

## **HALOTHERAPY: HISTORY AND EXPERIENCE OF CLINICAL APPLICATION**

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This is the first article of the series concerning the role of dry sodium chloride aerosol in managing upper and lower respiratory tract pathologies, mechanisms of its action, clinical results, and technical approaches to aerosol delivery to patients.

Speleotherapy forms the background for the development of halotherapy.

Last years demonstrate the increase of doctors and researches who understand the reasonability of use of therapeutic methods based on application of natural or physical factors for stimulating mechanisms of sanogenes, and restoration of organism compensatory abilities.

Modern pharmaceuticals provide sufficiently effective and quick eradication of acute pathology, resolution of exacerbation of chronic diseases. Frequently repeated, prolonged or, what is worse, continuous drug therapy, however, is associated with possible development of allergic or toxic reactions, development of antibiotic tolerant species of microorganisms, wide spreading of dysbacteriosis and other side effects.

The off-stated reason inspires physicians to revise centenary experience of our forefathers and to work out new drug free and physiotherapeutic methods of treatment. Speleotherapy (from Greek "speleon"- cave), in particular, is used for managing respiratory tract pathologies.

Speleotherapy is a therapeutic method based on prolonged staying under the specific microclimate of caves, salt mines, grottoes, mines etc. Specific microclimate features depend upon character of underground cavities. The microclimate is characterized by constant temperature, pressure, gaseous and ion air composition, low relative humidity, increased ionization, prevalence of negatively charged ions, presence of various salt aerosols, increased radioactivity (in caves), the absence of bacterial flora and allergens, slightly increased contents of carbon dioxide.

The management of respiratory tract diseases by staying in caves was scientifically explained in the 40's of our century. German researches compiled data on positive influence of prolonged staying of many people in the cave of Klutert that was used during the Second World War as a bomb shelter by citizens of Ennepetal. Those time many patients with bronchial asthma and chronic bronchitis demonstrated complete resolution of the diseases or considerable improvement of their condition. Further, due to clinical and experimental studies carried out by K. Spannagel, M.D., Ph.D. [38] a new scientifically explained trend — speleoclimatotherapy — aimed at the management of respiratory tract pathologies was developed.

At present several countries have speleotherapeutic clinics developed on the basis of natural caves — Hungary, Slovenia, Bulgaria, Austria, Germany, Georgia.

Artificial caves are, as well, applicable for the therapy as natural ones. Among these may be exhausted salt mines or specially cut niches in the salt stratum where such clinics are created.

Polish doctor F. Bochowski for the first time offered supposition that air saturated with salt particles provides the main therapeutic influence in 1843. Salt mines of Velichka in Krakow province was the place where he created salt spa, and where more than hundred years ago in 1958, research and clinical resort for pulmonic patients were organized.

The examples of use of salt mines for therapeutic purposes may be found as well in other countries - Salzbad-Salzeman in Austria, Velichka in Poland, Siget in Romania, Nakhichevan in Azerbaijan, Chon-Tuz in Kirgizstan, Berezniki (Perm region) in Russia, Solotvino (Zakarpatian region) and Artemovsk (Donetz region) in Ukraine, Soligorsk in

Belorussia. All these clinics for patients with chronic non-specific lung diseases (CNLD) are based on the therapeutic action produced by cave air saturated with particles of rock salt.

Thus, salt therapy or halotherapy (HT) (from Greek "halos"- salt) is a part of speleotherapy.

Big experience in managing patients with various forms of CNLD proved high efficacy of speleotherapy undertaken in the microclimate of salt cave in Solotvino. Achieved therapeutic effect in patients with bronchial asthma (BA) of different age groups and variants of the disease was confirmed by results of biochemical, immunologic, microbiological tests. Speleotherapy in the microclimate of salt mines provides non-specific hyposensitizing effect, decrease of infections and inflammatory process activity in the respiratory tract, stimulation of various stages of local and general protective mechanisms. During the treatment organism adapts to the specificity of microclimate, which causes the reorganization of all functional systems of an organism [24]. Multiple science studies allow working out indications for speleotherapy and differential complexes of its application.

Speleotherapy is widely recognized as highly effective drug-free therapy. However, the necessity of acclimatization of a patient arriving from other climatic zones, difficulties associated with crossing, shortage of beds in comparison with amount of persons seeking for a help and a lot of contraindications hamper the wide distribution of this method of treatment.

### **The development of artificial microclimate of salt caves**

The next step in the development of therapy with the help of inhalant substances containing dry sodium chloride aerosol was the creation of ground clinics with artificial microclimate similar to underground clinic environment. Among the first who started to work in this direction was the Uzhgorod branch of Odessa Science Research Institute (SRI) of Spa Therapy. In 1980 MD Torokhtin and V.V. Zheltvay reported about their invention on the approach to managing BA in the ground clinic where inner microclimate is modeled to obtain one similar to underground salt mine [25].

In 1982 in Perm Medical Institute there was made a climatic cell for managing respiratory allergic diseases which environment, according to the report of inventors, modeled the microclimate of speleoclinic [5]. In 1984 another kind of ground facility for managing respiratory pathologies was introduced, it was called "Halocamera" [19]. The following years were marked by appearing of comparable objects united under such names as "Halocamera", "Climatic camera"[8, 9, 18, 20].

Generally, all these structures have common characteristics, which may be united in accordance with their functional purposes. These are walls covered with various salt-derived materials or made of rock-salt bricks, devices for preparation and conditioning of the air, and machines for saturating cell air with salt aerosol. Another feature of all these structures is the deficiency of technical means for microclimate parameter control and their maintaining at the required levels. The study of halocameras produced by different manufactures revealed that microclimate characteristics within these structures differed greatly from those in natural objects. In particular, heat and humidity regime may be reproduced, however, such an important parameter, as aerosol concentration can not be guaranteed by available control equipment. The values of dispersion of sodium chloride particles and their quantity in the air vary within broad limits.

Halocameras equipped with salt powder spraying devices based on the principle of boiling layer demonstrate the following dynamic of air dispersed media during a session: the first minutes of a session are characterized by peak-like increase (3 times an even more) of salt aerosol concentration over the necessary level, by the 25-30th minute the concentration reaches trace level [14]. That is why more than half of patients demonstrate worsening of their condition as a reaction to management in these cells that in some cases necessitates additional administrations [10]. Moreover, physical and chemical characteristics of salt particles determine the specificity of their behavior, which differs greatly from that described

in literature [16]. Due to the rapid coagulation and sedimentation of the particles the qualitative composition of the dispersion changed with the following increase of geometrical dimensions of particles and decrease of respirable fraction share in the cell atmosphere [14]. That is why it is important to refresh particles during a session.

In cells where salt aerosol source is represented by, so called, saturating filters, labyrinth partitions [8,9], particles concentration does not increase higher than  $1 \text{ mg/m}^3$ , that subsequently requires the prolongation of a session and the whole course of treatment and restricts the possibilities of HT.

However, the study on therapeutic action of dry sodium chloride aerosol revealed that the achievement of therapeutic effect and avoidance of side effects and complications from HT required strict maintaining of parameters of air dispersed media during HT (aerosol concentration, dispersion of the particles), and may be provided only by permanent monitoring of the parameters. Moreover, the experience of HT application demonstrated that management of patients with respiratory tract diseases (RTD) necessitates differential approach to the choice of therapeutic concentrations.

Taking into consideration medical demands for the method, a new generation equipment based on principles of controlled and manageable air dispersed media has been developed [11]. Modern halocomplex (manufactured by SC "Aeromed") comprises halogenerator with a microprocessor control, probes for constant measuring of temperature, relative humidity, and mass concentration of aerosol throughout a session. Halocomplex generates and maintains concentration of highly dispersed haloaerosol at the preset necessary level. Respirable fraction of this aerosol according to optic-based measuring exceeds 97%. Concentration of dry sodium chloride aerosol in the therapeutic cell may vary from 0.5 to  $9 \text{ mg/m}^3$ , accordingly to preset limits (regime);

I regime —  $0.5 \text{ mg/m}^3$ , II regime —  $1.0\text{-}3.0 \text{ mg/m}^3$ , III regime —  $3.0\text{-}5.0 \text{ mg/m}^3$ , IV regime —  $7.0\text{-}9.0 \text{ mg/m}^3$ . Moreover, this equipment does not need any special preparations of salt used for a session.

The assessment of microbial contamination in the therapeutic cell of halocomplex demonstrated that during a session  $1 \text{ m}^3$  contained from 30 to 132 saprophytic microorganisms (according to WHO standards on air sterility  $1 \text{ m}^3$  should contain less than 300 microbial bodies). Sanitary important microorganisms (viridans, haemolytic, staphylococci, streptococci) are not revealed. These findings correspond to the sanitary and hygienic parameters of underground speleotherapeutic clinic air.

Additional psychosuggestive effect during HT sessions may be achieved through the application of special audiovisual programs.

### **Mechanisms of halotherapy action**

In contrary to speleotherapy based upon the therapeutic action produced by a complex of natural factors, HT is a method of aerosol therapy. Therapeutic action is provided by air dispersed media saturated with dry sodium chloride aerosol at mass concentration varying from  $5.5$  to  $9 \text{ mg/m}^3$  and particle size of  $1\text{-}5 \text{ mkm}$ ., these parameters were borrowed from different speleotherapeutic clinics. Haloaerosol has a considerable level of volumetrical negative charge of the particles ( $6\text{-}10 \text{ nK7m}^3$ ). The air has comfortable temperature ( $18\text{-}24^\circ\text{C}$ ) and relative humidity ( $40\text{-}60\%$ ).

Some studies demonstrated that sodium chloride aerosol improves rheologic properties of bronchial contents facilitating normalizing of mucocellular clearance [33,36,40]. The presence of sodium chloride is necessary for normal functioning of bronchial ciliated epithelium [69], whereas sodium chloride contents in bronchial secretion of patients with chronic pulmonary pathology is decreased [30]. Sodium chloride aerosol provides bactericidal and bacteriostatic impact on respiratory tract microflora [17,37], stimulates alveolar macrophage reactivity, facilitating the increase of phagocytic elements and their phagocytic activity [12], produces anti-inflammatory action [35]. Haloaerosol has a considerable level of

volumetrical negative charge of the particles (6-10 nK7m<sup>3</sup>). High negative charge also has therapeutic significance and improves stability of the aerosol [4, 14].

Together with biological properties of sodium chloride aerosol, its physical characteristics are, as well, very important for the HT method. The prevalence of respirable fraction (1-5 mkm) share in haloaerosol (97%) provides its penetration into all sections of respiratory tract up to its deepest parts.

The basic nature of the method is application of dry sodium chloride aerosol. The study of droplet and dry sodium chloride aerosol absorption in the respiratory tract revealed that the highest degree of particles delay in case of equal dispersion was higher for dry aerosol [13], therefore the application of dry highly dispersed aerosol allowed the administration of lower doses and prevention of unfavorable side effects.

The use of dry aerosol permits to produce optimal temperature and humidity parameters in the camera. That allows avoiding the development of respiratory tract mucus edema and bronchial spasm, reactions common in patients when moist aerosols are used.

Additional effect produced by HT is explained by patient staying under conditions of hypoallergenic, hypo bacterial air surrounding, noiseless, comfortable psychological atmosphere.

### **Results of clinical application of controlled therapeutic microclimate of halocamera for managing patients with bronchopulmonary and upper respiratory tract pathologies**

HT was used in practical health care since mid 80-s. In 1989 the method was officially recognized by Ministry of Health Care of the USSR and was largely used in various clinical establishments. The experience of HT demonstrated that the achievement of therapeutic effect and avoidance of side effects and complications necessitates strict maintaining of preset parameters of air dispersed media in halocamera. In 1995 based on experience of clinical application of the controlled therapeutic microclimate — HT — new practical recommendations which stipulates obligatory control and management of microclimate parameters in HC in the regime of real time, and differential approach to the selection of sodium chloride aerosol concentration [29] were adopted by Ministry of Health Care and Medical Industry of the Russian Federation.

Evaluation of therapeutic results of more than 4000 of the patients management in various clinical establishments according to improved method confirms its high efficacy. Thus, doctors of practical medicine reported that positive results of this method application were achieved in 82-97% of patients with different pathologic variants of BA, pollinosis, chronic non-obstructive and obstructive bronchitis (CNB and COB), acute bronchitis (AB) with recurred and persisting duration, bronchiectatic disease (BED), upper respiratory tract pathologies, and some forms of skin diseases [2, 6, 15, 23, 26]. The carried out therapy allowed to decrease the morbidity of these respiratory tract pathologies and associated with it economical loss by 1.5-2 times [27].

The overwhelming majority of patients demonstrate positive dynamics of their symptoms that proved the amelioration of respiratory passages drainage; easier expectoration of sputum, which becomes less viscous; decrease in cough intensity; changes in lung auscultation. These were associated with the number and severity of dyspnea attacks and discomfort on exhalation. The application of HT facilitated the efficacy of drug therapy and decrease of drug doses. Half of patients who were administrated inhalant corticosteroids as anti-inflammatory management could stop this therapy. One third of patients could lessen the dose of corticosteroids. 60% of patients who were treated with inhalant (3-agonists, sympathomimetics managed to stop their intake or lessen daily dose [23, 31, 32, 34]. Long term follow up revealed that 80% of patients demonstrated 3 to 12 months duration of uneventful period with the mean value of 8.5 months.

Functional testing of bronchopulmonary system may prove clinical efficacy of the method. Thus, the analysis of volume-flow loops of forced exhale revealed significant improvement of its parameters after HT course. However, there were no significant differences in parameters of external breathing function prior and immediately after the HT session [22]. While the further analysis of volume-flow loops demonstrated significant increase of bronchial passability by the seventh day of treatment [32]. The comparison of clinical and functional results suggests that HT does not provide direct impact on bronchospastic component of obstruction, but improves bronchial passability due to the gradual influence on its discrynic and inflammatory components [6, 7, 28].

Good results were also achieved in HT application for patients with vasomotor rhinitis of neurovegetative and allergic forms. The improvement of nasal breathing occurred in 98% of cases. The achieved positive result was proved by 21% mean decrease of nasal resistance measured by body plethysmography in this group of patients. Simultaneously patients with X-ray signs of edema in paranasal sinuses demonstrated considerable decrease of its intensity and sometimes its complete resolution [3].

HT management of patients with chronic tonsillitis resulted in reduced subjective and objective signs of concomitant pharyngitis, easier discharge of tonsil caseous contents and tonsil cleaning in 50% of cases. No exacerbation of the disease was revealed during the follow up period of 6 to 12 months. HT used as a part of rehabilitation therapy for patients following endonasal and endolaryngeal surgery resulted in accelerated postoperative wound healing due to the apparent anti-inflammatory influence of the aerosol. Moreover, patients with acute and indolent sinusitis subjected to HT demonstrated complete absence of purulent discharge in sinuses during repeated punctions, proving thus bactericidal effect of the therapy [1, 2].

HT provides positive effect on humoral and cellular immune system in patients with CNLD, stimulates metabolic activity of lung tissue, and causes non-specific desensitizing effect on an organism [6, 21]. The study of HT efficacy suggests that local sanogenic and anti-inflammatory action of dry highly dispersed sodium chloride aerosol provides indirect positive impact on the general organism reactivity.

Thus, the experience of HT clinical application, the study of its efficacy for different pathologies allowed optimizing the parameters of HT method, and working out the differential approach to its administration and enlarging the indications. The study of the specific action of the method was associated with the development and perfection of the equipment meant for this method. Clinical backgrounds together with new technical solutions permitted to work out new medical technology — manageable therapeutic halocamera microclimate.

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