MODERN METHODS OF NON-INVASIVE CORRECTION FOR DISTURBED REGIONAL BLOOD CIRCULATION THROUGH PHYSIOTHERAPEUTIC MEASURES (LITERATURE REVIEW)

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ABSTRACT — Microcirculatory disorders resulting from disturbed mechanisms for blood flow regulation, or developing as secondary disturbances, are the focal point within the pathogenesis of most pathological conditions in cardiology, surgery, dentistry and other areas of medicine. Aim of study: to analyze and summarize the literature data focusing on the contemporary opportunities for non-invasive correction of regional blood circulation disorders using physiotherapeutic methods.

KEYWORDS — terahertz therapy, disturbed microcirculation.

INTRODUCTION

The microcirculatory bed provides transportation needed for plastic and energy metabolism directly into the body cells, as well as for the removal of their metabolism products, thereby creating the conditions for due functioning in tissues and organs. Coherent interaction of all the links in this system is possible due to regulatory influences from the nervous, humoral mechanisms, as well as the involvement of factors released by endotheliocytes [1, 2].

Considering the important role that microcirculation system plays in most pathological processes, potential correction of microcirculatory disorders and improving trophism in tissues appears a very attractive option in treating a variety of diseases and pathological conditions in dental practice, as well as in offering rehabilitation for patients who underwent reconstructive interventions on maxillofacial areas.

RESULTS AND DISCUSSION

Microcirculation disorders developing as a result of regulatory mechanisms disturbances are known to be the cause behind a number of pathological conditions; in some cases they may be of secondary nature, anyway they are present in most diseases in cardiology, surgery, dentistry, etc. [3, 4].

A powerful factor that aggravates the state of the endothelium in the vascular wall is tobacco smoking. Tobacco intoxication doubles the number of endothelium cells circulating in the peripheral blood, which is a sign of endothelium desquamation. This effect is caused not only by the capacity of nicotine to inhibit NO-synthase, which is involved in the production of endothelial nitric oxide, yet also by the direct toxic effect that cigarette smoke works on endothelial cells [5].

The deterioration of regional blood flow through the development of hypoxia and trophic disorders, changing permeability of the vascular walls, play an important role in the pathogenesis of inflammatory and dystrophic periodontal diseases. It has been also found that in case of insufficient oxygen supply to the tissue, free radical oxidation is activated, which, under progressive inflammatory reaction, will only aggravate the course of the pathological process [6, 7].

Of great interest are the changes in microcirculation occurring in the tissues after a dental implant installation. Numerous studies focusing on this issue have revealed that the status of the vascular bed and the level of blood flow play a key role in reaching osseointegration. Therefore, under ischemization of the surrounding tissues, there is a tendency towards the development of fibrous and cartilage tissues rather than bone structures, which has a negative impact on orthopedic treatment prognosis [8, 9].

For non-invasive correction of microcirculation disorders, the pharmaceutical industry offers antihypoxants or antioxidants — drugs that increase tissues resistance to hypoxia or inhibit the development of free radicals, respectively. Drugs belonging to these groups can be used systemically or locally as part of comprehensive therapy for treating periodontal dis-

eases, in case of face and jaws traumas [10, 11].

However, in case of using pharmacological agents, it is important to consider the risk of side effects and in increase in the cost of treatment. These drawbacks of pharmacotherapy point at the need to search for new non-medication methods for correcting microcirculation issues. Such methods include low-intensity electromagnetic radiation (EMI) of the millimeter-wave range with a wavelength (λ) of 1–10 mm and an extremely high frequency of 30–300 GHz (EHF-therapy), as well as laser therapy, where only the wavelength range is specified (100 to 30,000 nm). It should be stressed that when the requirements for these methods are observed, no side effects will occur, be that mutagenic or carcinogenic. At the same time, the processes of reparation are stimulated, microhemodynamics is activated, while nutrients are improved in the tissues; besides, immunomodulation and analgesic effects are triggered [12].

The advantages of EHF and low-intensity laser therapy include their good compatibility with other physiotherapy methods as well as with each other. Parfenova S.V., et al. (2018), for instance, in her respective work showed possible correction of the platelets aggregation and adhesive activity in chronic inflammatory periodontal diseases, employing a combination of EHF and laser irradiation using a Matrix device [13].

Recently, a large number of works have been focused on the therapeutic application of terahertz frequency range electromagnetic radiation (EMR THF; 100 GHz – 10 THz), which stands in between extremely high frequencies and the optical infrared range. This wavelength range is interesting in terms of its containing the molecular emission and absorption spectra (MSEA) of such inevitably important cellular metabolites as molecular oxygen, nitrogen oxide, carbon dioxide and a number of others. The potential for controlling the reactive capacity of the mentioned metabolites in order to mediate metabolic regulation in cells and tissues explains the huge interest that researchers take in this method [14].

A number of papers have focused on studying the effect of terahertz radiation at the nitric oxide MSEA frequencies of 150, 176–150, 664 GHz. Nitric oxide (NO) is well known as one of the most important vascular wall tone regulator. Being a powerful vasodilator and antiplatelet agent, nitric oxide is important in regulating blood circulation and proper blood supply to organs and tissues [15].

The effectiveness of THF therapy in this frequency range has been shown in a series of experiments on animals where hemodynamic disturbances were triggered by acute or chronic immobilization stress [16].

The normalizing effect of EMR THF at frequencies 150, 176–150, 664 GHz on the antioxidant blood system [17], on the state of the gas and electrolyte composition of blood [18] has been shown.

Clinical studies of THF-radiation of this frequency range showed their high efficiency in cardiology, traumatology, and dentistry. Techniques have been developed for exposure to EMR THF at nitric oxide frequencies, which increase the effectiveness of treatment for patients with angina pectoris [19].

The capacity of terahertz radiation at frequencies of 150, 176–150, 664 GHz to improve blood rheological properties and microcirculation allow using it for prevention of venous thrombosis in patients with lower limb fractures [20], as well as a factor stimulating regeneration and shortening the consolidation period for fractured bones [21].

THF electromagnetic radiation at the frequency of nitric oxide MSEA has found its application in dentistry. A.V. Zelenova, N.V. Bulkina, et al. (2015) compared the results obtained through using a standard mode for treating patients with rapidly progressing periodontitis and the outcomes of applying the same mode yet combined with a course of THF therapy at NO frequencies. A comparative analysis involving the two groups showed that there was better dynamics of inflammation relief, as well as a more complete restoration of blood supply in periodontal tissues observed in the group that featured THF therapy as part of the treatment [22].

Equally interesting for experimental and clinical medicine is the radiation of the terahertz range at the frequencies of the atmospheric oxygen radiation and absorption molecular spectrum of 129 ± 0.75 GHz. In biological systems, oxygen acts as the main oxidant, an essential link in energy-intensive metabolic processes. It is part of plastic and energy metabolism reactions, the synthesis of biologically active substances required to maintain the vital functions of the body [23].

The group of authors conducted a series of experimental studies demonstrating possible correcting effect of terahertz range electromagnetic waves with a frequency of 129.0 ± 0.75 GHz on blood coagulation and fibrinolytic properties, nitrite concentration, and systemic hemodynamic parameters [24, 25, 26].

The antianginal effect of terahertz therapy on the atmospheric oxygen molecular spectrum frequency has been studied, as well as its effectiveness in treating unstable angina has been demonstrated [27].

The study by L.A. Zyulkina (2018) proved, both experimentally and clinically, the feasibility of using a specially developed course of irradiation with electromagnetic waves in the terahertz range at a frequency of 129.0 GHz through various stages of treating inflammatory and dystrophic periodontal lesions [28].

According to N.V. Bulkina, L.A. Zyulkina, et al. (2017), planning of reconstructive dental interventions should be carried out in view of the oral microcirculation system functional status. Dystrophic and inflammatory changes in the oral cavity are accompanied by disturbed microcirculation and functions of the vascular wall endothelium, which affects the course of the regeneration & reparation. Improving microcirculation through THF-therapy at the frequency of atmospheric oxygen of 129.0 GHz in the intervention zone takes place as a result of restoring the vascular wall balance, i.e. due to the endothelium factors (both vasoconstricting (endothelin (1-38, big), asymmetric dimethylarginine (ADMA) and vasodilating (endothelial nitric oxide synthase (eNOS), nitrite level) [29] expressed by the vascular wall.

Non-invasive correction of regional blood flow disturbances through physiotherapy can be used for treating various pathologies in the maxillofacial region [30-41].

CONCLUSION

In view of the above, the data available from respective literature shows that the modern physiotherapy method, terahertz range electromagnetic radiation, has a powerful potential in regulating various physiological processes, including systemic and regional hemodynamics and blood rheological properties. Considering the fundamental role that blood supply plays in most pathological processes affecting organs and tissues, search for new ways of its non-invasive correction through THF-therapy appears quite deserving due effort and requires further investigation.

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