

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ  
КРЕМЕНЧУЦЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ  
ІМЕНІ МИХАЙЛА ОСТРОГРАДСЬКОГО



**ХІХ МІЖНАРОДНА НАУКОВО-ТЕХНІЧНА  
КОНФЕРЕНЦІЯ  
ФІЗИЧНІ ПРОЦЕСИ ТА ПОЛЯ ТЕХНІЧНИХ  
І БІОЛОГІЧНИХ ОБ'ЄКТІВ**

Посвідчення УкрІНТЕІ № 657 від 11.11.2019

*Матеріали конференції*



**Кременчук – 2020**

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## **МАТЕРІАЛИ КОНФЕРЕНЦІЇ**

*XIX Міжнародна науково-технічна конференція  
«Фізичні процеси та поля технічних і біологічних об'єктів»*

## **МАТЕРИАЛЫ КОНФЕРЕНЦИИ**

*XIX Международная научно-техническая конференция  
«Физические процессы и поля технических и биологических объектов»*

## **CONFERENCE PROCEEDINGS**

*XIX International scientific and technical conference  
«Physical processes and fields of technical and biological objects»*

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RESEARCH OF THE SENSITIVITY OF THE COMPUTER CAPILLAROSCOPY METHOD UNDER LOCAL CHANGES IN TEMPERATURE

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The possibilities of the method of computerized capillaroscopy for studying the structure of the capillaries of the skin of the hands after exposure to temperature are considered. With local frostbite, there is a lack of sensitivity and insufficient expression of blood vessels, their blanching caused by constriction. The capillaroscopic picture is relatively normal, however, some characteristic changes can be observed: the blood flow slows down, external thinning of the vessel walls is observed, the capillaries are somewhat deformed, some of them empty.

**Key words:** capillaroscopy, temperature, vessels, blood, thermoscopy.

ДОСЛІДЖЕННЯ ЧУТЛИВОСТІ МЕТОДУ КОМП'ЮТЕРНОЇ КАПІЛЯРОСКОПІЇ ПРИ МІСЦЕВИХ ЗМІНАХ ТЕМПЕРАТУРИ

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Розглянуто можливості методу комп'ютеризованої капіляроскопії для вивчення структури капілярів шкіри рук після впливу температури. При місцевих обмороженнях спостерігається недостатня чутливість і недостатня експресія судин, їх бланшування, спричинене звуженням. Капіляроскопічна картина відносно нормальна, однак можуть спостерігатися деякі характерні зміни: кровотік сповільнюється, спостерігається зовнішнє стоншення стінок судин, капіляри деформуються, деякі з них порожні.

RELEVANCE. Computerized capillaroscopy makes it possible to reveal on the evidence level the peculiarities of the functioning of the peripheral circulation system according to the state of the capillary and to evaluate the effectiveness of treatment according to the aggregation state of blood, the state of blood rheology in hematological practice. This method is especially relevant in the diagnosis of any disease, since it expresses any changes and disorders in the body, including local frostbite [1].

PURPOSE. The purpose of this study is to assess the microcirculation indicators with a local decrease in temperature.

MATERIALS AND METHODS. Experimental studies were carried out using the apparatus Biobasegroup WXH-8 1004C, YOUMEDTECHco., Etl., Which has a 500x optical magnification, as well as a portable thermal imager Flir TG165. During the experiment, 27 volunteers of young age from 18 to 25 years old were under observation. The study was carried out on the ring finger of the left hand.

DISCUSSION AND RESULTS. Let us consider a general model of the capillaroscopy method, which is based on micro-video filming of an object in reflected light with a magnification of several hundred times.

This device contains an adaptive optical observation system placed in the housing with an illumination device and an image receiver connected to an electronic signal processing unit, and a lodgment attached to the housing for accommodating the subject's finger.

The capillaroscope includes a recording device and a focusing and positioning system located in the housing. The recording device consists of an image receiver with an optical system and an illumination system for the study area. In the body of the capillaroscope there is a cradle with a finger retainer. The image receiver is a CMOS sensor connected to a computer. The focusing and positioning system (not shown in the drawing) provides for the movement of the optical system along three coordinate axes in the vertical and horizontal directions. The CMOS matrix used in the capillaroscope provides a frame rate of at least 100 frames / sec and the possibility of increasing the frame rate (rate) with a decrease in the investigated area. The computer is equipped with a control software device for polling the pixels of the CMOS matrix with correction of the choice of the area of study and its retention in the field of view during the entire monitoring process. To implement the algorithm for processing blood flow parameters, an increase of 150 and 350 times by means of an optical system is used. To obtain a high-quality image with a high resolution, an interchangeable lens is used, which allows to obtain an enlarged image on the monitor screen by 1000 times [1].

The illumination system of the investigated area consists of a set of ray sources (at least 8), which are installed around the cradle 4, while their rays are directed to the illuminated area at an angle - the central axes of the rays form an illumination angle with the base of the cradle in the interval (10 ÷ 12 °). The lodgment provides for heating the patient's hand and fingers and a temperature sensor fixed on the finger for temperature control. The method for studying the

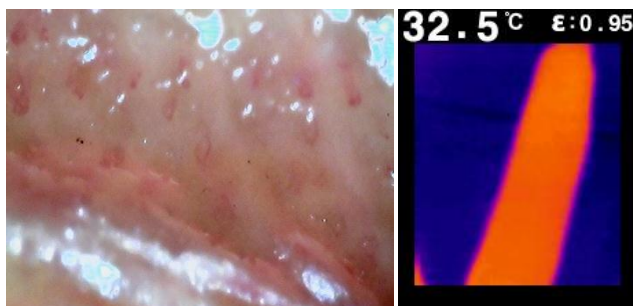


Figure 1 - Picture at normal temperature:  
a) capillaroscopic; b) by thermal imaging

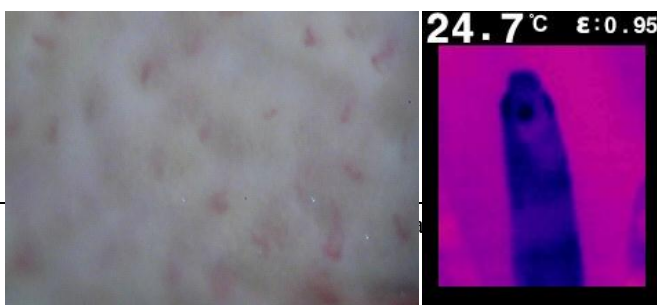


Figure 2 - Picture at low temperature:

characteristics of capillaries and capillary blood flow is carried out as follows [2]. After fixing the finger of the examined patient with a retainer in the lodgement so that the perivascular zone of the nail bed is in the field of view and focusing of the optical system, the beam sources of the illumination system are adjusted with the illumination angle  $\alpha$  formed by the central axis of the beam with the horizontal surface of the lodgment base, in the interval (10 h 12 °). Then the image of the perivascular zone of the nail bed is visualized. As a result of viewing the sets of frames obtained at different angles of illumination of the perivascular zone by each of the beam sources, the study area is selected (by contrast imaging and the number of capillaries). In fig. 1 and 2 provide a demonstration of conducting our own experiment.

The Flir TG165 thermal imager is capable of creating a visual image of the surface temperature distribution with a resolution of 320 by 240 elements.

As you know, any pathology in the body begins with slowing down or stopping the peripheral circulation and slowing down the natural movement of the intercellular fluid. Since the human body consists of more than 80% water, it is natural that the pathology begins with insufficient microcirculation.

At normal temperature, the following picture is observed (Fig. 1).

With local cooling, prolonged exposure to extremely cold temperatures causes a spasm of capillaries, stagnation of blood in them and, as a result, leads to numbness of the skin and subcutaneous tissues, and then to their death. This is due to the fact that the skin has special thermoregulatory vessels that play an important role in the implementation of a normal physiological response to temperature changes in the environment to maintain a stable body temperature [4]. These phenomena can be observed in Fig. 2a: spasm, capillary deformation, thinning of the walls.

It is known that cooling increases the production of oxygen radicals that activate Rho kinase, which causes  $\alpha 2c$ -adrenergic receptors to translocate onto the cell membrane, which are responsible for vasoconstrictor reactions. RhoK has been implicated in the pathogenesis of vascular disorders in many diseases. Vascular disorders in such diseases are associated with both changes in the functioning of smooth muscle cells and endothelial dysfunction.

At the same time, there is a lack of sensitivity and insufficient expression of the vessels, their blanching caused by narrowing. The capillaroscopic picture is relatively normal, however, some characteristic changes can be observed: the blood flow slows down, external thinning of the vessel walls is observed, the capillaries are somewhat deformed, some of them empty.

**CONCLUSIONS.** The paper considers the possibilities of the method of computerized capillaroscopy for studying the structure of the capillaries of the skin of the hands after exposure to temperature. With local frostbite, there is a lack of sensitivity and insufficient expression of blood vessels, their blanching caused by constriction. The capillaroscopic picture is relatively normal, however, some characteristic changes can be observed: the blood flow slows down, external thinning of the vessel walls is observed, the capillaries are somewhat deformed, some of them empty.

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