

Conference Paper

Stop Bleeding Mobile Device "Plasmamed" Based on Low-temperature Gas Plasma

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Abstract

Creation of a mobile device to stop bleeding, sterilize biological tissues and other surfaces (bandages), disinfect food, beverages, air, and stimulate rapid healing of wound surfaces is observed in this article. Plasmamed is based on the current (available) technologies of medical application of low-temperature atmospheric pressure plasma. The multi-digit combined plasma gun is created as part of the developed mobile device which is designed to achieve a coagulation effect, to stimulate accelerated healing of wound surfaces based on the use of low-temperature gas plasma of atmospheric pressure, which allows for effective hemostasis of wound surfaces with simultaneous sterilization of surrounding tissues and dressing materials. In addition, due to the using several types of high-frequency electromagnetic plasma production in one device, it was possible to significantly simplify the final product, to automate its operation modes, which provides mass-dimensional characteristics for its mobile use.

Keywords: plasma, medical device, stopping bleeding, low-temperature atmospheric pressure plasma.

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1. Introduction

This paper describes the current state of medical application of plasma and will also highlights the possibilities of applied design of low-temperature atmospheric pressure plasma (LTAPP) sources.

Using of plasma (ionized gas) in medicine application began in the middle of the 19th century [1]. The most famous experiments were carried out by Nicola Tesla in the second half of the 19th century, he demonstrated the possibility of exposure of a living person to powerful high-frequency currents without visible damage [2]. Tesla's work inspired many scientists to study the physics of plasma processes and biomedical effects on living tissues for the next century. These studies were much ahead of their time and quite consistent with our current views on certain aspects of the therapeutic mechanisms of various effects of application.

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The development of modern devices working with atmospheric pressure plasma at room temperature has significantly expanded the boundaries of the field of application of high-frequency discharges and currents in recent decades and, in fact, opened a new and rapidly growing interdisciplinary field called Plasma medicine [3].

Modern plasma medicine has originated over only about two and a half decades, but over the years the research community has evolved from fragmented laboratory research to widespread and rapidly developing clinical applications [3].

Today, research and development are taking place virtually in all fields of medicine, including the therapy of nonhealing ulcers and cancer treatment [4]. This study has identified plasma-modulated cytotoxic macrophages capable of releasing TNF- α (tumor necrosis factor), which blocks the growth of cancer cells and can help reduce tumor growth [4]. Studies by researchers at Thomas Jeffersonian University show that LTAPP therapy enhances immunomodulatory interventions that can be developed and used to improve antitumor immunity in patients. Combined approaches using standard and new treatments can finally eliminate cancer [5]. It is also worth noting, that scientists from Belgium have confirmed the effectiveness of the use of plasma technologies [4].

Although our knowledge and understanding of the fundamental mechanisms that play an important role in the interaction between low-temperature plasma and biological tissue cells have expanded significantly, there are many areas, which should be explored to obtain an accurate and detailed information of the physical and biochemical processes of interaction between LTAPP and living cells and tissues.

Practical advances in LTAPP research in recent years in dermatology, dentistry, therapy, and cancer treatment have led to significant results in medical applications. This has led the authors to the idea that LTAPP could be a basic technology for innovative treatment methods, which can be developed, suitable for overcoming a number of existing problems in Russian healthcare.

For example, there is a clear indication that LTAPP acts selectively on cancer cells and tumors and can penetrate deep under the surface of the treated tissues, which opens up the possibility for developers to create apparatuses to combat cancer, based on these principles, which can effectively fight against incurable or incurable to date nosologies, but requires intensive continuation of research, including extensive multicenter clinical trials.

1.1. Development of our technology

This article is devoted to the development of a mobile device for emergency stop of bleeding, accelerated wound healing, sterilization of tissues, as well as for disinfection of biological tissues using low-temperature gas plasma of atmospheric pressure.

Our research aims to create a device for wound treatment and bleeding stop using low-temperature atmospheric pressure plasma (Fig. 1).

The first type is monopolar devices used mainly in surgery, including for stopping intraoperative bleeding. The inert gas plasma of atmospheric pressure is produced in devices of this type with the help of streamer high-voltage high-frequency discharges between the electrode and the patient's body, to which a neutral electrode is attached. At such influences on the patient's tissues, including partial vaporization of cells of clean, ionization of molecules and secondary plasma chemical reactions with the penetration of their products into the tissue cells of the wound surface. This, in turn, introduces some restrictions on the use of monopolar discharge plasma for the treatment of conditionally healthy (non-pathological) tissues.

The second type is bipolar apparatuses in which low-temperature atmospheric pressure plasma is created using discharges between electrodes inside the apparatus itself. It allows to set of chemical and physical properties of the received plasma and, accordingly, to predict more precisely the results of medical intervention. With the help of such devices, it is possible to have a more gentle effect, including on conditionally healthy tissues (cosmetology, dentistry, etc.)

The main idea is to combine a set of bipolar and monopolar arresters to obtain greater efficiency in the coagulation of the wound surface with low-temperature atmospheric pressure plasma (Fig. 2)

For the first time in the world, we will create a medical device that combines the advantages of both monopolar and bipolar plasma. The multi-digit combined plasma gun created by us as part of the developed mobile device is designed to stop bleeding, achieve a coagulation effect, carry out hemostasis, sterilize biological tissues and other surfaces (bandages), disinfect food, beverages, air, as well as stimulate rapid healing of wound surfaces based on the use of low-temperature gas plasma of atmospheric pressure allows to carry out an effective hemostasis of wound surfaces In addition, due to the use of two types of high-frequency electromagnetic plasma production in one device, it was possible to significantly simplify and in the future to reduce the cost of the finished product, to automate its operation modes, to provide mass-dimensional characteristics for its mobile use.

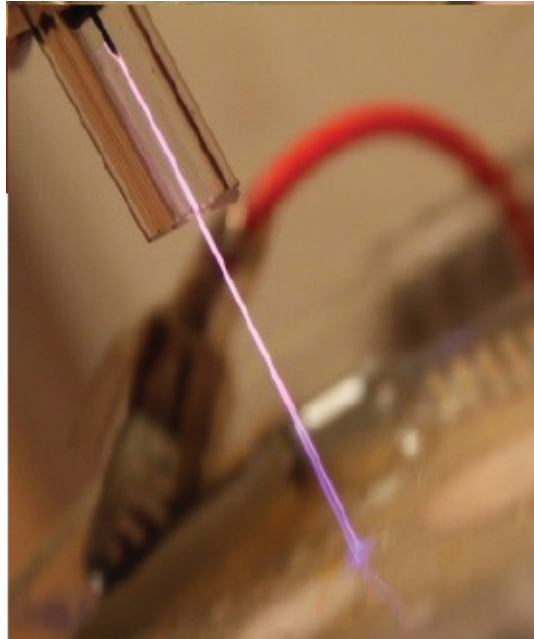


Figure 1: Surface Sterilization



Figure 2: Testing of a test bench prototype

Proceeding from the conducted researches [6], it is possible to assert that cold atmospheric pressure plasma is a useful tool for the treatment of chronic wounds. In addition to antimicrobial effects, plasma can stimulate wound healing, accelerating cell proliferation through the modulation of signal molecules. Besides, the article substantiates that during exposure to low-temperature plasma, a reduction in the size of the damaged area and improvement in the overall health of patients were found [6]. Also, in the course of the study, the first results of the project on blood coagulation caused by direct interaction with the helium plasma stream were presented in practice. In vitro studies have shown that the use of plasma does accelerate coagulation. The result was confirmed by animal models. The above experiments prove the increase in healing efficiency in the application of this technology [7].

Nowadays, there are technologies for the treatment of various diseases, including malignant neoplasms with the use of low-temperature atmospheric pressure plasma, which are being actively developed. For example, the studies show intercellular signaling pathways selectively inducing apoptosis in malignant cells. Understanding the use of technologies that work together can play an important role in creating the synergies that will enable the treatment of tumors. In turn, this will reduce the size of the tumors themselves in vivo and control the process of recovery of healthy tissues in the body [8].

After the analysis of scientific publications and research, original design of the device, which by its mass-dimensional characteristics is suitable for use in the field (military field) conditions as part of the standard equipment of a medical worker was developed.

It is a new scheme of a low-temperature atmospheric pressure plasma generator, which combines both bipolar and monopolar methods of cold plasma generation.

The achievement of acceptable mass-dimensional characteristics of the device is due to the more economical consumption of used gas (gas mixture) and the optimal capacity of the batteries used to perform the tasks.

2. Conclusion

It can be argued that medical technologies with the use of LTAPP are quite common and safe, ready for use not only in hospitals but also in outpatient, home and field conditions, to provide first aid in traumatology and therapy of a number of pathologies.

However, there are still a lot of issues, that should be met for fully understand the mechanisms of LTAPP action on biological cells and tissues, both in vitro and in the clinic.

Using the developed device to stop bleeding and disinfect wound surface tissues will reduce the number of purulent inflammatory complications in patients with open field (military field) trauma by dozens of times. Also, Plasmamed can be used for disinfection of any surfaces and cavities, air and water.

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