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THE ROLE AND EFFECTIVENESS OF OZONE THERAPY IN MEDICINE

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Abstract: This article discusses the role of ozone therapy in medicine, its mechanism of action in the human body, and its clinical effectiveness. The physicochemical properties of ozone, its biological effects, and its applications in the treatment of various diseases are analyzed based on scientific sources. In addition, the advantages of this method, safety issues, and contraindications are considered.

Keywords: ozone therapy, ozone, oxidative stress, immunomodulation, regeneration, infection.

Introduction

In recent years, interest in alternative and complementary methods of treatment has been steadily increasing. One such method is ozone therapy. Ozone (O_3) is an active allotropic form of oxygen with strong oxidizing properties. In medical practice, ozone is used as an oxygen–ozone mixture.

Scientific research in the field of ozone therapy is extensive and diverse. In previous years, numerous scientific studies were conducted on this topic, many of which focused on ozone's antibacterial, antiviral, antioxidant, and immunomodulatory properties. These studies provided important information on the effectiveness, potential risks, and clinical application of ozone therapy.

Ozone therapy began to be used in Europe at the beginning of the 20th century and is currently widely applied in surgery, dermatology, dentistry, neurology, and other fields of medicine. Several researchers have carried out scientific investigations in this area.

The Italian scientist Vittorio Benedetti is considered one of the leading researchers in ozone therapy. He studied the effects of ozone on microorganisms, including viruses and bacteria, and published several important works on the subject.

The Brazilian scientist G.V. Perez investigated the influence of ozone therapy on the immune system and its effects in chronic diseases, including diabetes and cardiovascular disorders. His research has been published in numerous medical journals.

The Mexican scientist X.L. Benitez also studied the clinical therapeutic potential of ozone, particularly its effects in rheumatic and orthopedic diseases.

The German scientist R.X. Schmidt conducted studies on the use of ozone therapy in hematology and blood disorders. He investigated the effects of ozone on blood circulation, hypoxia, and ischemic conditions. This article provides information about clinical studies of ozone therapy and its effectiveness. It also presents scientific and clinical research on the mechanisms of action of ozone therapy in various diseases.

Uzbek scientists have also conducted several studies on ozone therapy as a treatment. Among them, Sh. Gafurova investigated the effectiveness of ozone therapy in obstetrics and gynecology. The benefits of ozone therapy in treating bacterial infections and obstetric

complications, such as endometriosis and fibroids, have been demonstrated. Studies have also examined ozone's ability to strengthen the immune system, exert anti-inflammatory effects, and improve blood circulation. Thus, ozone therapy is considered an effective therapeutic method with significant beneficial effects.

A study conducted by D. Gulrux Davronova and co-authors examined the effectiveness of ozone therapy in patients with hearing impairment. In this condition, ozone's ability to improve blood circulation, reduce inflammatory mediators, and decrease tissue hypoxia is of particular importance. Ozone also activates cellular signaling pathways and accelerates the rehabilitation process.

A study conducted by Sh. Yusupov focused on the treatment of appendicular peritonitis with the use of ozone therapy. The study demonstrated that ozone exhibits activity against infectious agents and promotes the regeneration of damaged tissues. The effectiveness of ozone therapy as an adjuvant treatment after surgical interventions was also shown.

Ozone is a triatomic oxygen molecule characterized by high reactivity. It is considered a strong oxidizing agent and exhibits bactericidal, virucidal, and fungicidal effects against microorganisms. In water and biological fluids, ozone rapidly decomposes, forming oxygen and reactive radical species. This property largely determines its biological mechanism of action.

In ozone therapy, ozone (O_3) is generated using special methods. Ozone is an active and reactive form of oxygen consisting of three oxygen atoms. Two main approaches are commonly used for ozone generation: ozone generators and electrical discharge methods.

Generation of ozone using ozone generators

Ozone generators are special devices that use electrical energy to convert oxygen molecules into ozone (O_3). The basic principle of operation of ozone generators is the use of an electrical discharge. During the operation of an ozone generator, oxygen gas either passes through ambient air or is supplied directly from a medical oxygen source.

Under the influence of a high-voltage electrical discharge, oxygen molecules are split into highly reactive oxygen atoms. These oxygen atoms then combine with oxygen molecules to form ozone:

$$O_2 + ye\ (elektron) \rightarrow O_3$$

Thus, during electrical discharge, molecular oxygen is converted into a new triatomic molecule — ozone (O_3).

Ozone gas can be administered to the body through various methods. These methods are used to maximize the therapeutic effects of ozone in different diseases and pathological conditions. Ozone enters the body mainly in the form of gas or an oxygen–ozone mixture. The main methods of ozone administration are discussed below.

1. Intravenous method

Intravenous ozone therapy involves the introduction of an oxygen–ozone mixture directly into the bloodstream. This method is considered one of the most effective approaches for systemic ozone therapy. The oxygen–ozone mixture is produced using a specialized ozonator or ozone generator and then administered to the patient in a controlled dose via intravenous infusion or injection.

Administering accurately measured doses of ozonated oxygen into the blood stimulates the immune system, improves blood circulation, and supports detoxification processes. When ozone enters the bloodstream, it initiates controlled oxidative reactions, affects various biomolecules, induces mild oxidative stress, and helps the body fight microorganisms, including viruses and bacteria.

2. Administration through ozonated gas inhalation

Ozone gas inhalation refers to the introduction of ozonated air or gas into the body through the respiratory tract. This method has been described in relation to respiratory diseases such as pneumonia, bronchitis, and asthma.

Scientific note: direct inhalation of ozone gas is considered potentially harmful to the respiratory system, because ozone is a strong oxidizing agent and may irritate or damage the lung tissue. Therefore, in modern medical practice, ozone should be used only in strictly controlled concentrations and according to established safety protocols.

3. Local therapy

Local application of ozone gas involves the use of ozonated gas on wounds, acute infections, or damaged areas of the skin. This method is applied to ensure the local effect of ozone on injured, infected, or inflamed tissues.

In ozone therapy, the envelope of viruses or microorganisms can be destroyed as a result of oxidation. This process is associated with oxidative damage to lipids in the cell membrane. The membranes of viruses, especially enveloped viruses, and bacteria are mainly composed of lipid structures. Ozone acts on these lipid components, leading to their oxidation and structural disruption.

This process occurs in three stages.

1. First stage — ozone attacks the membrane

Ozone reacts with unsaturated fatty acids in the cell membrane, particularly at the sites of carbon–carbon double bonds (C=C).

Ozone (O_3) is a reactive oxygen species with strong oxidizing properties. Due to its high reactivity, it readily interacts with unsaturated lipid molecules. As a result, intermediate oxidation products are formed rather than simple molecular oxygen alone. These intermediates may include partially oxidized fatty acid derivatives and ozonides.

Lipids, especially phospholipids, are the main structural components of biological membranes. Many of them contain unsaturated carbon–carbon double bonds (C=C). Ozone attacks these double bonds and oxidizes them, leading to structural changes in the lipid molecules.

This reaction is known as **ozonolysis**.

The general scheme of the reaction can be represented as follows:

$$R\text{-}CH{=}CH\text{-}R + O_3 \rightarrow R\text{-}CH(O)\text{-}CH\text{-}R$$

Here, R denotes the fatty acid radical, while O represents an oxidized atom or oxygen-containing fragment.

As a result of the reaction between ozone and fatty acids, peroxides (ROOH) may be formed. These reactions can proceed according to the following general scheme:

$$R\text{-}CH(O)\text{-}CH\text{-}R+O_2 \rightarrow R\text{-}CH(O)OOH$$

Peroxides in the form of ROOH can damage fatty acids or other membrane components. Ozone cleaves the double bond, forming an intermediate compound known as an ozonide.

2. Second stage — formation of free radicals

During ozone decomposition or during the course of the reaction, various reactive compounds are formed, including:

- peroxides;
- hydroperoxides;
- free radicals, such as hydroxyl radicals (•OH).

These substances are highly reactive and may attack surrounding lipid molecules.

3. Third stage — initiation of a chain reaction

When one lipid molecule is damaged, it can trigger the oxidation of neighboring lipid molecules. This process is called a chain reaction.

As a result, the membrane becomes damaged, its permeability is disrupted, and the viral or bacterial cell loses its normal function.

Conclusion

After entering the body, ozone activates a number of biological processes:

1. **Antimicrobial effect** — ozone oxidizes the cell wall or membrane of bacteria, viruses, and fungi.
2. **Improvement of blood circulation** — it enhances the ability of erythrocytes to transport oxygen.
3. **Immunomodulatory effect** — it stimulates the production of cytokines.
4. **Anti-inflammatory effect** — it reduces the activity of inflammatory mediators.
5. **Activation of the antioxidant system** — it strengthens the body’s own protective mechanisms.

Theoretically, when used at low doses, ozone induces physiological adaptive responses and improves cellular energy metabolism.

Although positive results have been reported for some diseases, large-scale randomized clinical trials are still insufficient in many areas. Since ozone is a strong oxidizing agent, high doses may cause cellular damage and intensify oxidative stress. Inhalation of pure ozone may damage lung tissue. Therefore, the procedure should be performed only with specialized equipment and by a qualified medical specialist.

Ozone therapy is not recommended in the following conditions:

- hyperthyroidism;

- blood coagulation disorders;
- thrombocytopenia;
- acute hemorrhagic stroke;
- certain periods of pregnancy.

Ozone therapy may be a useful complementary treatment method in certain clinical conditions. It exhibits antimicrobial, immunomodulatory, and regenerative effects.

However, it cannot completely replace conventional treatment and should be applied only in accordance with the principles of evidence-based medicine, using an individualized approach for each patient.

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