GENERATOR OF LOW-TEMPERATURE PLASMA FOR NUCLEOPLASTY

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РАЗРАБОТКА ГЕНЕРАТОРА ХОЛОДНОЙ ПЛАЗМЫ ДЛЯ НУКЛЕОПЛАСТИКИ

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Аннотация. *В настоящей работе мы исследовали низкотемпературную плазму и ее параметры для разработки генератора холодной плазмы для нуклеопластики. На первом этапе нашей исследовательской работы мы изучили более 20-ти патентов на приборы, основной функцией которых являлось образование холодной плазмы в электролитах. Мы выявили наиболее приемлемые параметры разрабатываемого нами генератора, а также следующие особенности:*

1.Плазма формируется в электролите.

2.Для нуклеопластики используется малый размер электрода.

3.Необходимость возбуждения и удержания режима плазмы.

4.Для режима плазмы требуется меньше мощность, чем для нагрева проводящей ткани от прохождения переменного тока высокой частоты.

Первым экспериментальным шагом стало получение холодной плазмы на постоянном токе. При заданных параметрах источника тока, мы получаем холодную плазму в растворе NaCl. Однако сам генератор холодной плазмы мы не можем создавать на постоянном токе, в силу больших напряжений и возможности утечки токов на пациента.

На втором этапе мы, обобщив первые полученные экспериментальные результаты и сведения из патентов, взяли за основу нашего прибора обыкновенный генератор переменного тока и на выходе установили нейтральный провод и непосредственно электрод (мы использовали иглу от медицинского шприца). Экспериментальным путем мы установили, что наша струя плазмы способна разрушить и деформировать поверхность яблока, а также мясо и костные ткани.

Сейчас, на третьем этапе, мы уже занимаемся разработкой макета нашего генератора, а именно подбором идеального электрода, идеальных заданных параметров генератора, а также самого макета *прибора. Решается также вопрос облегчения создания плазмы в условиях работы с костными тканями, т.е. создания такого прибора, электрод которого с наибольшей легкостью сможет наносить повреждения тканей (деформирования), при этом не увеличивая напряжение генератора. Один из вариантов – создание системы подачи электролита непосредственно на электрод и оснащение электрода системой охлаждения, чтобы в процессе операции, при высоких температурах и динамичных движениях деформируемые ткани, а именно белок, не налипали на электрод и не предотвращали тем самым образование плазмы.*

Introduction. Plasma is an ionized quasi-neutral gas. Ionized gas contains free electrons, both positive and negative ions. In a broader sense, plasma can consist of any charged particles. Since gas particles are mobile, plasma has ability to conduct an electric current. In the stationary case, plasma screens a constant electric field external towards it due to the spatial separation of the charges. However, due to the presence of a nonzero temperature of charged particles, there is a minimum scale at distances less than those which quasi-neutrality is violated.

Plasma is divided into low-temperature (temperature less than one million K) and high-temperature (temperature of one million K and above) ones. This division is due to the importance of high-temperature plasma in controlled thermonuclear fusion. Various substances pass into the state of plasma at different temperatures, what is explained by the structure of the outer electronic shells of atoms of matter: the easier an atom gives up electrons, the lower the temperature of the transition to plasma state is.

A low-temperature plasma is a plasma whose average electron energy is less than the characteristic ionization potential of an atom (<10 eV); its temperature does not usually exceed 105 K. A low-temperature plasma is used for nucleoplasty and other surgical operations. [2]

The method using cold plasma allows much lower removal (burning out) or dissection of human tissues at temperatures up to 70 ° C than when using conventional electrosurgical devices. The tissue is exposed to a narrowly focused (50-100 μm) cloud of sodium plasma formed on the working surface of the electrode in *NaCl* medium (isotonic saline). The energy of *Na* + ions of plasma cloud is 8 eV and is sufficient for cleavage of the cartilaginous and connective tissue to low-molecular compounds. At the same time, temperature does not increase outside the core. [1]

The method is used in traumatology to perform a wide range of arthroscopic operations. The method makes it possible to carry out manipulations on the cartilaginous tissue and periarticular tissue, to carry out incisions and process the surfaces of the cartilage and ligaments without thermal damage to the treated tissues. There is completely no "sticking effect" of the tissue to the working surface of the electrode.

Analysis of US patents made it possible to reveal the following information: the power supplied to the common electrode and the electrode array would be at high or radio signals, typically from about 20 kHz to 20 MHz, usually between 30 kHz and 1 MHz, and preferably between 50 kHz to 400 kHz. The RMS (RMS) voltage is generally in the range of about 5 volts to 1000 volts, preferably in the range of about 50 volts to 800 volts, and more preferably in the range of about 10 volts to 500 volts.

Research methods. At the first stage of our research, we studied more than 20 patents for instruments, the main function of which was the formation of cold plasma in electrolytes based on the material analyzed. We identified the most acceptable parameters of our generator, as well as the following features:

1.Plasma is formed in the electrolyte.

2. A small electrode size is used for nucleoplasty.

3. The need for excitation and confinement of plasma regime.

4. For plasma regime, less power is required than for heating the conductive tissue from passing an alternating current of high frequency.

Results. The first experimental step was to obtain cold plasma at a constant current. As you can see (*Fig.1)*, the experiment was successful. With the given parameters of the current source, we got cold plasma in *NaCl* solution.

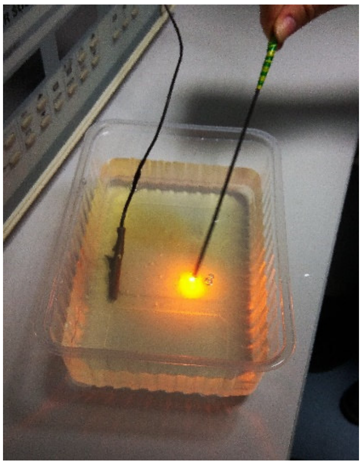

Fig.1. Results on first step

However, we cannot create the cold plasma generator on a direct current due to high voltage and the possibility of leakage of currents to the patient.

At the second stage, we generalized the first experimental results obtained and the information from patents, based on our instrument, an ordinary alternator and installed a neutral wire and, directly, an electrode (we used a needle from a medical syringe). As you can see, we again received plasma in the electrolyte. However, at that time, the voltage was lower and the generator contained a two-stage system to protect against burnout and leakage of current to the patient. Experimentally, we established that our plasma jet can destroy and deform the surface of the apple, as well as meat and bone tissue.

Now, at the third stage we are already working on the development of the model of our generator, namely: the selection of the ideal electrode (material + size), ideal set parameters of the generator, as well as the device itself. The problem of facilitating plasma creation under the conditions of working with bone tissues has also been solved. The creation of such a device, whose electrode with the greatest ease can cause tissue damage (deformation) while not greatly increasing the voltage of the generator. One of the options is to create an electrolyte supply system directly to the electrode and to equip the electrode with a cooling system so that during the operation during high temperatures and dynamic movements, the deformable tissues, namely the protein, do not stick to the electrode, thereby preventing plasma formation.

Conclusion. At the present stage of the work, we have obtained a low-temperature plasma with direct current and alternating current, have tested its effect on real tissues and have obtained the necessary parameters of a low-temperature plasma generator

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