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Review Article

Advantages of High Frequency Electric Welding in Comparison with Endovenous Laser Coagulation in Varicose Veins

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Abstract

The high prevalence of varicose veins and the likelihood of developing severe complications determine the socio-economic importance of finding effective methods of treating this disease. In recent decades, open surgical interventions have been replaced by minimally invasive percutaneous techniques. One of the most effective methods is endovenous laser coagulation, which is widely used both abroad and in leading domestic clinics. Along with laser coagulation, the high-frequency method of electric welding is also successfully used.

On the basis of our experiment, the advantages of the high-frequency method of electric welding are clearly shown, as a result of which destructive phenomena do not develop in the working area and in the immediate environment, due to moderate temperature conditions, in comparison with the use of laser coagulation, which is accompanied by quite frequent thermal postoperative complications.

Keywords: Great saphenous vein; Varicose veins of the lower extremities; Conservative methods of treatment; surgical methods of treatment; Minimally invasive methods of treatment; Thermal complications; Temperature regimes

Introduction

The high prevalence of varicose veins of the lower extremities and the likelihood of developing severe complications determines the socio-economic importance of finding effective treatments for this disease. The risk factors are traditionally considered to be age, height, female sex, overweight and heredity.

In the developed countries of Eastern Europe, the prevalence of varicose veins of the lower extremities is up to 30%, including 3.6% to 8.6% - in severe form; the peak of varicose veins falls on the age range of 40 years to 60 years. The cost of treatment of CVI in European countries is up to 2% of the total healthcare budget [1-3].

The pathogenesis of varicose veins of the lower extremities is a complex and multifactorial process. The main pathogenetic link in the development of varicose veins of the lower extremities is the damage of endothelial cells of the wall of the great saphenous vein, which leads to a violation of their antithrombotic properties. Subsequently, other membranes of the vein wall are involved in the pathological process. Also, venous valves dysfunction and their lesions play a role in the development of varicose veins of the lower extremities. The main method of diagnosis of varicose veins of the lower extremities is ultrasound angioscopy, which allows simultaneous visualization of the vessel under study, determining the direction of blood flow and its parameters, individual anatomical features [1,4].

Conservative methods of treatment are used in the initial stages of the disease. When they prove to be ineffective, there is a need for surgical treatment and the only pathogenetically sound way to treat varicose veins of the lower extremities is to eliminate pathological vertical and horizontal refluxing the main saphenous veins.

In recent decades, open surgical interventions have been replaced by minimally invasive percutaneous techniques. One of the most effective methods is endovenous laser coagulation, which is widely used both abroad and in leading domestic clinics [2,5,6]. But this method of surgical treatment is not without drawbacks, which consist in the occurrence of quite frequent recurrence of varicose veins. According to the classification REVAS (Recurrent Varices after Surgery) in the period of at least 2 years after surgery, recurrence occurs from 8.4% to 19.6% of patients (According to ultra sound examination). The most common cause of recurrence is recanalization of the great saphenous vein, which can reach 10% to 13.3% within a year after the procedure [2,6,7].

Regarding the choice of light guides for endovenous laser coagulation, there is also no consensus. In particular, the maximum (largest) diameter of light guides for obtaining positive results using a diode laser with a wave length of 1470 nm for different types of light guides has not been determined [8,9]. But the main disadvantage of this minimally invasive method of treatment is that endovenous laser coagulation is accompanied by a significant increase in temperature in the working area, which is often the cause of thermal effects on paravasal tissues. The most significant complication in the early postoperative period is post-traumatic thermal neuropathic of the saphenous nerve (n. saphenus), which accounts for 6.25% of all

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complications. These patients had pain (4-6 points) in the middle and lower third of the lower leg for 1-3 months [2,5,10]. Top recent thermal complications during end ablation with diode laser, surgeons perform Tumescent Anesthesia (TLA), which is not always effective [11,12].

The aim of the work is to conduct an experiment, which will substantiate the advantages of using electrocoagulation of damaged veins using the HF-electro coagulator EKVZ-300 "Paton med", which was developed at the E.O. Paton Institute of Electric Welding of the National Academy of Sciences of Ukraine.

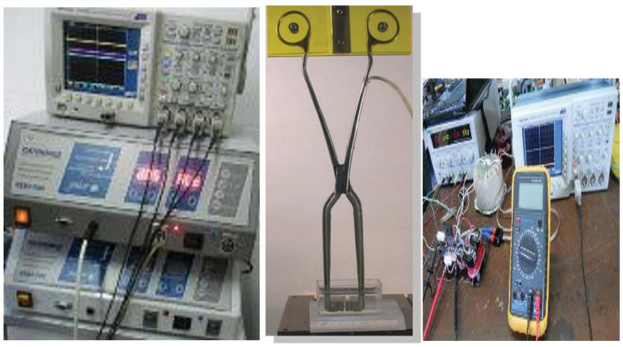
In the course of the experiment, it is planned to prove that temperature changes depend on the voltage and resistance growth, when using the HF-electro coagulator EKVZ-300 "Paton med".

Materials and Methods

The research was carried out by experimental methods on specially designed equipment by physical modeling in the Institute of Electric Welding named after E.O. Paton of the National Academy of Sciences of Ukraine, under the guidance of Doctor of Technical Sciences, Chief Researcher Y.M. Lankin.

To conduct the research, a system for temperature measurement was created (Figure 1), which consists of an HF-electro coagulator EKVZ-300 "Paton med" (a), a thermal electromotive force amplifier, an external ADC module E14-440 "L-Card", a laptop with "Power Graph" software.

A bipolar clamp (b) was also used, which was immersed in a saline solution of serum albumin and egg white, which served as an experiment a medium close to the environment of a living organism.



a *b* *c*

Figure 1: a) Power source of the EKVZ-300 "Paton med" apparatus, b) a container with a protein solution in which the bipolar clamp is immersed, c) measuring equipment.

Results and Discussion

The main technological parameter of resistance welding of biological tissues and biological solutions is the amount of current that passes through the biological medium. The electrical conductivity of current through biological media is due to the composition of the biological environment, namely electrolytes that are in the biological environment and in soft issues- intracellular and extracellular fluid, which is 86% of the total bodyweight.

To better understand the phenomena that occur during resistance welding, it is necessary to know the characteristics and role of each of the components of the composite, because soft biological tissues and biological solutions are composite materials with a wide range of properties of their components and morphology. They are formed by cells, connective tissue and biological solutions, which in turn consist of fibrous and globular proteins and aqueous electrolytes. In our experiment, a solution of albumin and egg white in physiological a line was used as an experimental biological medium. This environment is as close as possible to the composition of the human body.

Due to the application of high frequency welding of biological tissues, their heating is crucial. Therefore, determining the temperature of biological tissue and biological fluid during the study of all aspects of electric welding is extremely important. But the difficulties of temperature measurement in this process have led to the fact that this issue is poorly understood. This is the reason that forced us to conduct these experiments.

The results of our research are shown in the graphs (Figure 2), where the ratios of current, voltage and resistance and their fluctuations, depending on the amount of heating of biological solutions, are registered.

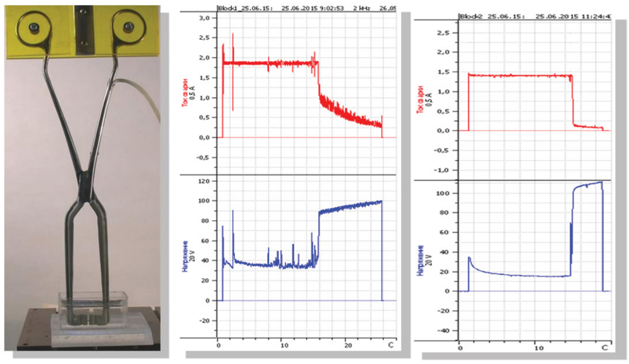


Figure 2: a) Experiments were conducted with the growth of solutions of albumin and egg white, in which the bipolar clamp was immersed. b) The graphs show the correlation between voltage and temperature in the study of serum albumin and, c) egg white.

It was found that the resistance of electrolytes decreases and conductivity increases with increasing temperature. This is due to the fact that with increasing temperature for weak solutions increases their dissociation and thus increases the number of positive and negative ions. The most pronounced conductive capabilities are inherent in biological extracellular fluids, which are based on electrolyte solutions. Firstly, it is blood, which contains 0.85% NaCl solution and, in lower concentration, salts of other monovalent and divalent metals.

During bipolar electric welding of biological tissues, heat is generated in an electrically conductive biological fluid, which is an electrolyte, when an electric current passes through it. Solid substances of biological tissues, which are surrounded by biological fluids or are in it, are not electrically conductive, so they are not heated by electric current and, thus, are always colder than the liquid. The normal temperature of the human body is in the range of 34°C to 37°C, the temperature increases up to 40°C passes without significant changes in the structural integrity of the cells and tissues of the body. But when the temperature of the cells reaches 50°C, cell necrosis occurs in about 6 min, and if the temperature rises to 60°C, cell necrosis occurs instantly.

In the range of 60°C to 95°C, proteins are denatured, which is usually called "coagulation" - the result of a process similar to hard-boiled egg white. This effect on tissue is used in electro surgery to close tubular structures and blood vessels for hemostasis. If the temperature during electric welding rises to 100°C or more, the intracellular fluid boils, followed by massive intracellular expansion, which leads to explosive damage to the cell membrane, evaporation of the fluid with a cloud of steam [9].

The above diagrams clearly shobhawat "complete" dehydration of solutions of albumin and egg white it practically loses its electrical conductivity, heat is no longer released in it and as a result there is a sharp drop in voltage and current due to increased resistance, which prevents deep destructive changes in protein structures in the welding zone. This is due to the fact that when applying high-frequency electric current, temperature conditions are observed in the range of 40°C to 110°C, without the phenomena of necrosis in the working area and, thus, it is expected that thermal damage will be absent in the paravenous structures, which must be proved by morphological studies.

These data were obtained during the experiment with a solution of albumin and egg white in saline and registered in the graphs below (Figure 3 and 4).

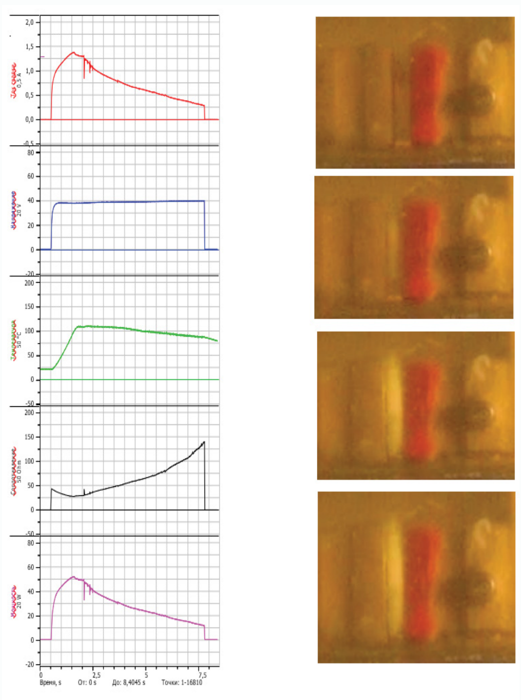


Figure 3: The correlation of current voltage fluctuations is registered, with the growth of which the temperature of the biological environment increases. But with "complete "dehydration of albumin and egg white solutions, it practically loses its electrical conductivity, heat is no longer released in it and as a result, there is a sharp drop in voltage and current due to increased resistance, which prevents deep destructive changes in protein structures in the working zone of electric welding.

The above data clearly demonstrate the advantages of high-frequency electric welding in comparison with laser coagulation, which develops high temperatures around the working area, which is the cause of quite frequent post operative complications in the form of thermal burns, while when using high-frequency electric welding, the temperature conditions fluctuate in the range of 40°C to 110°C, without necrosis.

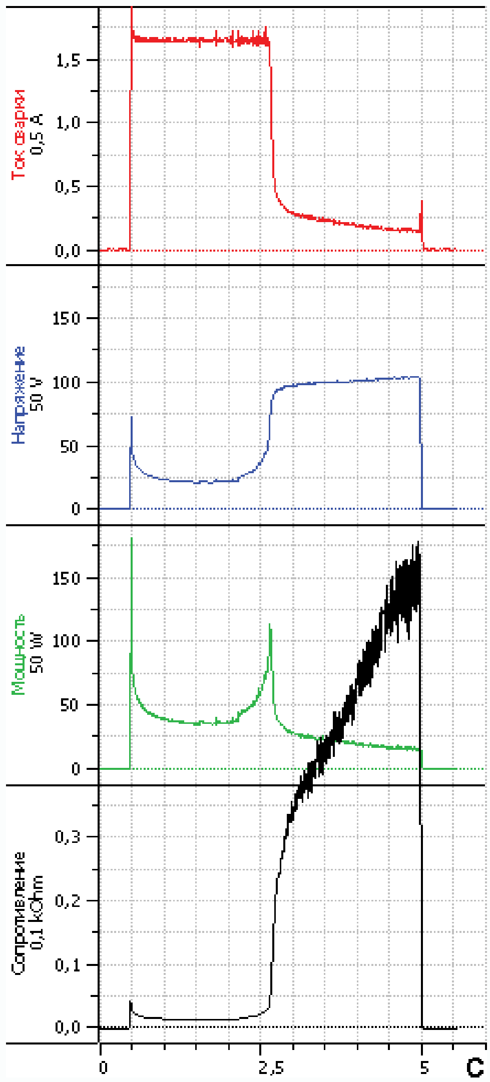


Figure 4: The data obtained using serum albumins are similar. The graph shows changes in current and temperature in case of "complete" dehydration of albumin solutions. It practically loses its electrical conductivity, heat is no longer released in it and as a result, there is a sharp drop in voltage and current due to increased resistance, which prevents deep destructive changes in protein structures in the working zone of electric welding.

Conclusion

1. In our experiment, we have obtained observational data on the safety of high-frequency electric welding, in the application of which a temperature regime from 40°C to 110°C is observed, which is not accompanied by necrosis phenomena, both in the working area and in the surrounding space.
2. High-frequency electric welding has a number of advantages compared to laser coagulation, due to the simplicity of its application methodology and the safety of high-frequency current, does not require tumescent anesthesia and will not have a destructive effect on paravasal tissues.

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