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INFRARED DIAGNOSTICS OF NON-EQUILIBRIUM PROCESSES IN HUMAN TISSUE

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Abstract - In this work the examples of infrared thermography use for analysis of some physical factors thermal impact on biotissues in therapeutical purposes is presented. The experiments were carried out by computer thermographic system on the basis of infrared imaging camera IRSnapShot (USA). Qualitative and quantitative estimation of thermograms is a gauge of character and degree of physiothermal procedures thermal effect.

Introduction

By the law of biogenic energy maximum [1] "each biological system is in the state of "stable non-equilibrium", that is to say of flexible equilibrium with environment". In this state the system is appears to be at rest. System's parameters are not change due to own regulation mechanisms. The thermodynamic parameters differences of different parts of the system under investigation are general for non-equilibrium state. Temperature – is one of the parameters for state description of the system macroscopic parts which are at the local thermodynamic equilibrium. Quasi-equilibrium electromagnetic emission is radiated in going from one equilibrium state to another. Energy emitted by biological object under 30 ^{o}C is maximal in infrared (IR) spectral band. This fact is used for composition of diagnostics systems which are based on objects IR radiation perception and reconstruction of temperature distribution on their surface. IR thermography is widely used both in biomedical researches and for industrial objects monitoring [2, 3].

Dosimetry of most therapeutic procedures is realized due to subjective sensations of patients. So physiotherapy is not as efficiency as it desirable. This is the reason why all investigations directed to understanding of physical factors action mechanisms and improving methodology of therapeutic measures are important.

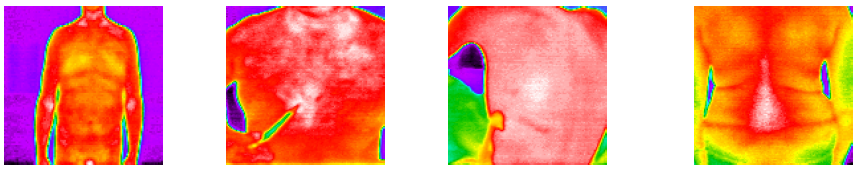
Experimental description

The method

Thermogram – 2-D temperature distribution on human skin – is a result of thermografic experiment. Advantages of IR thermography are non-disturbance of the object, responsiveness, high resolution, possibility of simultaneous investigation of different human organs and systems and knowledge of each point temperature withal.

When human organism is at quasi-equilibrium state the thermoregulation mechanisms are balanced and show the average thermotopography of skin surface. Using of IR thermography for medical purposes is based on near-symmetric temperature distribution on human skin (Figure 1a). Deviations from symmetric distribution or unnatural hyperthermic areas signal about processes in human organism which are often have disadvantage character (Figure 1b, c, d). Beside diagnostic purposes IR thermography can be used for thermal state investigation of biological objects (including man) under external influences of different nature (electromagnetic, mechanical, chemical etc.)

In this work the examples of IR thermography use for analysis of some physical factors thermal impact on biotissues in therapeutical purposes is presented. The experiments were carried out at the clinic of NASB by computer thermographic system on the basis of IR imaging camera IRSnapShot (USA). The system includes thermal vision camera and software for thermograms getting, keeping and processing. Thermograms are recorded on flash-card by camera mentioned above.



a) b) c) d)

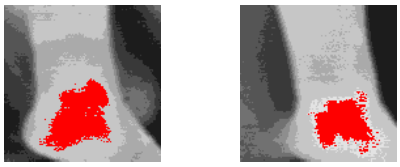
Figure 1. Thermograms of health man (a) and patients with different diseases.

It is necessary to maintain optimal microclimate in the investigation room during research into human temperature field reconstruction especially with thermal vision techniques due to its high sensibility. The reason is action of both internal and external factors (such as temperature, humidity, air velocity, illuminance) on human skin temperature distribution. Air temperature of 22 ±1 ^{o}C at humidity of 40 – 70 % is most acceptable. Air velocity should not exceed the value of 0,15 m/s. Electromagnetic emission sources including infrared should be screened. Before each procedure the air temperature was measured. The patients were at sitting, back-lying or pronation during procedure and did not move almost. The temperature topography before procedure was visualized after 10-15 min environmental adaptation of the patient. Temperature readout was carried out direct before and after influence to exclude heat losses from nude parts of the body at the time between measuring and séance itself.

The results and discussion

The electrotherapy is a very important method among other physiotherapeutic methods. Sinusoidal modulated currents (SMC) are impulse currents (5 kHz), which are modulated by sinusoidal low-frequency (from 10 to 150 Hz) oscillations. They penetrate into deep tissues easily, are active to nerve-muscle and vessel systems, metabolism. It is well known that such currents are of analgesic and antiphlogistic influence. Exposure to SMC is carried out by apparatus "Amplipulse – 5" during 15 minutes.

Influence of sinusoidal modulated currents on the area of ankle causes skin temperature rise on 2,5 ^{o}C in random point. In the process the area of maximal temperatures is diminished in general (Figure 2). On the slides obtained in isothermal camera software working regime the red (charcoal grey in the case of black and white image) color corresponds to the area of temperatures above 28,5 ^{o}C before and 32 ^{o}C after procedure. Thermometric investigation of skin temperature reaction on SMC carried out earlier showed that temperature is increasing on 0,43 ^{o}C at the knee-joint [4]. High temperature elevation in comparison with thermometric investigation during SMC therapy is probably the result of influence area choice. Blood vessels are located with high density and close to skin surface in the area of ankle.



a) b)

Figure 2. Thermograms of the ankle before (a) and after (b) SMC therapy.

To generate thermal effect in deep tissues and organs radio-frequency irradiation is used including very-high frequency irradiation. VHF electric field is a factor of non-selective penetration. It influences on all tissues in the between-electrodes space. Experimental VHF exposure was carried out by the apparatus "Ekran 2 VHF 350-2" which works at the frequency of 40,68 MHz.

Thermograms of foot before and direct after VHF exposure are presented on Figure 3. The power is 40 W, procedure duration is 15 minutes. The temperature of maximum after procedure-heat point is denoted for each shot. VHF stimulates blood circulation including the pathology area. It is mirrored on thermograms as reducing of high temperature area after therapy. Isothermal regime of camera software

allows visualizing the regions of preset temperature. This is good for more clear estimation of pathology localization.

a) 34,7 ^{o}C b) 35,8 ^{o}C

Figure 3. Thermograms of foot before and after VHF-therapy (a – before, b – after influence)

Concluding

Thus infrared thermography is informative and safe method for obtaining the information about thermal state of surface tissues under external physical factors influence.

Temperature field investigation of human skin under impulse currents and VHF electric field influence was carried out in a way of infrared thermography. Qualitative and quantitative estimation of thermograms is a gauge of character and degree of physiothermal procedures thermal effect. Eventually alike investigations allow to infer about therapy effectiveness and to optimize the operation modes.

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