Mathematical modeling of the nature of the distribution of currents in the organs of the human body at hand-to-hand abduction electrotherapy

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Numerical modeling of current distribution in human body organs during electrupunctural therapy

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RESUME

Numerical modeling of current distribution in human body organs during electropunctural therapy on pathway “hand-hand” was realized by means of software SEMCAD X v.14.8. Current density values and character of current density distribution in human body model were obtained and theoretically evaluated. Numerical modeling showed to be a perspective direction for study and optimization of electropunctural therapy.

Keywords: electropunctural therapy, numerical modeling, human body model, current density.

SUMMARY

Mathematical modeling of the nature of the distribution of currents in the organs of the human body during electropuncture therapy for abduction "hand-hand" using the program SEMCAD X v.14.8. Specific values and character of the distribution of currents in the numerical model of a human phantom are obtained and their theoretical assessment is carried out. The prospects of using mathematical modeling to improve the methods of electropuncture therapy are shown.

Key words: electropuncture therapy, mathematical modeling, human phantom,current density.

Introduction

Electro-acupuncture therapy is a therapeutic method that involves exposure to certain biologically active points or areas of the skin with a constant, alternating or pulsed electric current. Electropuncture, in comparison with classical acupuncture, allows you to accurately dose the strength and nature of the effect, which is impossible to achieve with the introduction of a needle. The improvement of the method of electropuncture therapy is due to the theoretical substantiation of this method, associated with the organ-specific orientation of the impact, while at present the empirical approach prevails. One of the founders of electropuncture therapy in our country F.G. Portnov, considering the mechanisms of this method, pointed out the difficulty in interpreting the nature of the passage and distribution of electric current in tissues: “When electrodes are placed between them, an electric field arises ... multi-layer and different electrical conductivity of tissues is the reason that the lines of force of the electric field in the body do not always coincide with the shortest path between the electrodes, but can capture distant areas. The current rushes into the intercellular spaces filled with a conducting fluid, along the blood and lymphatic vessels, the sheaths of the nerve trunks, through the ducts of the sweat and partly the sebaceous glands, i.e. along the path of minimum resistance ”[1, p. 120-121]. The study of the functional relationships in the human body between the skin and internal organs for a long time was carried out empirically, by the method of "trial and error", which made it possible to significantly develop practical methods of treatment.

In this regard, the purpose of this study was to evaluate, using theoretical modeling, the nature of the distribution of currents flowing in the organs of the human body and their values during electropuncture therapy according to the method of R. Voll using the "hand-hand" lead.

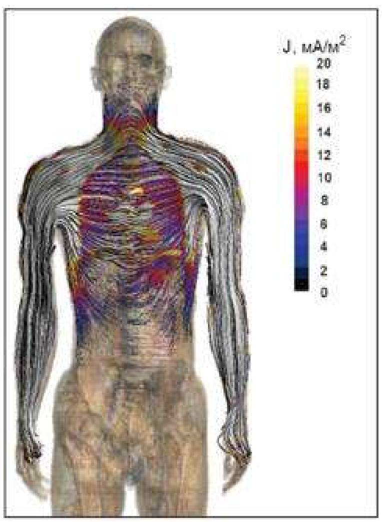
Materials and methods

The studies carried out numerical modeling using the SEMCAD X v.14.8 program, developed by Schmid & Partner Engineering AG, "SPEAG", Zurich, Switzerland [2] together with the Foundation for Research on Information Technology in Society (IT'IS) Swiss Federal Institute of Technology (ETH), Zurich, Switzerland [3]. As a method of electropuncture therapy in modeling, the method of quadrant alignment of the energy balance of biologically active zones with the use of the “hand-hand” abduction according to R. Voll was used [4]. A numerical phantom of an adult was used, in which the hand-arm lead was modeled with a positive electrode with a voltage of 1.2 V located in the right hand and a negative electrode in the left.

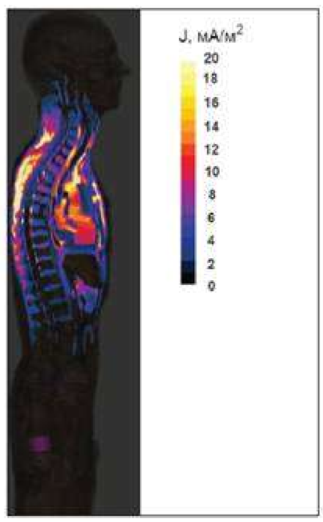
Results and discussion

The use of the SEMCAD program made it possible to theoretically determine the magnitude and nature of the current density distribution J (mA / m^2), which occur in the organs of the human body during electrotherapy for the abduction "hand-hand".

A general view of an adult phantom with the simulation results is shown in Fig. 1. Calculated values of current densities J, mA / m^2 in the organs are presented in table. 1. The highest current density values are observed in the following organs: thyroid gland - up to 29 mA / m^2, esophagus - up to 24 mA / m^2, thymus - up to 21 mA / m^2, stomach - up to 19 mA / m^2, heart - up to 18 mA / m^2, aperture - up to 16 mA / m^2, pancreas and lungs - up to 12 mA / m^2, gallbladder - up to 8 mA / m^2, spleen - up to 5 mA / m^2, liver - up to 4 mA / m^2, kidneys and cervicothoracic spine - up to 3 mA / m^2... The nature and structure of the current density distribution in the sagittal section of the phantom is shown in Fig. 2, and with a frontal section in the esophagus, stomach, heart, diaphragm, lungs and cervicothoracic spine in Fig. 3, 4, 5, 6, 7, 8 and 9, respectively.



Rice. 1



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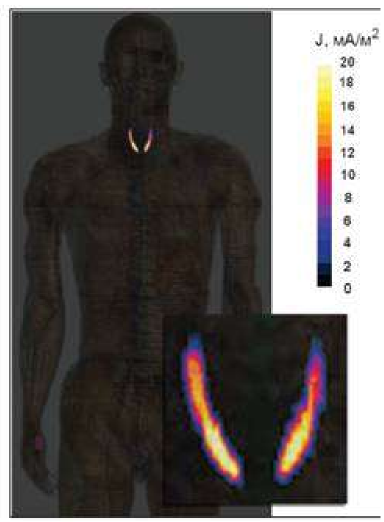
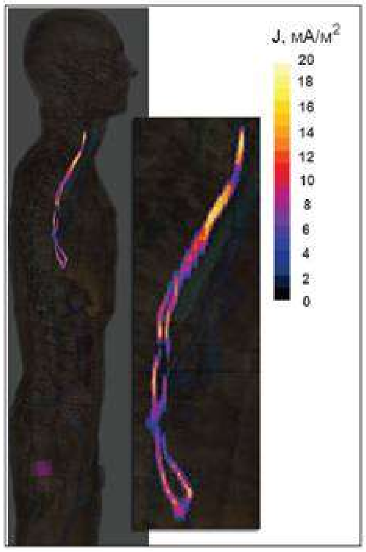


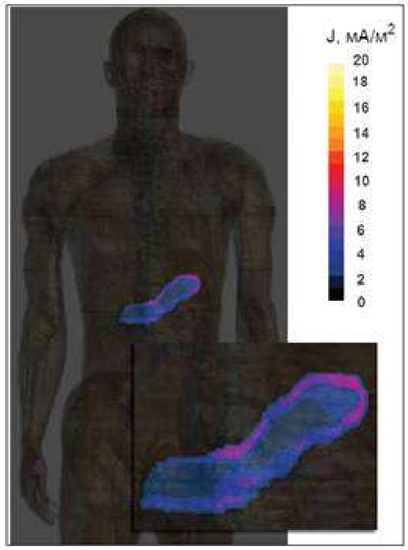
Rice. 3

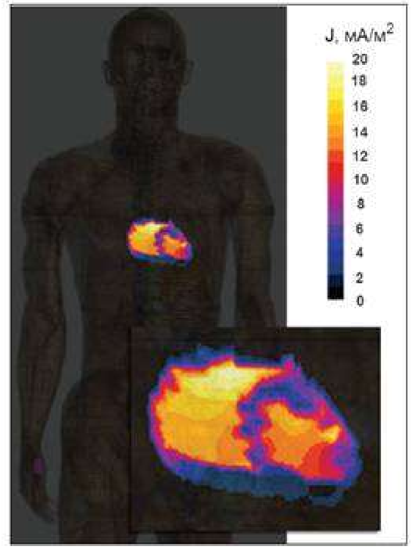
Rice. 1. The nature and structure of the distribution of current densities in the phantom of an adult (type front).

Rice. 2. The nature and structure of the distribution of current densities in the phantom of an adult (sagittal section).

Rice. 3. Distribution of current densitiesJ, mA / m^2 in the thyroid gland (frontal section).



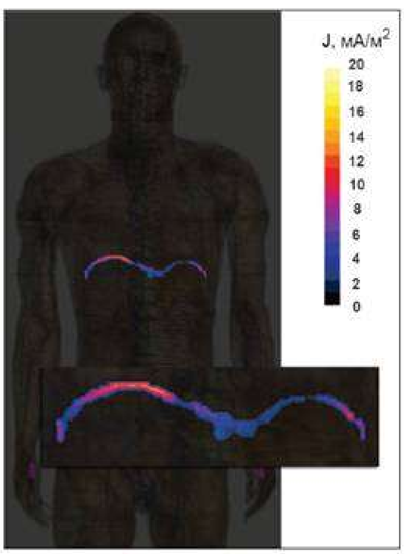


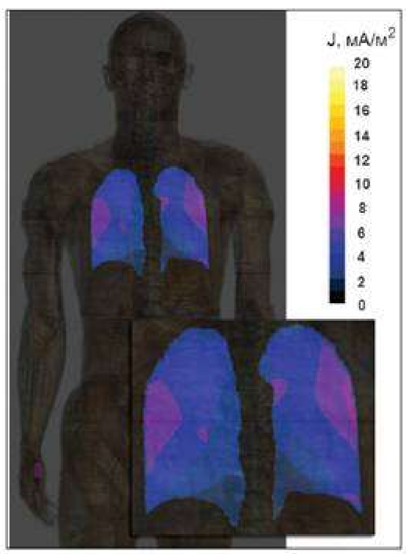


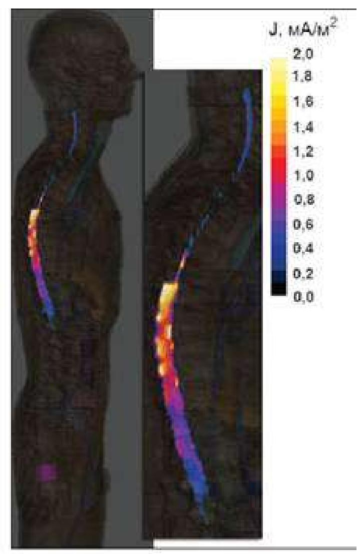
Rice.

4 Rice. 5 Rice. 6

Rice. 4. Distribution of current densitiesJ, mA / m2 in the esophagus (sagittal section).
Rice. 5. Distribution of current densitiesJ, mA / m2 in the stomach (frontal section).Rice.
6. Distribution of current densitiesJ, mA / m2 in the heart (frontal section).







Rice. 7 Rice. eight Rice. nine

Rice. 7. Distribution of current densitiesJ, mA / m2 in the diaphragm (frontal section).
Rice. 8. Distribution of current densitiesJ, mA / m2 in the lungs (frontal section).
Rice. 9. Distribution of current densitiesJ, mA / m2 in the cervicothoracic spine (sagittal section).

The structure of the passage and distribution of the DC current density in the organs and tissues of the human body is determined by the value of their electrical resistance, which is a function of the current strength, the time of its passage and its direction and depends on the material and design of the measuring electrodes [5]. In addition, with a short-term application of a potential difference, an oppositely directed electromotive force arises due to polarization processes in tissues at the interfaces [6]. In accordance with Ohm's law, resistance to direct current is determined by measuring the magnitude of current and voltage, however, as it was assumed, for living tissues all this is in some contradiction in comparison with physical systems [7]. Despite these problems, an empirical relationship was found between resistance to direct electric current and the functional state of organs and tissues. As a result of numerous studies, it was found that the cells surrounded by a membrane have a very high resistance to direct current, and all the current passes through the intercellular space filled with electrolytes. However, the cell membrane is not an ideal dielectric, but is characterized by resistance, determined by its ionic permeability, which, when the normal functioning of the cell is disrupted, decreases and tends to zero with irreversible changes [8]. Distribution structure and magnitude of direct current in tissues,

Table 1

Average values of current densities (J, mA / m2) in organs interconnected with the hand-hand lead

№	Орган	J, мА/м²
1.	Щитовидная железа	7,5
2.	Пищевод	5,5
3.	Тимус	6,6
4.	Желудок	4,4
5.	Сердце	5,2
6.	Диафрагма	4,0
7.	Поджелудочная железа	4,3
8.	Легкие	3,7
9.	Желчный пузырь	2,5
10.	Селезенка	1,4
11.	Печень	1,1
12.	Почки	0,8
13.	Шейно-грудной отдел позвоночника	0,003

The values of the currents in various organs are directly proportional to the values of the electrical conductivity of tissues that make up a particular organ, which depends on the content of water and electrolytes dissolved in it in physiological concentrations [5]. So, for example, the tissues of the thyroid gland and heart are characterized by a higher concentration of water in them than in the lungs or osteochondral tissues of the spine. In addition, the analysis of the data obtained allows us to assume the dependence of the current density value on the degree of blood supply to the tissues forming a particular organ, as well as the degree of their functional relationship in relation to the modeled hand-hand lead.

conclusions

As a result of the simulation, the values and pattern of the distribution of currents in organs on a human phantom were obtained during electrostructural therapy according to the method of R. Voll on the "hand-hand" abduction. It is shown that the use of theoretical modeling with the help of the SEMCAD X v.14.8 program is promising for studying the mechanisms and improving methods of electropuncture therapy.

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