http://dx.doi.org/10.35630/2199-885X/2020/10/4.13

STUDY OF HEMOMICROCIRCULATION IN UPPER-EXTREMITY SKIN IN HEALTHY MEN IN NORMAL CONDITIONS WITH ACCOUNT OF HANDEDNESS

Received 29 October 2020;
Received in revised form 24 November 2020;
Accepted 26 November 2020

***Vadim Astashov*[1]✉, *Valentin Kozlov*[1], *Victor Sidorov*[2], *Mihail Uloga*[1], *Inna Borodina*[1], *Ilya Pushkar*[1], *Pavel Novokreshchenov*[1]**

[1] *RUDN University (Peoples' Friendship University of Russia), Moscow;*
[2] *LLC NPP Lazma, Moscow, Russia*

✉ *vastashov3@gmail.com*

ABSTRACT — In this study we used laser doppler flowmetry to investigate the parameters of peripheral blood flow in the upper extremities in young males both right- and left-handers. Based on the data obtained we found that in right-handers (dextrals) active mechanisms of regulation of blood microcirculation prevail on the leading hand, In left-handers (sinestrals) active and passive mechanisms of its regulation are involved in the regulation of blood flow on the leading hand (left) and on the opposite (right). However, the contribution of active mechanisms is lower than that of right-handers.

KEYWORDS — hemomicrocirculation, laser doppler flowmetry, asymmetry.

INTRODUCTION

Prevention of circulatory disorders requires creation of a database containing normal values of hemomicrocirculation indicators. The relevance of the concept of *asymmetry* was realized at the end of the XX century due to its significance in science in general and in biology in particular. It is known that when viewed in detail, the axial symmetry of the human body is largely conditional — the left half of the face is not similar to the right, the right hand to the left, the left leg to the right. The leading hand is considered an individual sign of psychomotor development, arising from the unequal development of motor skills in the left and right hands [2].

A person who is more right-handed is called a right-handed person (dextral), and someone who uses the left hand more often is called a left — handed person (sinestral). A minority of people are equally skilled with both hands — they are called Ambidextrous. According to the literature, approximately 8–15% of the adult population were left-handed [7]. Studies indicate that men are more likely to be left-handed than women [8]. Left-handers are most common among identical (monozygotic) twins [3], and some groups of people with neurological disorders such as epilepsy [7], autism [1], mental retardation [4] and dyslexia [6]. Laser doppler flowmetry (LDF) is a modern non-invasive method for evaluating the microcirculatory system. For diagnostics, the tissue is probed by laser radiation; processing reflected from the tissue radiation based on allocation of registered signal Doppler frequency shift of the reflected signal proportional to the speed of motion of particles in the microvasculature; the ongoing research is the registration of changes of blood flow or lymph flow in the microvasculature — flowmetry [5].

In this regard, the study of the parameters of local tissue blood flow in the norm, with account of the predominant hand, is relevant in terms of diagnosing circulatory disorders and choosing an adequate treatment method.

The aim of the study was to simultaneously study hemomicrocirculatory parameters in the upper-extremity skin of healthy men in normal conditions.

MATERIALS AND METHODS OF RESEARCH

Twenty-three young men (medical students) aged 19 to 23 years were examined in the laboratory of the Department of Human Anatomy (RUDN University, Moscow, Russia). Informed consent for participation in the study was obtained from all subjects. Hemocirculation was studied using laser Doppler flowmetry (LDF) in the skin of the third finger of the left and right hand. When analyzing the results of the study, the sign of the predominant hand (sinestrals and dextrals) was taken into account, the subjects were in the supine position. The study of blood flow was performed using a new approach of a distributed system with two laser analyzers "LAZMA PF". The laser analysers were designed by LLC NPF "LAZMA", Russia» for individual assessment of micro-blood flow (with a fixed fiber-optic probe). Analyzing dopplerograms we

determined the average value of the microcirculation index (perfusion index) — (M) in perfusion units (PF. units), the average square deviation of the amplitude of blood flow fluctuations from the arithmetic mean value — (σ), the coefficient of variation — (KV). The last two parameters reflect blood flow modulation. The tissue perfusion index determined by the LDF method is proportional to the product of the number of red blood cells and the average speed of their movement (range 0.5–5 mm/s). The total time of the recording of hemomicrocirculation was 5–6 minutes. The rhythmic structure of oscillation was studied using LDF-gram spectral analysis: active (endothelial — VLF, neurogenic — NF and myogenic — MF) and passive modulations (cardiac — CF, respiratory — RF). The hemocirculatory parameters (PM) recorded in LDF, the amplitude of active and passive blood flow modulations, were processed using variational statistics methods, the significance of differences was determined using the student's criterion, and the results were considered reliable at $p < 0.05$

THE RESULTS OF THE STUDY

The index of microcirculation (PM) on the upper limbs in the studied groups of left- and right-handers ranged from 18 to 21 in perf. units and the average was 19.5 ± 0.32 mm perf. units.

The results of the study of the upper limb in sinestrals showed that the microcirculation index is higher in the left limb than the right limb (Table 1). The microcirculation index in the right upper limb in dextrals is higher than the values in the left limbs.

The index of blood flow modulation (σ) on the upper right limb in sinestrals is slightly higher than on the left limb, which may indicate some differences in the mechanisms of blood flow modulation. In dextrals it did not change statistically significantly, which indicates that the mechanisms of blood flow modulation are preserved (Table 1).

The coefficient of variation (Kv) defines the relationship between perfusion and the magnitude of its variability, so the source it was significantly different from sinestrals and dextrals depending on the dominant hand (Table 1). Differences in this indicator may indicate differences in the conditions of the microcirculation in the left and right hand, a characteristic that dominant hand, values lower than the opposite (Table 1).

MC indicators (PM, mean square deviation of the amplitude of blood flow fluctuations from the arithmetic mean, coefficient of variation) reflect only the general state of the blood MC. A detailed analysis of the functioning of the microcirculatory bed is possible when studying the amplitude-frequency rhythms (modulation) of blood flow with an assessment of certain mechanisms of perfusion control.

The results of the study showed that the skin of the dominant hand (left) in sinestrals among the active modulation is dominated by neurogenic (NF) and the passive modulation of the heart (CF). On the right hand sinestrals have more pronounced respiratory (RF) modulation among the passive ones, and myogenic (MF) oscillation among active ones (Fig. 1).

In dextrals, endothelial modulation (VLF) predominate in the skin areas of the left and right upper extremities, and the indicators are higher on the leading arm (right). On the leading arm of dextrals, the indicators of neurogenic modulation are higher than on the left, and the values of passive blood flow modulations (respiratory and cardiac), on the contrary, are lower compared to the left limb (Fig. 1).

Table 1. *Average indicators of microcirculation in male subjects*

Indicators	Senestrals		Dextrals	
	Left hand	Right hand	Left hand	Right hand
PM, perf. ed.	21,73+1,092	18,25+0,910*	18,69+0,340*	19,34+0,318
σ, perf. ed.	2,74+0,464	3,59+0,278*	2,57+0,516	2,76+0,519
Kv, %	16,20+1,100	32,95+3,261*	29,12+0,791*	25,53+0,956

** P < 0,05 — the differences are significantly different when compared with the data of the leading hand.*

DISCUSSION AND CONCLUSION

Currently, the LDF method is widely used in various fields of medicine. Obtaining specific data on the state of microcirculation, taking into account individual anatomical and functional features of the body, allows us to take them into account in the diagnosis and treatment of cardiovascular pathology. During the analysis of the results we obtained, it was revealed that the upper limb in men revealed an asymmetry of blood

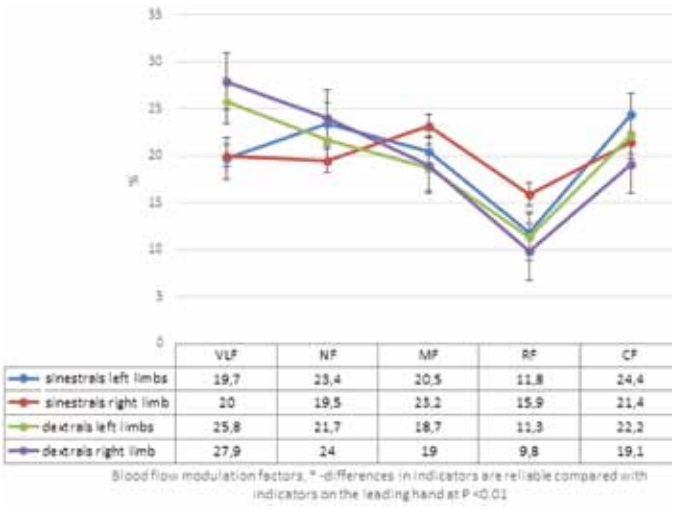

Fig. 1. *Normalized values of the amplitude of active (VLF, NF, MF) and passive (RF, CF) modulations of microcirculation,%,*

circulation associated with the sign of the leading hand — the values of the microcirculation index are higher on the leading hand. Apparently, this is due to a greater functional load on the leading hand in the process of daily life, which leads to an increase in peripheral tissue perfusion.

Based on the analysis of the upper extremity blood flow modulation index, it can be concluded that sinestrals have different modulation mechanisms compared to dextrals. This was confirmed in the study of the spectrum of modulation microcirculation. It was found that under normal conditions, the indicator of tissue hemomicrocirculation in the skin areas of the leading hand (right) extra low primarily affects endothelial and neurogenic modulation, that is, the active modulation of blood flow. On the left hand of dextrals, these indicators are lowered, but at the same time, the values of respiratory and cardiac (passive) modulation are higher. Sinestrals on the leading hand (the left) is dominated by neurogenic (active) and heart (passive) modulation. The right hand of senestrals dominated by myogenic (active), breathing and respiratory modulation (passive).

Thus, the obtained data lead us to conclude that right-handers (dextrals) have active mechanisms of blood circulation regulation on the leading hand, which are less pronounced on the opposite (non-leading) hand. In left-handers (senestrals) on the leading hand (left) and on the opposite (right), active and passive mechanisms of its regulation participate in the regulation of blood flow, but the contribution of active mechanisms is lower than in right-handers.

Thus, the use of laser doppler flowmetry to detect changes in the magnitude and/or ratio of active and passive modulation indicators can serve as a method for diagnosing violations of the mechanisms of microcirculation regulation in various pathological conditions. The data obtained by us can be used both for the diagnosis of blood flow disorders in inflammatory, circulatory, and tumor processes in the upper and lower extremities, and for evaluating the effectiveness of the treatment.

FUNDING

This publication was prepared with the support of the Program of the Peoples' Friendship University of Russia "University 5-100" in the framework of the initiative theme No. 030210-0-000, 2019-2020.

REFERENCES:

1. **Batheja M., & McManus I. C.** Handedness in the mentally handicapped/ Developmental Medicine and Child Neurology - 1985.- v.-27, p.63-68, doi. org/10.1111/j.1469-8749.1985.tb04526.x.
2. **Belyakov V.V., Protsenko V.N.** Symmetries of the body structure of a modern person. Clinical and diagnostic aspects // Manual therapy - 2010 – No 2 - v.38 - p.66-76
3. **Cantor J. M.; Klassen P. E.; Dickey R.; Christensen B. K.; Kuban M. E.; Blak T.; Williams N. S.; & Blanchard R.** Handedness in pedophilia and hebephilia // Archives of Sexual Behavior - 2005.- v. 34- p. 447—459. doi: 10.1007/s10508-005-4344-7.
4. **Cornish K. M., & McManus I. C.** Hand preference and hand skill in children with autism //Journal of Autism and Developmental Disorders - 1996. – v. 26 – p.597—609, doi: 10.1007/BF02172349.
5. **Dremin V.V., Kozlov I.O., Zherebtsov E.A., Makovik I.N., Dunaev A.V., Sidorov V.V., Krupatkin A.I.** The capabilities of laser Doppler flowmetry in assessment of lymph and blood microcirculation. Regional blood circulation and microcirculation. 2017;16(4):42-49. (In Russ.) https://doi.org/10.24884/1682-6655-2017-16-4-42-49
6. **Grouios G.; Sakadami N.; Poderi A.; & Alevriadou A.** Excess of non-right handedness among individuals with intellectual disability: Experimental evidence and possible explanations, //Journal of Intellectual Disability Research - 1999.- v. 43 – p.306—313. doi: 10.1046/j.1365-2788.1999.00217.x.v
7. **Hardyck C., & Petrinovich L. F.** Left-handedness //Psychological Bulletin - 1977.-v. 84, p. 385—404, doi: 10.1037/0033-2909.84.3.385
8. **Raymond M.; Pontier D.; Dufour A. and Pape M.** Frequency-dependent maintenance of left-handedness in humans // Proceedings of the Royal Society of London - 1996 - B 263 - p.1627—1633, doi: 10.1098 / rspb.1996.0238.