# NEW HORIZONS
# OF NONINVASIVE REFLECTANCE OXIMETRY

Rogatkin D.A., Karpov V.N., Gorenkov R.V., Bychenkov O.A., Polyakov P.Yu.

Department of Radiology of Moscow Regional Research & Clinical
Institute «**MONIKI**», Shepkina str., 61/2, Moscow, 129110, RF
tel. 7-095-684-56-23, email: laserrog@mtu-net.ru

## ABSTRACT

Recently we have reported of created new portable spectrophotometry noninvasive medical diagnostic apparatus "Spectrotest"®, for the reflectance tissue oximetry in particular. During last year it was being tested in different clinical application at Moscow Regional Research and Clinical Institute **"MONIKI"**. One of the fields of its application in medicine is the real-time monitoring of peripheral blood microcirculation and peripheral capillary blood oxygenation (**PCBO**) processes for the patients with different peripheral haemodynamics disorders including a number of professional diseases, for example "vibration white fingers". The ability of apparatus to register and calculate all medical diagnostic parameters in a real time mode allows a doctor to apply different functional tests in his medical inspection. In our study it was estimated that PCBO during a number of functional tests has its specific changes and rhythms like the blood perfusion, measured by well-known Laser Doppler Flowmetry (**LDF**) technique. That is opening new horizons for noninvasive oximetry to study and apply a frequency analysis technique like in LDF to diagnose (analyze) a clinical state of patients' peripheral blood vessels and microcirculation and to differentiate organic and functional disorders of the vessels system.

## 1. INTRODUCTION

Today the noninvasive (in vivo, in situ) and real-time methods of diagnostics are desirable for a general clinical practice. One of such promising technique is the optical multi-wave elastic-scattering and absorption spectrophotometry[1-3]. It potentially allows a doctor to measure easy a number of important medical and biological (**M&B**) parameters such as the peripheral blood saturation (**SO2**) during the different medical procedures directly in the doctor's cabinet. Recently we have reported of our new medical noninvasive portable spectrophotometry diagnostic apparatus **"Spectrotest"**®, which had been created by our cooperation[3,4] (see Fig.1). During last year it was being tested in different clinical application at Moscow Regional Research and Clinical Institute "**MONIKI**". One of the promising fields of its application in medicine is the real-time monitoring of peripheral blood microcirculation and peripheral capillary blood oxygenation (**PCBO**) processes for the patients with different disorders of the peripheral haemodynamics including a number of professional diseases, for example – the "**vibration white fingers**" (**VWF**). The ability of apparatus to register and calculate all M&B diagnostic parameters in a real time mode allows a doctor to apply different functional tests in his medical inspection with the use of our apparatus. This functional test technique was used in our study for the patients with VWF to understand the abilities of the "Spectrotest" ® to register patients' peripheral blood stream disorders and a vessels' dysfunction.

## 2. MATEREALS AND METHODS

In our study the 20 patients with VWF and 20 healthy volunteers were under our examination. All patients had a first (40%) or second (60%) stage of illness. The average age of them was 42.2 years. Two functional tests – the occlusion test and the respiratory test – were used to understand better the specialties of patients' clinical state. The "Spectrotest"® was used to register and indicate a hand's finger PCBO during applied functional tests. In a parallel an index of microcirculation **IM** (blood perfusion) was measured from the same patients' hand finger by the Laser Doppler Flow-meter "LAKK-01" ("Lasma" Ltd. Inc., Russia). The duration time of functional tests was: 6-10 min for the occlusion test (**OT**) and 1-3 min for the standard respiratory test (**RT**). Temporal resolution for the "Spectrotest"® to measure and calculate an average PCBO was around 0.1 sec.

## 3. RESULTS AND DISCUSSION

The more visual results are presented in fig.2-6. It was shown that the "Spectrotest" ® can indicate the changes in SO2 parameter during both of OT and RT. Under occlusion, for example, it allows a doctor to observe an SO2 decreasing in a tissue, while the LDF index of microcirculation (**IM**) shows for a doctor nothing except the so-called "*biological zero level*" (Fig.2). After occlusion procedure both parameters show the post-occlusion hyperemia in a finger skin. In a common case for the patients with VWF the decreasing of SO2 during OT was more differ and fast than for the healthy volunteers (Fig.3-4). As it was estimated the different changes in SO2 and different peripheral blood rhythms can be observed during the RT as well. Moreover, in the same time the similar rhythms have been displayed both LDF and spectroscopy technique (Fig.5-6). From one hand, it shows the good work of our oximeter "Spectrotest" ® and a reality of calculated SO2 parameter. From the other hand, one can ask a question: what a parameter is registered by the "Doppler" device if the simple absorption spectroscopy technique can register the same rhythms without the use of any complex Doppler's frequency shifts and signals? We can assume, that in a common case the LDF apparatus registers a complex process in a capillary blood flow. Not only a Doppler signals, but also a number of processes accompanying a tissue blood circulation. It is sensitive as well to the total light attenuation by the hemoglobin and by the oxy-hemoglobin of a blood, especially in a case of the use of He-Ne laser in the LDF equipment when the spectral absorption by different fractions of hemoglobin is differ for the wavelength 632 nm. In any case for the discussed noninvasive reflectance oximetry problem our results indicate that:

1. The reflectance oximetry can be a powerful instrument in medicine for a diagnostics of peripheral blood circulation disorders under a different functional tests;
2. The different PCBO rhythms can be detected by the real-time reflectance oximetry like the blood perfusion rhythms in LDF;
3. The frequency analysis technique like the same in LDF can be applied for the real-time reflectance oximetry signal to analyze the different frequency spectra in PCBO rhythms.

## 4. CONCLUSION

Not touching the special medical information we have studied an ability of our new reflectance real-time oximetry technique and apparatus "Spectrotest"® in a real clinical practice. One of the questions which was interesting for us is: the abilities of "Spectrotest"® to detect a real-time PCBO during different functional tests for the patients with VWF (peripheral blood circulation dysfunctions). We have obtained good results and, in particular, the very surprising correlation between oximetry and LDF data. That is opening new horizons for noninvasive real-time oximetry to study and apply a frequency analysis technique like in LDF to diagnose (analyze) a clinical state of patients' peripheral blood vessels and microcirculation and to differentiate organic and functional disorders of the vessels system.

## REFERENCES

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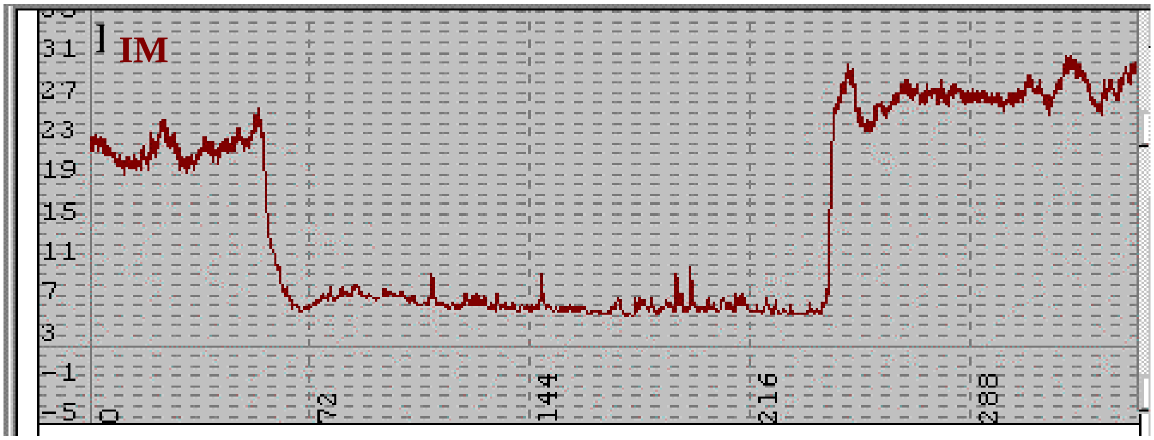
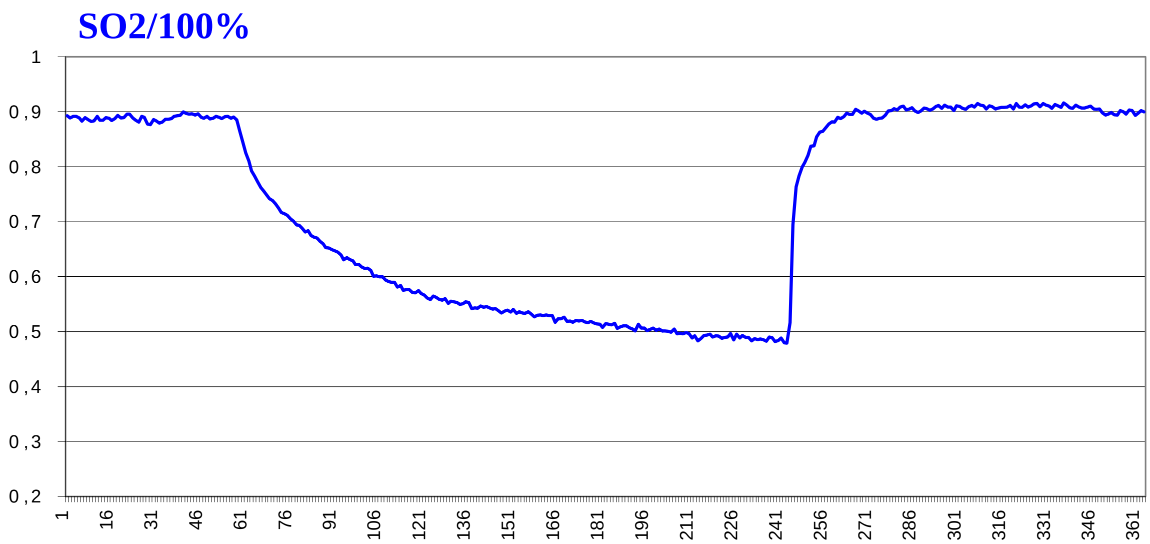
**Fig. 1.** Spectrophotometry diagnostic apparatus "Spectrotest"®.
Version for monitoring.




Time, sec.




Time, sec.

**Fig.2.** Test with occlusion for a healthy volunteer.

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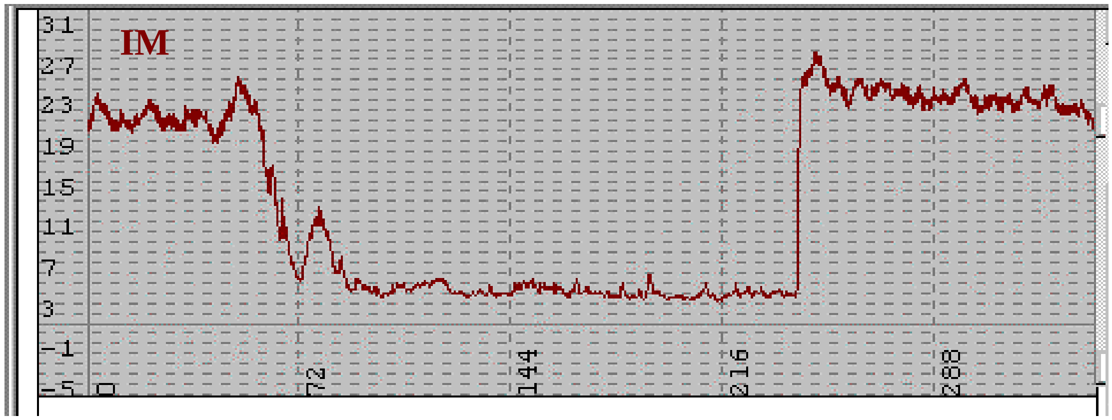


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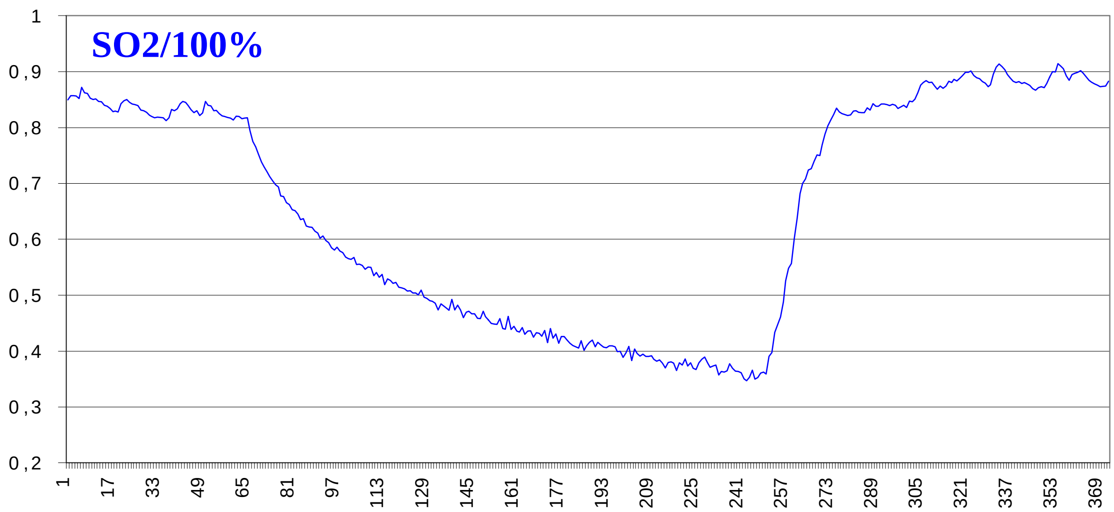
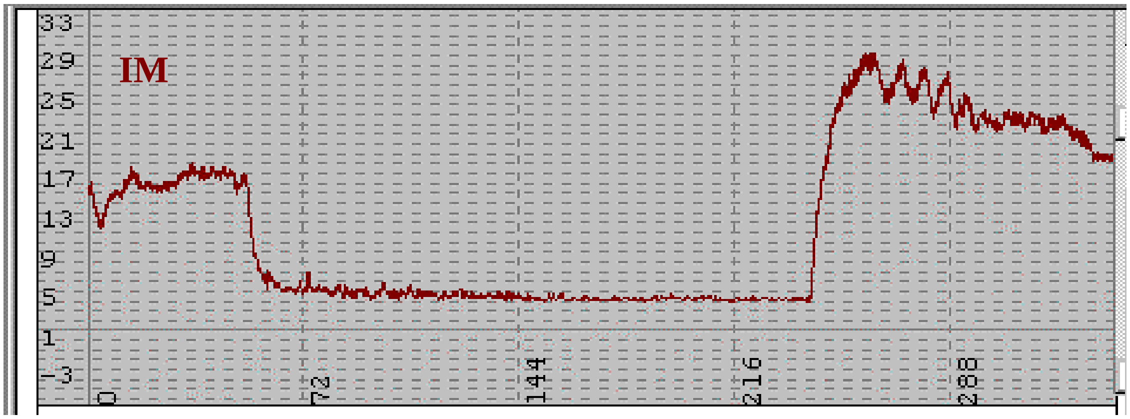



Time, sec.

**Fig. 3.** Test with occlusion for a patient with VWF (1-st stage).

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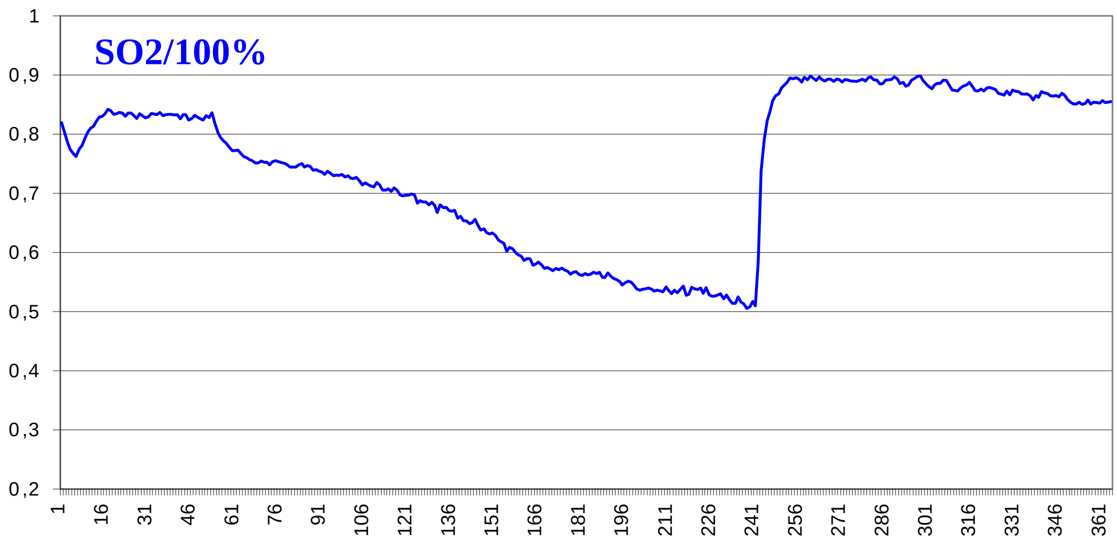
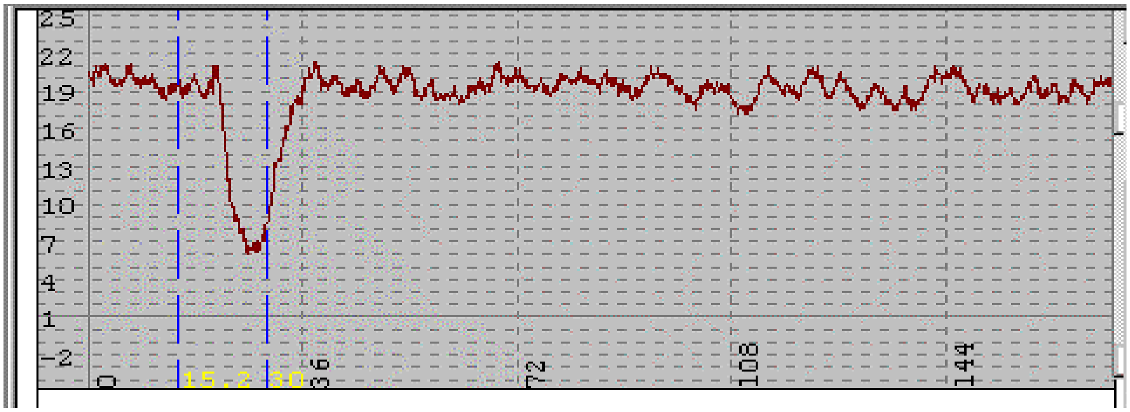



Time, sec.

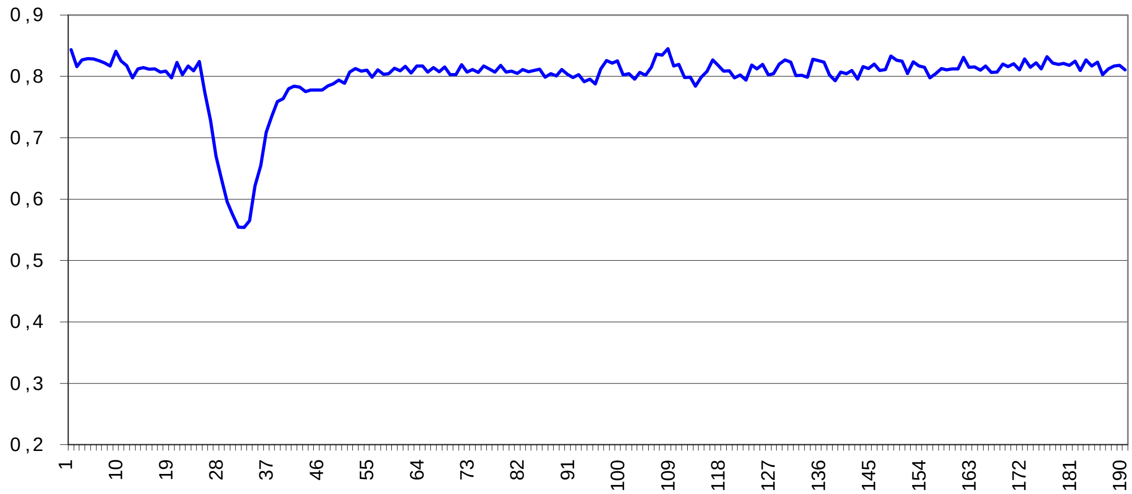
**Fig. 4.** Test with occlusion for a patient with VWF (2-d stage).

**IM**



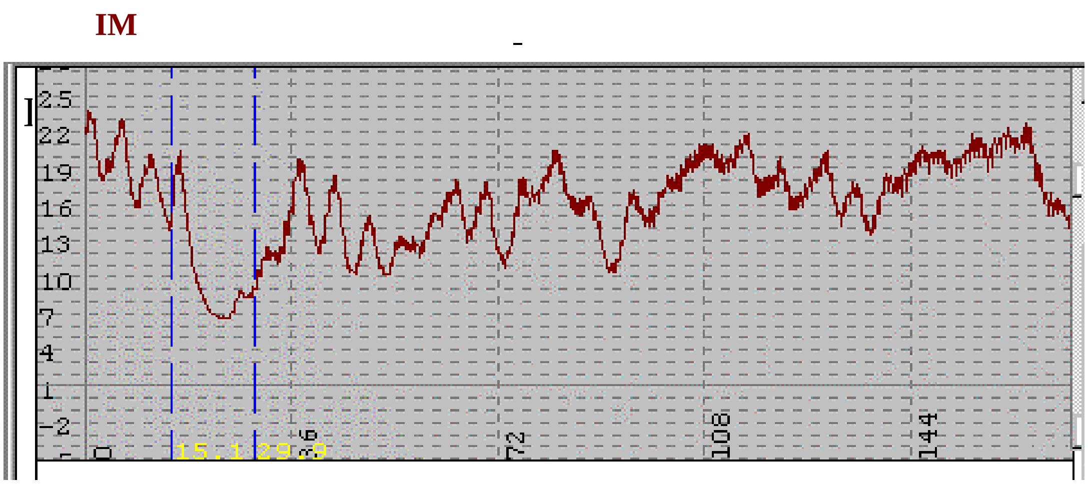

Time, sec.

**SO2/100%**




Time, sec.

**Fig. 5.** Respiratory test for a patient with VWF (1-st stage).

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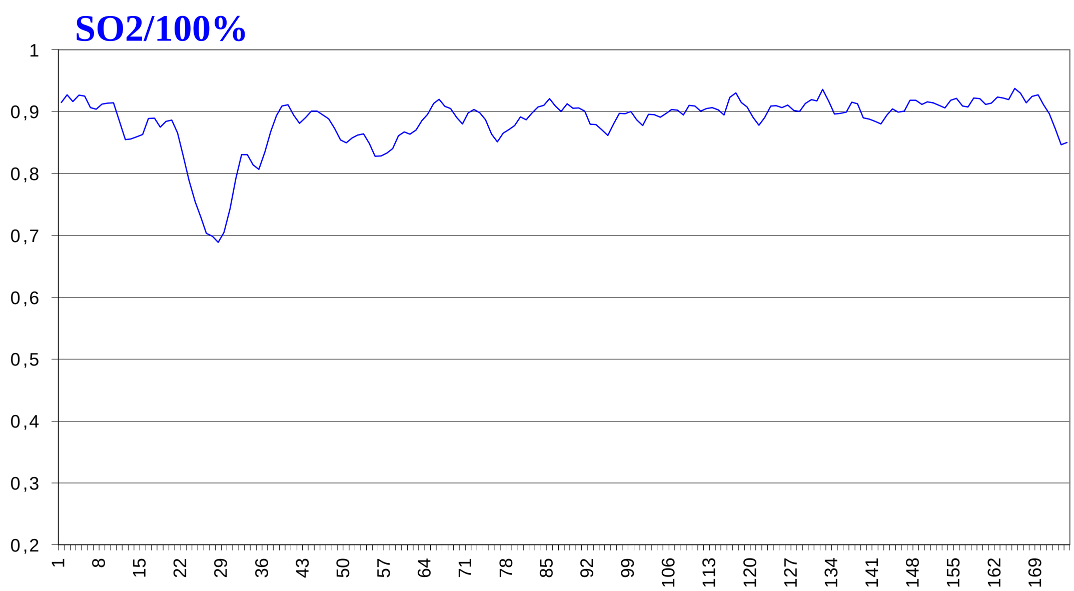


Time, sec.

**Fig. 6.** Respiratory test for a patient with VWF (2-d stage).