammations are abdominal pain (~100%), vaginal/cervical discharge (100%), noticeable discharge (55%), raised temperature (33%), bleeding (35%), and symptoms of urethritis (19%).

About 11%-25% of women experience Pelvic Inflammatory Disease (PID). More than 70% of PID cases are diagnosed in females aged < 25; 1 in 8 sexually active 15-year-old girls, 1 in 10 sexually active 16-year-old girls, and 1 in 80 sexually active 24-year-old women have PID. This is the most serious infectious disease among women aged 18-24 years in the USA: 1 million cases and 250-300 thousand hospitalisations annually. PID is associated with infertility - after one episode (9%-20%), after three episodes (up to 80%), and increases in the risk of ectopic pregnancy (3-10-fold) [4]. In Europe, 5%-25% of PID are from *neisseria gonorrhoeae*, and 20%-50% from *chlamydia trachomatis*. In nearly two-thirds of cases, aetiology is not connected with *neisseria gonorrhoeae* or *chlamydia trachomatis*. Bacterial vaginosis-related microflora is a non-standard risk factor for PID.⁴ PID is associated with a range of diagnostic issues: clinical diagnosis is challenging and imprecise, there is no test or set of tests for precise diagnosis, clinical diagnosis [5, 6].

Physiotherapy stimuli were used in pregnancy and gynaecological disorders as early as in Hippocrates' time in the 5th century B.C.E. and are gaining in importance [7].

AIM

The aim of this paper is to present alternative and supportive methods/ways of treatment of female genital inflammations by means of physiotherapy and

balneoclimatology. Physiotherapy and balneoclimatology can be a very good complement to the treatment of women, as very friendly treatments for the female body. For this reason, the authors decided to present this topic.

MATERIALS AND METHODS

Two independent reviewers searched medical and public databases, e.g. PubMed, Google Scholar, MEDLINE, using search terms and MeSH such as physiotherapy (in Polish: fizjoterapia), physical therapy (in Polish: fizykoterapia), balneoclimatology (in Polish: balneoklimatologia), balneology (in Polish: balneologia), inflammation (zapalenie), gynaecology (in Polish: ginekologia), women (in Polish: kobiety). The inclusion criterion was to be an article published in a peer-reviewed journal with no restriction on the publication year range.

There were no restrictions on the language of publication or the type of research. In this article, the authors consider aspects of the use of physiotherapy and balneoclimatology for inflammation in gynaecology. Failure to meet the inclusion criterion was treated as exclusion from the analysis. A review of journal databases was carried out between September and October 2022.

These records were then assessed for compliance with the inclusion and exclusion criteria on the basis of abstract analysis. Of the 162 articles initially shortlisted for further analysis, 137 were rejected at this stage. The 25 remaining articles were subjected to content analysis and a further 3 were rejected on the basis of further analysis due to duplication. The remaining 22 articles were subjected to further analysis (Fig. 1). All the articles collected were analysed in terms of the following parameters/content: what form/measure/modality of physiotherapy and balneology was used in the treatment of inflammatory conditions, what conclusion was obtained as a result of the review.

REVIEW AND DISKUSSION

Physiotherapy is aimed at reducing or eliminating inflammations and the resulting pain. The basic methods used in physical therapy are light therapy, electrotherapy and therapy with natural resources, e.g. peloid therapy, balneotherapy and chemotherapy [7, 8]. The following physical stimuli are also used: light therapy with Sollux and Bioptron lamps, electrotherapy, high-frequency radio e.g. with short-wave diathermy for deep heating and pain relief, and Transcutaneous Electrical Nerve Stimulation that blocks nerve conduction of impulses, reduce the activity of uterine muscle receptors [9, 10].

In physical therapy, short-wave diathermy is most frequently used, as the application of electromagnetic energy to the body at a frequency of 27.12 MHz, generating and absorbing heat in tissues, as well as improving tissue metabolism due to heat-induced accelerated biochemical reactions. Increased cell transformation has clinical analgesic and anti-inflammatory effects, which is why diathermy is used in women with chronic anxieties and small pelvic pain [11, 12] (Table 1) but the use of this method in obese women is limited [13]. Physiotherapy is becoming increasingly

common in the preventive treatment of genital statics disorders and stress urinary incontinence in women [14, 15]. Adequate physio-therapeutic techniques and cooperation with a patient can bring good treatment outcomes [16, 17]. The development of urogynaecological physiotherapy gives patients the opportunity to exercise at home, and standardised scales, surface electromyography and the subjective feelings of patients are used to evaluate the effectiveness of a selected technique.

In physical therapy, electrotherapy [18-20], magnetotherapy and magnetostimulation are most common [20-24] (Table 1). The effects of electrostimulation lie in direct stimulation of striated pelvic muscles that support the urinary sphincter during contractions. It has been noted that in electrostimulation, the neck of the urinary bladder is displaced in the sagittal plane and the posterior vesicourethral angle is reconstructed. It has been observed that electrical stimuli also run to the muscle through the pudendal nerve, so there is a direct route through the tissue layers and an indirect route through the nervous system. If the peripheral motor neurons and the spinal centre are maintained, electrostimulation through efferent fibres inhibits stimulation of the smooth muscle of the detrusor muscle that is used in urination disorders of neurogenic origin, and also in urinary incontinence in urinary urgencies and overactive bladder [25, 26] (Table 1).

In the preventive treatment of urinary incontinence, the selection of parameters (the length of the impulse phase, the length of the relaxation phase, intensity and frequency) are of key importance. It has been determined that a frequency of 50 Hz is most effective for urethral closure, and between 5 Hz and 12 Hz for relaxation of the detrusor muscle. Treatment should last at least 10 minutes. Electrostimulation can be performed with vaginal probes, rectal probes or electrodes attached to the outer surface of the skin (Table 1) [25, 26]. It should be noted that it is not stated the literature which of the physiotherapeutic interventions is most effective in the treatment of stress urinary incontinence in women after menopause (Table 1).

Magnetostimulation is a therapeutic use of very low-level alternating magnetic fields ranging from 30 to 70 μ T. Flat mini applicators of just a few centimetres are inserted into the patient's underwear in the perineal area. Stimulation consists of continuous or periodical exposition of the small pelvis to the magnetic field. This form of stimulation is treated as a supplementation of other forms of preventive activities. The magnetic field affects the structure of biological membranes, transport of ions and enzymatic activity of exposed tissues (Table 1) [26, 28-31]. The magnetic field has a direct impact on motor fibres of the pudendal and splanchnic nerves. In the treatment of urinary incontinence, a chair with embedded field coils is used. The effectiveness of this procedure, particularly in urinary incontinence, and its ease of use should be highlighted (Table 1) [26, 28-31].

Treatments with electrostimulation and magnetic fields cannot be used in pregnant women, women during their period, patients with cancer, tuberculosis, hyperthyroidism, bleeding from the digestive tract, acute viral, bacterial and



Fig. 1. Diagram of the systematic literature review (n – number of records)

fungal infections, and electrical implants, e.g. pacemakers.

In order to relieve pelvic pain, the procedure with capacitive resistive monopolar radiofrequency (CRMRF) at 448 kHz can be used [32]. It is also hard to determine which physiotherapeutic procedure is most effective in reducing inflammations and the resulting pelvic pain. The advantage of short-wave diathermy over superficial heat sources is the possibility to heat the deep-lying organs [33]. The amount of heat generated is proportional to tissue hydration. Another type of diathermy used in gynaecology is microwave diathermy using shorter waves of higher frequency. Their action is more physiotherapeutic procedure

is most effective in reducing inflammations and the resulting pelvic pain [33].

Peloid therapy using peat plays a special role [34, 35]. Peat is a natural raw material and when crushed appropriately, its compounds form a solid substance with therapeutic properties. In Poland, peloids are mainly peat arising from geological processes (from organic matter of peat plants with microorganisms and water) [35]. The primary therapeutic importance of peat lies in humic compounds, acids, amino acids, esters, sugars and bituminous compounds (similar to carbohydrates that are carriers of other oestrogens). These substances act through the skin and mucous membranes. Water-insoluble peat components absorb water, retain heat and have anti-inflammatory and anti-bacterial effects [34, 35]. The use of peat is particularly beneficial not only due to heat being retained inside the body, but also due to bitumens that are carriers of oestrogens and stimulate the hypothalamus and the pituitary glands [36].

Peloid peat demonstrates many specific physical and chemical properties, of which high water capacity, small thermal conductivity, low heat capacity, large sorption properties of humic acids, ion-exchange properties of components and trace amounts of substances of oestrogen-like action are most frequently used [37]. Humic acids penetrate through the skin to the body and at the same time reverse transport (from the skin to the peat layers) takes place. In this way, the skin and the body are purified along with anti-swelling and anti-inflammation effects [37].

In menopause and inflammations, therapeutic peat affects the activity of the endocrine glands. The influence on the ovary is bidirectional: directly associated with overheating gonads, and indirect due to the activity of absorbed peat components of oestrogenic character and non-standard influence of the procedure on the hypothalamic-pituitary axis [38]. The impact on the autonomic nervous system can play a crucial role in relieving menopausal disorders. Peat treatment increases tension in the sympathetic nervous system and then the parasympathetic part of the autonomous nervous system dominates for several hours [38]. Peloid therapy consists of using wrappings, hip baths, as well as peat tampons or underwear. Rectal injections of peat are also common [39].

Peat tampons (columnisation) are used in patients with recurrent vaginal infections and adnexities. High-grade purified peat, most often peat paste (peloidine), is used. Peat is ground for 6-7 h until particles of c. 0.01 mm in diameter are produced, after which water is added [40]. The paste has a creamy consistency and is applied intravaginally in an isothermal or hyperthermal (37°C) form (42°C-44°C). Its components are quickly and easily absorbed through the mucous membrane. The degree of fragmentation affects the mass properties. The more ground the mass, the easier the substance exchange through the mucous membrane and the skin [40]. A treatment is performed for 10-20 minutes, three to five times a week. Peat tampons are inserted on a gynaecological chair. The woman lies in this position during the treatment and then the tampon is removed by rinsing with sterilised water (38°C-40°C) [40].

Table 1. Physiotherapeutic treatment

| Study | Treatments | Materials and methods | Clinical benefits |
|--------------------|--|--|--|
| Morsi et al. [12] | Applied ShortWave Diathermy (CURAPULS 970; EnrafNonius, The Netherlands). 7 Sessions were given every 48 hours. Each session duration was 20 min divided into two parts of 10 min per one, with intensity that generated moderate sensation of warmth. | 80 patients with chronic PID for more than 6 months diagnosed by thorough history, clinical examination and cervical swabs. Patients were divided into two groups: First group (group 1): patients received both medical treatment and shortwave diathermy. Second group (group 2): patients received only medical treatment. | There was a statistically highly significant improvement of clinical and laboratory manifestations in the first group of patients compared to the baseline and compared to the second group. Shortwave diathermy has a fair therapeutic efficacy in the treatment of chronic Pelvic Inflammatory Diseases. |
| But et al. [23] | In this study we determined the efficacy of Functional Magnetic Stimulation (FMS) compared to placebo for treating women with Mixed Urinary Incontinence (MUI). | A total of 39 women with MUI were randomly assigned to the FMS group (23 patients) or to the placebo group (16 patients). FMS was applied continuously at 18.5 Hz day and night for 2 months. Conventional urodynamic studies were performed before and after stimulation. Outcome measures assessed were clinical (daytime frequency, nocturia, pad use, pad weight) and urodynamic variables (first sensation of bladder filling, maximum cystometric capacity, maximum urethral closure pressure), and patient subjective assessment (visual analogue scale). | After 2 months of FMS significant decreases in voiding frequency and pad use were observed only in the FMS group. First sensation of bladder filling and maximum cystometric capacity increased significantly after stimulation compared with prestimulation levels only in the FMS group, respectively. A total of 18 women (78.3%) reported an improvement in symptoms after FMS with an average success rate of 41.9%. The success rate was significantly lower in the placebo group. Functional magnetic stimulation was useful and safe for treating women with MUI. |
| Hoscan et al. [24] | Evaluate the clinical efficacy of Extracorporeal Magnetic Stimulation (ExMI) for the treatment of stress urinary incontinence. | A total of 30 patients with demonstrable stress urinary incontinence were enrolled in this study. All were neurologically normal with normal urinalysis and none was pregnant. Evaluation before treatment included 3-day bladder diaries, a dynamic pad weight test, urodynamics, and a validated quality of life survey. Treatment sessions lasted 20 min, twice a week, for 6 weeks. After ExMI, all measures were repeated at follow-up including 3-day bladder diary, dynamic pad weight test, urodynamics and quality of life survey. The follow-up was done at 3, 12 and 24 months after ExMI therapy but urodynamics were performed only at first follow-up. | After ExMI therapy, 8 out of the 27 patients were cured (29.7%) and 13 patients were improved (48.1%) at 3 months. The cumulative success rate was 77.8%. Six patients did not show any improvement after treatment. Pad weight was reduced from 14.4 +/- 10.7 to 6.5 +/- 5.1 g. The mean score of quality of life survey at baseline was 61.6 and this increased to 75.4 at 12 weeks. The effect of ExMI approximately continued until the 1st year after therapy but gradually decreased and came close to baseline at the 2nd year after therapy. As a result, ExMI therapy offers a new effective modality for pelvic floor muscle stimulation. ExMI also offers a noninvasive, effective and painless treatment for women with stress urinary incontinence. |

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| Yamanishi et al. [26] | To evaluate the efficacy and safety of Magnetic Stimulation for the treatment of urinary incontinence in women with overactive bladder. | A total of 151 women with urgency incontinence were randomized to the active stimulation group or the sham stimulation group in a 2:1 order. An armchair type magnetic stimulator was used for 25-min magnetic stimulation twice a week, with the maximum magnetic flux density of 560 mT peak at 10 Hz. The sham device was set to deliver in a 5-s „on“-5-s „off“ pulsing manner with the maximum intensity of 20.4% of active stimulation at 1 Hz. The study consisted of a baseline period for 1 week, and a treatment period for 6 weeks. The primary end-point was the number of leaks/week from the bladder diary. The secondary end-points were the number of voids and urgency/24 h, mean and maximum voided volume, and the quality of life assessment. | Magnetic stimulation is effective for the treatment of urgency incontinence in female patients with overactive bladder. |
| Carralero-Martínez et al. [27] | This study aims to evaluate the efficacy of Capacitive Resistive Monopolar Radiofrequency (CRMRF) at 448 kHz as an adjunct treatment to other physiotherapeutic techniques for reducing pain and improving the quality of life of patients with Chronic Pelvic Pain Syndrome (CPPS). | This triple-blind (1:1) randomized controlled trial included 80 women and men with CPPS. Participants were randomized into a CRMRF activated group or a CRMRF deactivated group and receive physiotherapeutic techniques and pain education. The groups were undergo treatment for 10 consecutive weeks. At the beginning of the trial there were an evaluation of pain intensity (using VAS), quality of life (using the SF-12), kinesiophobia (using the TSK-11), and catastrophism (using the PCS), as well as at the sixth and tenth sessions. | The results of this study will shown that CRMRF benefits the treatment of patients with CPPS, together with physiotherapeutic techniques and pain education. |
| Unsal et al. [28] | To evaluate the clinical efficacy of Extracorporeal Magnetic Stimulation for the treatment of stress and urge urinary incontinence in women. | A total of 35 patients with stress incontinence and 17 with urge incontinence were enrolled in this study. All patients were evaluated by means of a detailed history of incontinence, a gynecologic examination, urine culture, urinary system ultrasound and a urodynamic study. All patients were asked to keep a 3-day voiding diary. A pad-weighting test was done for each patient at their first visit. For treatment, the patients were seated on a special chair containing a magnetic field generator. Pelvic floor muscle stimulation was performed for 20 min (10 min at 5 Hz and 10 min at 50 Hz) twice a week for a total of 8 weeks. The mean follow-up period was 16.8 months (range 12-32 months). A total of 44 patients completed 1 year of follow-up and were re-evaluated by means of voiding diary, pad-weighting test and cystometric study. | Of the 44 patients, 11 (38%) with stress incontinence and 6 (40%) with urge incontinence were cured 1 year after the treatment. In addition, there was an improvement in symptoms in 12 patients (41%) in the stress group and 7 (47%) in the urge group. Extracorporeal Magnetic Stimulation therapy offers a non-invasive, effective and painless treatment for stress and urge incontinence in women. |

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| Fujishiro et al. [29] | Investigational study and placebo controlled trial to evaluate the potential efficacy of Magnetic Stimulation of the sacral roots for the treatment of stress incontinence. | A total of 75 patients with stress incontinence were studied. A 15 Hz, repetitive magnetic stimulation of the sacral roots with 50% intensity output and duration of 5 seconds per minute was applied for 30 minutes. Urodynamic investigations under magnetic stimulation were performed in 13 patients to evaluate acute effects to lower urinary tract function. There were 62 women (mean age 58 years) enrolled in a placebo controlled study to investigate the short-term efficacy of magnetic stimulation. The number of leaks for 3 days, amount of urine loss on a pad test and quality of life score were evaluated before and 1 week after stimulation. | The urodynamic investigations revealed an apparent elevation of urethral closure pressure induced by stimulation and a significant increase in bladder capacity after stimulation. In the placebo controlled study the number of leaks and amount of urine loss on a pad test significantly decreased more in the active than in the sham stimulation group. The quality of life score significantly improved in the active stimulation group in contrast to no significant improvement in the sham stimulation group. The improvement rate in the active stimulation group was 74%, which was significantly higher than the 32% in the sham stimulation group. No adverse effects were noted in any patients. These results suggest that magnetic stimulation of the sacral roots may be useful for the treatment of stress incontinence. |
| Böyükbas et al. [30] | Evaluate and compare the effects of 2 conservative treatment modalities, Functional Electrical Stimulation (FES) and Functional Magnetic Stimulation (FMS). | Studied 22 female patients with urinary incontinence and divided them into 2 treatment groups (14 patients in the FES and 8 in the FMS group). The mean age of the patients in the FES group was 51.14±/-11.9 and in the FMS group 42.25±/-6.9 years. Functional electrical stimulation was applied continuously at 10 Hz and 30-50 Hz in urge and stress urinary incontinence respectively. In mixed urinary incontinence stimulation was applied at 10 Hz for 15 min and at 50 Hz for 15 min. The treatment sessions were for 20 min, 3 times a week for 6-8 weeks (12 with mixed, 2 with stress incontinence). FMS was applied by a magnetic chair, twice weekly for 6 weeks (6 with mixed, 1 with stress urinary and 1 with urge urinary incontinence). The efficacy of the treatment was judged from patient impressions, records in urinary diaries, results of 1 h pad test, perineometry value and digital palpation score. | The perineometry value, digital palpation score increased significantly during stimulation compared with prestimulation levels in both groups. For the pad test significant improvement was also noted in both groups. The urinary diaries and frequency of micturition were significantly more cured or improved in the FES group. However, reduction of the frequency of nocturnal micturition wasn't significant in either group. Both FES and FMS treatments were effective. |

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| Weber-Rajek et al. [31] | Assess the effectiveness of Pelvic Floor Muscle training and Extracorporeal Magnetic Innervation in treatment of urinary incontinence in women with stress urinary incontinence. | The randomized controlled trial enrolled 128 women with stress urinary incontinence who were randomly allocated to either one out of two experimental groups (EG1 or EG2) or the control group (CG). Subjects in the experimental group 1 (EG1) received 12 sessions of pelvic floor muscle training, whereas subjects in the experimental group 2 (EG2) received 12 sessions of extracorporeal magnetic innervation. Subjects in the control group (CG) did not receive any therapeutic intervention. The following instruments were used to measure results in all study groups at the initial and final assessments: Revised Urinary Incontinence Scale (RUIS), Beck Depression Inventory (BDI-II), General Self-Efficacy Scale (GSES), and King's Health Questionnaire (KHQ). | In both experimental groups, a statistically significant decline in depressive symptoms (BDI-II) and an improvement in urinary incontinence severity (RUIS) and quality of life (KHQ) were found in the following domains: „social limitations,” „emotions,” „severity measures,” and „symptom severity scale.” Moreover, self-efficacy beliefs (GSES) improved in the experimental group that received ExMI (EG2). No statistically significant differences were found between all measured variables in the control group. Comparative analysis of the three study groups showed statistically significant differences at the final assessment in the quality of life in the following domains: „physical limitations,” „social limitations,” „personal relationships,” and „emotions.” Pelvic Floor Muscle Training and Extracorporeal Magnetic Innervation proved to be effective treatment methods for stress urinary incontinence in women. |
|-------------------------|--|---|---|

Table 2. Balneology treatment

| | Type of procedure | Interaction |
|---|--|---|
| Habek et al. [47] | Hyperosmolar (salty iodine) or aromatic baths | Hyperosmolar (salty iodine) or aromatic baths are most commonly used, especially in chronic inflammatory and/or painful conditions. |
| Beer et al. [48] Kauffels [49] | Sulfide water | Sulfide water reduces the inflammatory response by reducing the exudative and infiltration components of inflammation, including the formation of a fibrotic reaction, and a sulfide concentration of 100-150 mg/L is required to treat gynaecological disorders. It is recommended for vulvodynia, vulvitis and skin diseases because it is keratolytic and keratoplastic. |
| Beer et al. [48] Kauffels [49] | Intravaginal pelotherapy | Intravaginal pelotherapy uses applications heated up to 45-50°C which are applied to the vagina for 4 hours. The vagina has thermoreceptors up to 50°C, so by its trophotropic effect on neural plexuses and blood vessels it causes a vasodilatory effect in the small pelvis by improving the flow in the uterine artery by 50% in the first 24 hours of application. Intravaginal pelotherapy improves the tone of periurethral tissue and improves vascularization in cases of urogenital atrophy and as a result reduces urinary incontinence. |
| Fortuna et al. [50] | Radon water | Radon water has analgesic, haemostatic, sedative and anti-inflammatory effects in the concentration of radon in water of 40-200 nCi/L. |
| Ovsienko et al. [51] | Brine baths with sodium chloride | Brine baths with sodium chloride water have an effect on the secretion of mineralocorticoids and glucocorticoids, and the activity to sympathetic nervous system. Salt baths with sodium chloride water have a resorptive effect while salty iodine water has an effect on congestive venous syndrome. |
| Capoduro et al. [52] Kuca et al. [53] Vuković et al. [54] Moses et al. [55] Min et al. [56] Akin et al. [57] | Arsenic water, nitrogen thermal water, iodine-bromine water. | Arsenic water reduces the intensity of the oxidation-reduction processes. The nitrogen thermal water has analgesic effects with poor fibrinolytic activity. Iodine-bromine water is especially recommended in gynaecologic patients but precautionary measures should be taken in thyroid disease, while the carbon-acid bath is especially used in those patients. |

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| Capoduro et al. [52] Kuca et al. [53] Vuković et al. [54] Moses et al. [55] Min et al. [56] Akin et al. [57] | Drinking mineral waters | Drinking of spring mineral waters completes balneological treatment especially for constipation that is a consequence of chronic pelvic pain and premenstrual syndrome. |
| Artymuk et al. [58] Zambo et al. [59] | Peloids (mud) | Peloid baths and cataplasmas trigger the strongest reaction of the body, so it is important to recommend them after the inflammation has ended. Alternating vaginal irrigations are recommended for chronic pelvic hyperaemia. Peloid therapy (fango, mud) is recommended in chronic pelvic inflammatory disease (PID) and parametritis for 4-6 weeks. It should be applied only up to a belly height 2-3 times per week for 20 minutes. while its temperature should range from 40-42°C. Fangoshaped peloids are particularly recommended in menopausal syndrome, infertility treatment, and sexual disorders such as vaginismus, dyspareunia, apareunia, and frigidity. |
| Min et al. [56] Zambo et al. [59] | Sitz baths in bitter salt (Bittersalz) | Sitz baths in bitter salt (Bittersalz) are recommended when the patients suffer from dysmenorrhea, chronic pelvic pain and vaginismus, and can be used domiciliary at a temperature of 36-40° C for 10-20 minutes. In the subacute phase of inflammatory pelvic disease, after a week of febrility, warm baths of 35-37° C (acratotherme) up to 40° C can be applied for 15-20 minutes alternately with mud baths 3-4 times a week. Iodine baths and radioactive baths are recommended in recurrent pregnancy loss. It is recommended to have balneo-gynecological treatment in the spa twice a year. May also be used at home. |

Peat wrapping is used in patients with chronic adnexities and chronic pain in the small pelvis. The patient lies down, a 5 - cm-thick layer of peat paste (45°C) is applied to the lower abdomen or the sacral region and the patient is then wrapped in a sheet, film or blanket. The recommended length of the treatment is 20 - 30 min. Heating is gradual and the thermal effect, particularly internal vessel dilution, is maintained for several hours. Peat underwear ensures topical heating of tissues and thus improves oxidation, metabolism and elimination of decay products. The concentration of compounds responsible for pain sensation is also reduced. After the treatment, tension in the paraspinal muscles is reduced, which is important in treating small pelvic pain of unclear origin [41].

Peat ionophoresis is also practised. High-grade 3-cm-thick peat is applied to the sacral region, and then a cathode with galvanic current (10 mA-20 mA) is attached. The treatment lasts 15-20 minutes and can be repeated 3-4 times a week [42].

Balneology is used in gynaecology in recurrent vaginal or cervical inflammation. The main treatments are brine and radon baths, as well as brine vaginal irrigations [39] that have a sterilising effect and stimulate immune reactions. Irrigations are performed on a gynaecological chair using a tool with a special end that is inserted into the vagina and allows for precise control of liquid drips into the vagina and the resulting spread [43].

In brine baths, a chloride solution (2%-3%) and water (36°C-38°C) are used. During this treatment, dilation of superficial blood vessels, skin redness and muscle relaxation are observed. It also affects the autonomous nervous system by increasing the secretion of some tissue hormones, e.g. histamine, adrenaline and serotonin. The

influence of brine baths on the body stems from the high osmotic pressure and large specific gravity of brine [44]. The basic mechanism of action lies in triggering many topical and systemic reactions due to activating skin receptors and the autonomous nervous system, and a noticeable response comes from the endocrine system [45], which is manifested by normalisation of blood pressure, improved functioning of regulation mechanisms of the circulatory system, decreased excitation of sensorimotor nerves, increased blood supply to the skin, and the increased response of non-specific immunity.

Radon waters contain small amounts of the non-durable radioactive element-radon. Radon baths have an anti-bacterial effect and enhance immunity [45]. In health resort treatment conditions, gas baths with CO₂ achieve very good effects in treating inflammations. They dilate blood vessels with a slight anti-coagulative effect, reduce tension of the sympathetic nervous system, and have relaxing, calming and analgesic effects. Increased diuresis and decreased glucose concentration have been observed, which decrease the need for insulin in patients with diabetes [46].

Balneological treatment is becoming increasingly popular in treating inflammations and infertility, but contraindications should also be taken into account, e.g. endometriosis, cancers and metrorrhagia (Table 2) [47-50, 52-59]. Treatment methods are external bath hydrotherapy, sedentary baths and topical dressings/cataplasm, and internal (intravaginal or intrarectal use of peloids and mineral waters) (Table 2) [47-50, 52-59].

CONCLUSIONS

Physiotherapy and balneoclimatology are essential in treating inflammations in gynaecology as supplementary/

supportive treatments. Interdisciplinary treatment performed by gynaecologists, obstetricians and physiotherapists can improve female health, which is crucial in terms of their quality of life. The statement that further randomised

controlled clinical studies on the use of physiotherapy, physical therapy and balneoclimatology in treating inflammations in gynaecology and obstetrics seems to be appropriate.

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THE ESSENCE AND ROLE OF PHYSICAL MEDICINE AND REHABILITATION

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ABSTRACT

Aim: To summarize the development of physiatry and to define the role of physical medicine and rehabilitation in the modern army.

Materials and Methods: Analysis and summarization of literary sources and Internet data on the implementation of rehabilitation services, systematic analysis and synthesis.

Conclusions: Thus, the experience of previous wars and the modern Russian-Ukrainian war emphasized the valuable contribution of Physical Medicine and Rehabilitation to the optimal care and functional recovery of wounded soldiers. Physical therapists treat functional problems of wounded soldiers using strengthening exercises, range of motion exercises, orthotics, physical modalities, and gait training. However, when physiotherapists are present in medical centers, physical therapy and occupational therapy departments with physiotherapists are organized. When physical therapists are not available, orthopedic services usually include therapists.

KEY WORDS: physical medicine and rehabilitation, physiatry, occupational therapy, physiotherapy, orthopedics

INTRODUCTION

Physical medicine and rehabilitation have long been closely associated with the military. In fact, the medical treatment needed for the wounded during the First and Second World Wars, and now the Russian-Ukrainian war, has been the main stimulus for extensive growth and development in the field of rehabilitation. The basic principles of exercise, early range of motion exercises, early mobilization and training that were developed and worked well during the war are still relevant today. To a large extent, the medical specialty of physical medicine and rehabilitation, physiatry, owes its birth to pioneering military medics who helped establish it as a medical specialty in 1947 [1-4]. Other rehabilitation professionals, physical therapists and occupational therapists, also have their origins in military events.

AIM

The aim is to summarize the development of physiatry and to define the role of physical medicine and rehabilitation in the modern army.

MATERIALS AND METHODS

Analysis and summarization of literary sources and Internet data on the implementation of rehabilitation services, systematic analysis and synthesis.

REVIEW AND DISCUSSION

Physiatry has its origins in the two great wars of the 20th century. Initially, physiatry was closely related to the

increasing use of physical methods in the care of injured patients. The name physiatrist (pronounced fiz-ee-at'-rist) comes from the Greek words physis, referring to physical phenomena, and iatreia, referring to healer or physician [5]. Thus, a physiatrist is a doctor who uses physical agents.

In 1939, the term "physiatrist" was proposed by Dr. Krusen, who recognized the similarity of the word to psychiatry and therefore proposed its modern pronunciation. The focus of physical medicine has expanded from the restoration of independent movement and strength to comprehensive rehabilitation of the individual-mental, emotional, occupational, and social.

At this time, scientific studies began to emerge that indicated that early activity had many more benefits than prolonged bed rest. In 1944, at the 94th annual session of the American Medical Association, a symposium entitled "Abuse of Rest in the Treatment of Diseases" was held [6].

A physiatrist deals with functional and professional limitations resulting from a soldier's primary injuries. These limitations include muscle and joint contractures, loss of fitness due to immobility, mobility and activities of daily living (ADL) impairment, and occupational impediments (military service). A physiatrist has special knowledge of the pathophysiology of painful processes and functional consequences that affect the patient. In addition, a physiatrist has extensive knowledge of physical therapy, occupational therapy, and other interventions initiated by the rehabilitation team that can address patients' functional problems. Physicians who know the prognosis, the treatment

needed, and the current activity limitation precautions that allow the injury to heal are in the best position to lead the team. For these reasons, a physiatrist or other primary care physician coordinates the rehabilitation care team.

Rehabilitation services also include those professionals who use their special training to prevent and treat disabilities. These include physiotherapists, physiotherapists and occupational therapists. In the military sphere, the development of physical therapy and occupational therapy is closely related to physical medicine and rehabilitation (physiatry). The First World War marked the beginning of physical therapy and occupational therapy. World War II saw a dramatic expansion of these disciplines, driven by the need to care for the vast numbers of wounded soldiers.

A rehabilitation team in the military usually consists of doctors, physical therapists, occupational therapists, and therapists. The team may also include speech therapists, psychologists, social workers, and nurses. This is called "interdisciplinary team management". Unlike traditional multidisciplinary care, where each specialist forms his own diagnosis and set of goals, the interdisciplinary team establishes common goals that all members of the team accept and implement together with the wounded soldier. This concept is critical and provides the best rehabilitation care. The importance of close collaboration between physician and therapist was clearly emphasized during World War II, when physical therapy was incorporated into orthopedic departments in all hospitals [7].

A physical therapist is a trained physician and, when necessary, due to the tactical needs of the unit, can provide post-traumatic life support, triage the wounded, and treat medical problems (diarrhea, hepatitis, pneumonia, minor surgical injuries, etc.) that are often encountered in the army troops. In addition, physiotherapists are recognized experts in the care of patients with musculoskeletal injuries. Because musculoskeletal problems are common in active military personnel, a physiatrist can provide advanced care for these specific problems. This allows orthopedists to focus their energies on the many surgical needs of soldiers injured in war.

In the Russian-Ukrainian war, there were many shrapnel wounds, leg amputations due to shelling or mine explosions, as well as bullet wounds. 80% of wounded soldiers receive proper medical care in the first hour. The percentage of wounded and sick servicemen of the Armed Forces of Ukraine who return to service after treatment is quite high. It is more than 82%.

The National Academy of Medical Sciences was the developer of the Military Medical Doctrine of Ukraine, which follows the Israeli principle. According to this doctrine, all civilian hospitals become military hospitals at the same time [8].

From the experience of previous wars, Hertzman [9] described three main areas: (1) prevention and correction of disability for those soldiers who return to service; (2) early rehabilitation of the wounded who will be evacuated; and (3) proper diagnosis and rehabilitation of many musculoskeletal, neck, lower back, and other conditions.

Early initiation of joint range-of-motion exercises and training was extremely important. Soft tissue injuries of the thigh and lower leg were particularly prone to contractures. Joint mobility was maintained by early range-of-motion exercises-performed first by physical therapists or technicians, then by the soldier after proper training. Muscles immobilized for long periods can lose 7% of their strength per week and up to 50% after 1 month, but early rehabilitation with isometric and isotonic exercises can prevent this muscle wasting [10]. Hertzman [9] included exercises to strengthen exhausted and injured muscles.

The birth of physical medicine occurred during World War I and expanded significantly during World War II. During World War II, army hospitals used physical medicine and rehabilitation services.

Rehabilitation of an injured hand has always been important and often difficult. In all patients in whom this was practically possible, the general rule was to introduce early movement and mobilization through activity and steady traction [11].

Renowned hand surgeon Dr. Sterling Bunnell championed the importance of occupational therapy and physical therapy, calling these combined disciplines "physical medicine." Occupational therapy played an extremely important role in the rehabilitation of the damaged hand. The patient was assigned a job based on his needs, not just for him to work. The occupational therapist knew the desired results and devoted her efforts to restoring the special function that was lost [11].

Europeans also realized the value of physical medicine and rehabilitation. Dr. L. Guttmann, neurological surgeon in charge of the Spinal Injury Centre, Stoke Mandeville, Buckinghamshire, England, spoke about the importance of physiotherapy in the care of soldiers with paraplegia [13]. Interventions included correct positioning of the paralyzed limbs, regular range-of-motion training, dressing, weak muscle exercises, balance training, wheelchair ambulation, and walking with crutches and braces if possible. In addition, vocational activities such as wheelchair polo were promoted to improve the psychological state of these soldiers.

During World War II, the Committee on Physical Medicine [5] emphasized the importance of an organized, coordinated team of occupational therapists, physical therapists, and other rehabilitation specialists under the direction of a physical medicine specialist. The committee also emphasized the importance of professional training and involvement of nurses who are familiar with the rehabilitation team's approach to care. While World War I established orthopedics as a specialty, World War II is generally considered to have done the same for physical medicine [5].

Early intervention played an important role, with physical therapists beginning exercises in bed and occupational therapists offering arts, crafts, and hobbies as constructive activities during the often long recovery period. Group support through round table discussions helped the injured to resolve the psychological problems associated with the new disability; this caring group of trauma soldiers and amputees supported each other through shared

experiences and feelings. As the soldier recovered, active physical training was introduced along with prosthetics and gait training. Preventive activities (such as driving, dancing, and various sports) were encouraged, which facilitated adaptation to the new disability.

Often complex rehabilitation included significant needs for physical therapy, occupational therapy, and prosthetic support; these, along with the psychological needs of the wounded soldier, clearly required a multidisciplinary team approach to care.

In rehabilitation centers in Ukraine, daily exercises are prescribed to strengthen weakened muscles, and functional activities are actively considered to ensure that the amputee can perform the basic activities of eating, dressing, bathing, toileting and personal hygiene. Independence in these basic self-care skills provided the survivor with an important level of control over their environment and contributed to improved psychological well-being.

The following rehabilitation methods are used in Ukraine: physical therapy, classes with a rehabilitator, classes with an occupational therapist, classes with a physical therapist. Physiotherapy methods are: electrotherapy, heat therapy, light therapy, hydrotherapy.

Musculoskeletal injuries were the most frequently reported diagnoses, followed by nerve injuries, penetrating injuries, and then fractures. Victims with amputations, burns, traumatic brain injuries, and spinal cord injuries were less common, but these patients required extensive rehabilitation care with physical therapy, occupational therapy, psychological intervention, skilled nursing care, and fabrication of prostheses and orthoses.

Nerve injuries were closely associated with penetrating injuries, amputations, and fractures. Electrodiagnostic assessments are valuable in determining the extent of nerve damage. According to the recommendations of the American Association for Electrodiagnostic Medicine, only doctors with special training in electrodiagnostic medicine are allowed to perform these consultations [14]. Provision of electrodiagnostic consultations in hospitals can allow accurate diagnosis of nerve damage in the theater of operations without evacuation. Portable commercial electrodiagnostic devices are available and can be used for this purpose.

Nerve injuries of the lower extremities were common, and the fibular nerve was most often damaged. This injury often required orthotics to prevent foot drop and improve ambulation, as well as strengthening, gait training, and range of motion exercises.

Amputations took place in the wounded, but they required considerable rehabilitation. The main goal was to install temporary prostheses for patients with upper and lower limb amputations. Temporary prostheses have allowed amputees to move as early as possible during rehabilitation. Early ambulation has enormous psychological benefits for amputee patients. In the case of traumatic amputations, early movement is possible within two weeks after the final closure of the wound. Steinbach dealt with Israeli amputees for 25 years and considered the installation of

temporary plaster prostheses for these patients as the main goal of rehabilitation [15]. Steinbach believed that specialized rehabilitation centers provide optimal care for amputees, and early professional intervention returns most amputees to productive work [15].

Care of a patient with amputated limbs is most effective thanks to the early intervention of the rehabilitation team. Phantom pain and other residual limb pain syndromes can seriously interfere with a soldier's functional rehabilitation and require a comprehensive treatment approach that includes early prosthetics, drug trials, physical therapy, and occasional surgery. A physiatrist has special knowledge of residual limb pain and can best coordinate this multifaceted treatment.

Although spinal injuries are not as common, they require a comprehensive rehabilitation approach that addresses medical issues, functional limitations, and patient education.

Traumatic brain injuries during the war revealed cognitive impairments that required additional directed rehabilitation. Research highlights the need for early rehabilitation of soldiers who have sustained traumatic brain injuries during war to prevent complications and to initiate early rehabilitation that maximizes the functional outcomes of these soldiers.

Functional impairments most commonly observed among war casualties are related to locomotion [18]. Treatment for these problems included strengthening weakened muscles, improving joint range of motion, exercise, orthotics, and gait training. Many soldiers required special wheelchair adaptations for fractures and amputations, while ensuring maximum mobility during recovery. Walkers, crutches, and canes were often required in the short term for early mobilization and for long-term mobility in cases of severely injured soldiers.

During a protracted conflict, returning trained soldiers to duty can be extremely important. Eldar and Ohri reported in their article on the creation of rehabilitation systems for war, which in Britain was recognized as "cost-effective and effective in time" [12] to rehabilitate injured crews instead of training new ones. This was also noted by Parry [16] in the case of some highly skilled and valuable upper limb amputees who were retained in active service in Britain. Israeli literature also reports on efforts to rehabilitate some burn victims, which led to a return to full-time military service [17].

CONCLUSIONS

Thus, the experience of previous wars and the modern Russian-Ukrainian war emphasized the valuable contribution of Physical Medicine and Rehabilitation to the optimal care and functional recovery of wounded soldiers.

Physical therapists treat functional problems of wounded soldiers using strengthening exercises, range of motion exercises, orthotics, physical modalities, and gait training. However, when physiotherapists are present in medical centers, physical therapy and occupational therapy departments with physiotherapists are organized. When physical therapists are not available, orthopedic services usually include therapists.

In wartime and peacetime, there is often a shortage of orthopedists and physiotherapists to assess and treat all diseases of the musculoskeletal system in concentrated troops. For this reason, occupational therapists and physical therapists are qualified to work as extension physicians, providing initial assessment and treatment of common musculoskeletal problems. Ideally, doctors who are skilled in the diagnosis and treatment of the musculoskeletal system should be readily available for consultation. If the diagnosis remains unclear or the treatment is ineffective, timely referral of the therapist to a physiatrist or orthopedist is important.

Occupational therapists also perform a vital stress management function. In a military environment,

psychological stress can be a major factor that depletes an army's strength. Occupational therapists in the theater and in major medical centers provide support to these psychological casualties through structured therapy.

Currently, the rehabilitation of wounded Ukrainian servicemen is carried out in the Unified Medical Space – in hospitals of the Ministry of Defense, hospitals for civilians of state and municipal ownership, as well as in institutions of the National Academy of Medical Sciences of Ukraine. The Ministry of Defense approved the Concept for the Development of Rehabilitation of Wounded Servicemen, which provides for their treatment in specialized institutions.

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CONFLICT OF INTEREST

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