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INFORMATIVENESS AND SOURCES OF ERRORS OF *IN VIVO* LASER SPECTROPHOTOMETRY METHODS IN DIAGNOSTICS OF BLOOD MICROCIRCULATION DISORDERS

D. A. Rogatkin, D. S. Макarov, L. I. Dmitruk
Moscow Regional Research and Clinical Institute "MONIKI" named after M. F. Vladimirskiy

Complex laser methods of *in vivo* medical spectrophotometry are now widely studied and used in different medical applications [1]. A number of them - Laser Doppler Flowmetry (LDF), Tissues Reflectance Oximetry (TRO), etc. - seem to be very effective in estimation of blood microcirculation disorders on early stages of that [2]. So, today there are a number of main questions: How informative are they to distinguish illness in each concrete patient? What should the doctor do for this purpose? What accuracy of such noninvasive diagnostics is? And so on.

At "MONIKI" on the example of the model of occupational diseases as well as with the use of assistance of healthy volunteers we have studied both the information content (informativeness) and sources of errors of two main noninvasive medical spectrophotometric techniques - LDF and TRO. The research was aimed, first of all, at an estimation of reliability of distinctions in results of noninvasive medical spectrophotometry (NMS) between healthy group and groups of industrial workers with different occupational diseases leading to vascular disorders on initial stages of them. Additionally, the various factors of diagnostic errors and uncertainties, including a factor of individual physiological variations of measured diagnostic parameters have been studied as well. All diagnostic measurements were taken from the surface of 3-4 distal finger bulbs. Parameter of blood perfusion – the index of microcirculation $\boldsymbol{I_m}$ (pf. un.) - was measured by LDF technique. By means of TRO technique two parameters – the fraction of blood in tissue (total hemoglobin content) $\boldsymbol{V_b}$ and the fraction (saturation) of oxy-hemoglobin in the mixed peripheral blood $\boldsymbol{S_tO_2}$ (in percents) - was registered also. Both LDF and TRO techniques were applied with the use of multifunctional laser noninvasive diagnostic system "LAKK-M" (SPE "LAZMA" Ltd. Co.) [3].

At the first stage of the study the basic levels of I_m, V_b and S_tO_2 and its changes during a number of functional tests (respiratory test, test with arterial occlusion, etc.) was registered for all groups of examinees. An example of the most visual differences in I_m, and S_tO_2 during a conventional test with 3-minutes occlusion for a healthy volunteer and a worker with the vibration occupation disease is presented in Fig.1. The difference in a blood-groove reserve under the relation of levels of I_m before and after occlusion is well visible. Vascular disorders such as angiodystonic or angiospastic syndrome, predominantly on fingers, along with the lesions of distal ends of peripheral nerves of upper extremities, play a leader's part among clinical features of vibration disease caused by the local vibration [4]. So, this result was quite expected. But such pictures were observed not always. More frequently there were observed much less expressed distinctions, especially for basic levels of I_m, V_b and S_tO_2 for initial stages of disorders, what was a problem for a comparative estimation of the data between all groups.

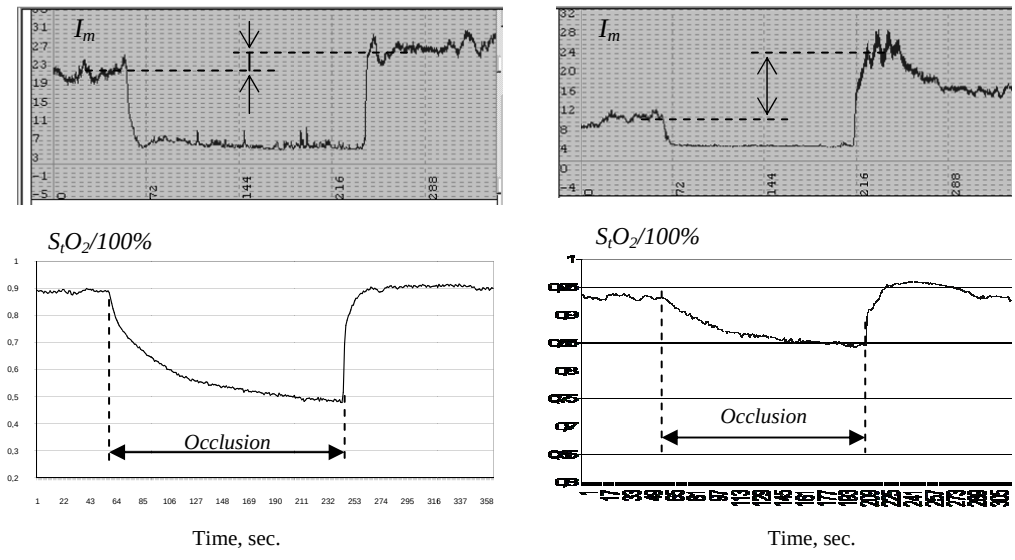

Fig. 1. An example of the most visual differences in I_m, and S_tO_2 during a conventional test with 3-minutes occlusion for a healthy volunteer (left) and a worker with the vibration occupation disease (right).

So, at the next stage of our study we have pointed our attention on more correct estimation of both the groups' dispersion and individual dispersion of main microcirculatory parameters measured by LDF and TRO methods, on reproducibility and repeatability of the measurements. For that some additional examinations for a number of healthy volunteers have been carried out. In one of the series of our experiments under the multiple repeated measurements we have evaluated more exactly the empirical mathematical expectation "*M*" (average value) of all registered physical and medical diagnostic parameters, their

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empirical statistic deviation "σ" (standard deviation) and the average relative random error "δ" (dispersion) of them in percentages as follows:

$$\delta = 100 \cdot \sigma / M \quad (1)$$

It has been shown, that all main diagnostic parameters in up-to-date NMS had the standard uncertainties (standard deviation) not less than ±25…30% from the registered average values. It is caused by normal (or pathological) physiological variations of the individual microhemodynamic parameters as well as by the errors of the applied diagnostic techniques. Normal physiological deviations of the main LDF and TRO diagnostic parameters were detailed evaluated for two healthy volunteers (men). For one of the examinees it was evaluated daily, within 10 days on end; for another one – during the last 6 years by means of retrospective analysis of existing data for him. These results are presented in Table 1 and Table 2 accordingly. As it is well-visible from the tables, on a level of one σ such parameters as I_m and V_b have the dispersion of an order of 30-40%. So, in a general (classic) case the difference of an order of 70-80% (2σ - level) in I_m or V_b can be accepted today as the authentically expressed distinctions. In turn, calculated on the basis of functional tests such parameter as a blood-flow reserve has much less dispersion. So, the blood-flow reserve can be accepted as more reliable diagnostic criteria from the metrological point of view.

Table 1. Statistics results in a normal case during 10 days (daily measurements).

Localization	Statistic parameters	Measured basic parameters			Calculated parameter
		M, pf. un.	S_tO_2, %	V_b, %	blood-flow reserve, %
2-nd finger of the left hand	**M**	18,42	83,15	10,68	138,35
	σ	7,04	6,44	3,22	23,43
	δ, %	**38,21**	**7,75**	**30,15**	**16,94**

Table 2. Statistics results in a normal case during 6 years (from time to time measurements).

Localization	Statistic parameters	Measured basic parameters			Calculated parameter
		M, pf. un.	S_tO_2, %	V_b, %	blood-flow reserve, %
2-nd finger of the left hand	**M**	17,67	88,75	10,09	136,73
	σ	4,71	8,31	3,87	17,77
	δ, %	**26,69**	**9,36**	**38,35**	**12,99**

The sources of errors of diagnostics have been studied in our research by means of multiple repeated measurements with the use of non-alive and non-biological special measures (tissues-like phantoms). It was shown that the conventional instrumental random errors of diagnostics lay in the range of 2…3% from the measured parameters' values. But the methodical errors of diagnostics, especially the errors of calculation algorithms in the equipments' software, had more significant values ±10…15% [5]. Additionally, it was obtained, that the another sources of diagnostic errors are located both in techniques of carrying out of diagnostic examination of patients and in the interactive component of errors connected with the interaction of an optical probe of equipment with soft tissues of the patient. Together with individual physiological variations all these errors lead to uncertainties of the results of up-to-date NMS of an order of 30-40%, or even more.

Thus, today, only values of diagnostic NMS' parameters that differ from each other more than in twice standard deviation (not less than 50…60%) can be considered as the significantly different results. To minimize the operational clinical errors the standard clinical examination technique should be developed. To minimize the basic individual variations it is necessary to apply various functional tests. Without that, using the basic diagnostic parameters I_m, V_b and S_tO_2 for a base (simplest) recorder-test only, the in vivo LDF and TRO examinations have the risk not to give for a doctor the clinically important results.

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