On physiological mechanism of SCENAR-therapy.

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Abstract

Based on theoretical analysis study of SCENAR-therapy effectiveness in the treatment of various diseases and pathological conditions, a suggestion about the physiological mechanism of its action has been made. A technique was suggested and factual data that prove the validity of the hypothesis have been provided. Some results and practical recommendations obtained by the proposed technique have been presented.

The analysis of SCENAR therapy effectiveness research in multiple treatment of diseases of various severity, etiology and pathogenesis (chronic coronary heart disease, duodenal ulcer, acute myocardial infarction, early postinfarction angina, neurocirculatory asthenia, nonorganic sleep disorders, acute renal failure with compression injury, tubo-peritoneal infertility, etc.) allows to single out two important facts specific to the state of patients, regardless of the disease.

In my publications I have already mentioned **the first of them** - the normalization of the ANS (autonomic nervous system) functional characteristics disturbed by the disease: functional activity, tone, reactivity and autonomic support of activity.

The second one - the antioxidant effect, or rather normalization of redox balance of the body, i.e. ‘prooxidants – antioxidants ratio’ as also reported in several publications.

Understanding these two facts as manifestations of a single process let us formulate a hypothesis about the physiological mechanism of SCENAR-therapy action.

The essence of the hypothesis is as follows (Fig. 1).

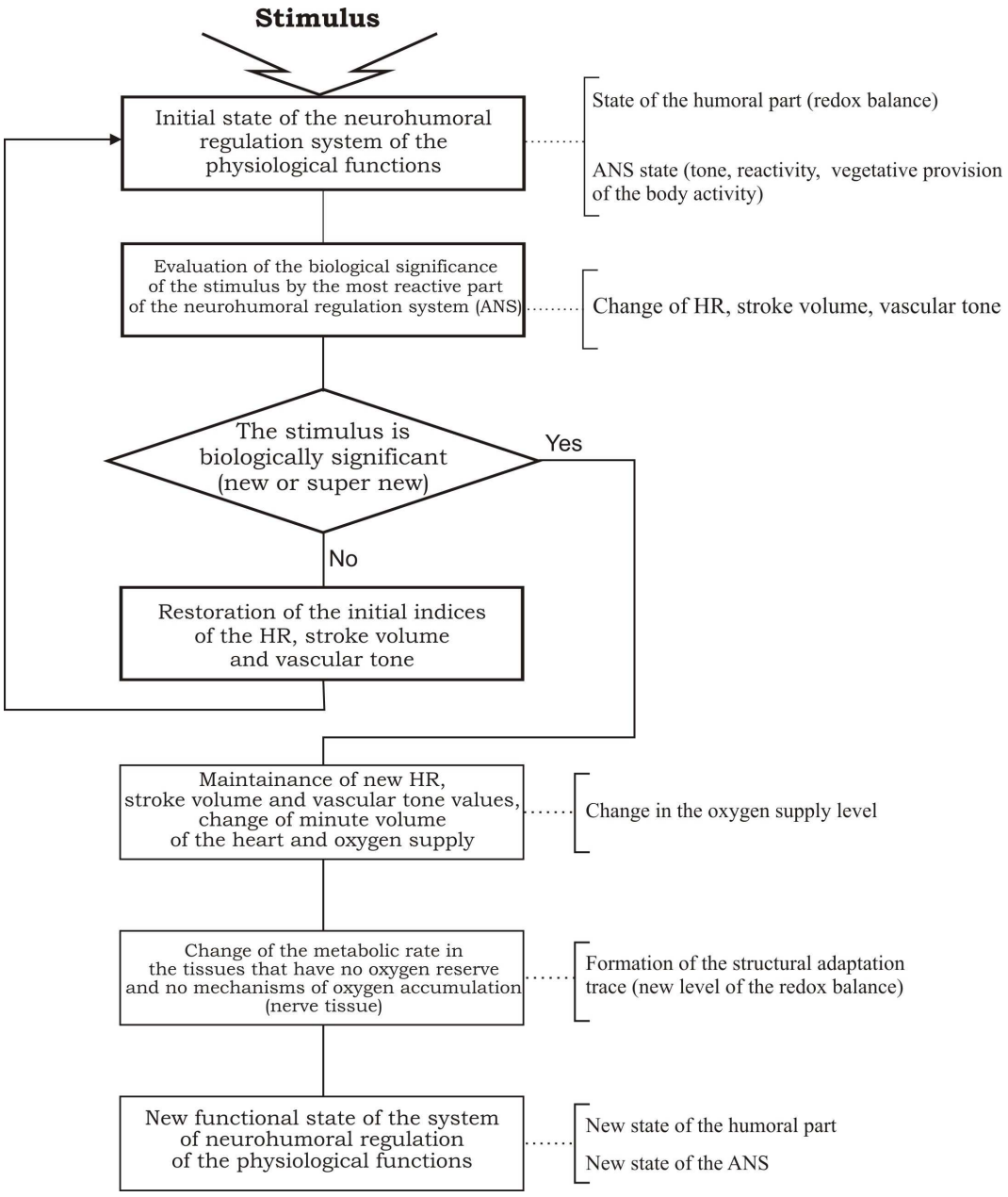

Fig.1

Under the SCENAR action, the nervous system evaluates the biological significance of the stimulus. The evaluation process is accompanied by reflex changes in initial values **of heart rate, and/or stroke volume, and/or vascular tone.**

If the stimulus is not biologically significant in relation to the initial state of the body, then after a relatively short time, these parameters return to their initial level and no changes occur in the functional state of the neurohumoral regulation system. However, if the biological significance of the stimulus is high, then changed **heart rate, and/or stroke volume, and/or vascular tone** remain at a new level for a relatively long time. It is known that these characteristics of the cardiovascular system are the main factors regulating the level of oxygen delivery. Therefore,

their change naturally cause a change in the oxygen delivery. Many body tissues have mechanisms for oxygen accumulation and mechanisms of its use in situations where the intensity of oxygen delivery for any reason does not meet the metabolic needs. The exception is the nerve tissue as it has no such compensatory mechanisms. Therefore, in response to a decrease or increase in the level of oxygen delivery, it changes the metabolism. This, in turn, changes its functional characteristics, i.e. **a new functional status of the VNS and, then, of the entire neurohumoral regulation system** develops - the structural trace of adaptation develops.

Thus, from session to session, a new state of the neurohumoral regulation system is formed. Objectively this appears, specifically, as well-known improvement of the ANS function and enhanced capacity of antioxidant systems, as well as, perhaps, other signs of development of the structural trace of adaptation. In particular, it was shown that SCENAR is more effective than drug therapy in restoring the hormonal status of women suffering from a particular form of infertility. At that, as a stimulus the device's signal is most likely **new** to the body rather than super-strong. This is indicated, in particular, by standard tests for teratogenecity and embryotoxicity, as well as long-term experience of its safe practice.

I would like to mention another practical observational evidence in favor of considered mechanism of SCENAR-therapy action. It is no mere chance that when selecting treatment tactics, the doctor first of all examines **subjective complaints** of the patient as they suggest that the existing level of nervous tissue metabolism does not provide adequate function of neurohumoral regulation. After all, subjective symptoms and complaints are sensations, whose development is the function of the nervous system.

So, we believe that the physiological effect of SCENAR signal is based on significant and relatively persistent reflex changes in systemic (heart rate and stroke volume) and tissue (vascular tone) regulators of oxygen delivery level. The new values of the parameters are set in the process of assessing the biological significance of the stimulus characterized by increased novelty for the body. This, in turn, changes the level of oxygen delivery and nerve tissue metabolism, and that changes its functional state.

To test this hypothesis, we used RISTA-EPD examination and heart rate variability (HRV) research methods, and initial data for assessing HRV were obtained from finger photoplethysmography (PPG).

The RISTA-EPD system was used to assess the functional state of the ANS (ANS functional activity (ANS FA), tone and balance of the segmental apparatus function), and identify optimal

zones for treatment. In parallel, ANS was evaluated from PPG. This allowed us to get more accurate assessments of the ANS, as one method verifies another. In addition, localization of optimal zones for treatment based on RISTA-EPD investigation data made it possible to compare the body responses to stimulation of recommended and randomly selected areas.

It should be said that in finger photoplethysmography the subject is pulse waves (Fig. 2).

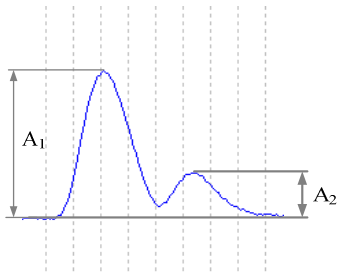

Fig.2

The first peak of the pulse wave (A1) is formed during systole. Its amplitude **corresponds** to the ***stroke volume in cardiac output,*** thereby providing indirect information about the degree of ***inotropic effect.***

The second peak of the pulse wave (A2) is formed by the reflection of blood volume from the aorta and great vessels and provides information on changes in **vascular tone.**

Although amplitude characteristics of the pulse wave are relative, their study in dynamics provides valuable information about the relative strength of the vascular response and changes in stroke volume - two more regulators of oxygen transport.

The duration of each cardiac cycle, which already has absolute values, can be determined from the horizontal axis of photoplethysmography diagram. It reflects information on rhythmothropic effect (change in the heart rate) and can be used to assess the ANS functional state using heart rate variability indices - a method which is currently the accepted standard for researching the

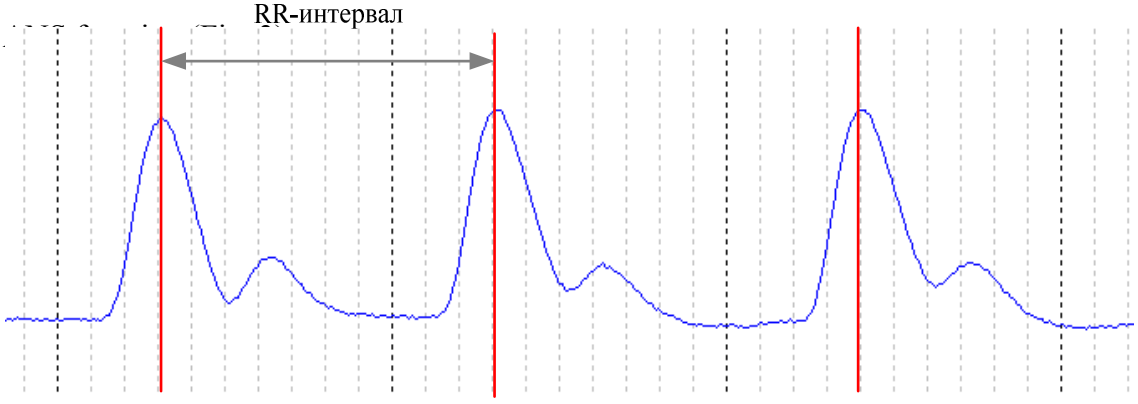

Fig.3

To verify the above hypothesis, we used a limited set of heart rate variability indices. These included: pulse rate - HR, some spectral parameters of HRV (total spectrum power - TP, the powers of very low frequency (VLF) , low frequency (LF), high frequency (HF) spectrum regions and the ratio of low to high frequency spectral powers (LF/HF) and one of statistical indices - the index of tension of regulatory systems (SI) calculated by R. Baevsky method.

HR – shows the average performance level for the circulatory system

TP – shows the cooperative effect of the autonomic regulation of the circulation. Sharp decrease in TP is interpreted as a increase in tension of regulatory systems.

HF – characterizes the activity of the parasympathetic part from the peripheral level of ANS.

LF – describes mainly the status of the sympathetic center of the vascular tone regulation.

LF/HF allows to estimate the degree of tone shift to the sympathetic or parasympathetic. The growth of this ratio indicates increased sympathetic influence on the cardiovascular system function, the decrease indicates increased parasympathetic influence.

SI - Stress Index – characterizes the degree of regulatory mechanism stress. The higher the index is, the more intensely the autonomic regulatory mechanisms are working.

In the context of the problem being studied, the VLF-component of the HRV spectral characteristics is of particular interest. Although its physiological interpretation is not determined by recommendations of the European Society of Cardiology, data from a number of researchers suggest that this index relates to the functional state of the brain. An increase in the power of the VLF-component of the spectrum in response to stress (load) indicates hyperadaptive behaviour and increased brain metabolism, and a decrease in it indicates the afterload deficiency of energy supply or decreased metabolism level. It has been shown that growing VLF-component of the HRV spectrum indicates the development of a regular stage of adaptation and the increasing involvement of higher autonomic centers in adaptation to the action of the investigated factor.

It is this index in this physiological interpretation that was successfully used by the Institute of Biomedical Problems (IBMP) for investigating, in particular, astronaut adaptation to weightlessness and for developing the measures to increase the duration of their stay aboard the International Space Station (ISS). IBMP - is one of the leading organizations in Russia engaged in providing biomedical support of space flights. However, in contrast to the method used on board the ISS, we prefer to use not the cardiographic signal but PPG, which, as was shown, allows to evaluate changes in all three regulators of oxygen transport simultaneously.

The ANS was evaluated by five-minute records not containing transients, with the patient in the lying position.

In general, investigation design was as follows.

1. Investigation was carried out using the RISTA-EPD system with the patient in the lying position. Based on these data, the character of ANS dysfunction was estimated and optimal zones for treatment were determined. That took 5 to 7 minutes.
Then background PPG recording for 10 - 15 min was started. Based on all the data obtained, the initial state of the testee's ANS was evaluated.

2. Continuing to record the PPG, the patient in the lying position was exposed to the intervention.

3. To assess the aftereffects, PPG recording was continued for another 10-15 minutes after exposure. After PPG recording was completed, the testee was again investigated with RISTA-EPD.

As the 'influencing factors' we investigated:

1. Being at rest, i.e. no action applied.
2. Electric heating pad at a comfortable temperature level applied on the lumbosacral area.
3. Kuznetsov multipin applicator on the lumbosacral area.
4. Multiple (12-segment) electrode with SCENAR- DE device on the lumbosacral area.
5. Add-on 'rotating' zone electrode with SCENAR-DE device on the lumbosacral area.
6. Add-on ophthalmologic electrode on periorbital zones.
7. Standard SCENAR electrode on the lumbosacral area and zones recommended by RISTA-EPD.

In all cases the intervention was carried out by application method for at least 10-15 minutes. The amplitude was adjusted based on subjective feelings of the testee to be at a comfortable level. The frequency was standard - 60 or 90 Hz, depending on the device type. When using dynamic electrodes (also called: multiple electrode), one of the modes of spatial modulation modes was used, i.e. automatic shifting of the focus of action within the electrode area.

In general, the testee was in the lying position for about 30-35 minutes.

The investigation involved apparently healthy volunteers that had no complaints on state of their health. The investigation was conducted in the afternoon, when a typical work stress have already taken effect.

It is supposed that the effect of SCENAR develops due to changes in the functional state of the natural mechanisms of neurohumoral regulation, so in their status the same changes should occur as in the absence of intervention but have a more pronounced form. So we decided to evaluate the fact of intervention using the variation degree of investigated indices in relation to their initial background values.

In this paper we will focus only on one of the oxygen transport regulators – heart rate (HR).

Table 1 shows the changes in the state in relation to background values in **the first** (after the intervention) **stationary 5-minute** interval, **i.e. on the 7th-10th minute after the intervention.**

Table 1.

Index	After a 15-minute SCENAR stimulation on the zones recommended by RISTA-EPD	After a 15-minute rest in the lying position	After a 15-minute SCENAR stimulation by different types of electrodes
1	2	3	4
HR, min^{-1}	**-1.4 ± 3.4***	**-0.4 ± 1.9****	-2.6 ± 2
SI	1.2 ± 65**	-23 ± 83*	-17 ± 82*
VLF, ms^2	**536 ± 1069***	420 ± 677	**93 ± 658****

In the table "*" denotes the indices whose variation in relation to the initial background values is maximal, "**" – those ones whose variation is minimal.

In accordance with the hypothesis being verified, we are interested in **HR** variation combined with variation of the **VLF-**component of the spectrum of the heart rate variability. Variation of the latter index, as noted above, indicates the possibility of a physiological increase or decrease in metabolism of the brain structures due to providing adaptation to the action of investigated factor. We used the Stress Index to assess the 'usefulness' or 'harmfulness' of the intervention for the ANS function as compared to its background level. If it does not increase or increases slightly, the intervention does not worsen the initial state.

SCENAR-treatment of the zones recommended by RISTA-EPD after investigation results in the highest variation of the HR and brain metabolism level, with minimal variation of SI.

Being at rest in the lying position provides a minimum **HR** variation, average level of the brain metabolism change, and almost the same variation of SI as in treatment of an arbitrarily chosen area.

Treating an arbitrary zone with different types of electrodes results in average variation of **heart rate** with the lowest level of brain metabolism variation and almost the same variation of SI as in the passive rest. Treating an arbitrary zone with different types of electrodes immediately after intervention in the least degree extends the limits of physiological changes in the brain metabolism level.

Table 2 presents similar data for the last stationary 5-minute interval of PPG recording, i.e. 10-15 minutes after exposure. Additionally the table shows the effect of physical activity.

Table 2

Index	After a 15-minute SCENAR stimulation on the zones recommended by RISTA-EPD	After a 15-minute rest in the lying position	After a 15-minute SCENAR stimulation by different types of electrodes	After a physical activity (maximum number of push-ups from the floor)
1	2	3	4	5
HR, min^{-1}	-2,5 ± 3	-1,4 ± 3,5*	-0,3 ± 2,4**	-1,7 ± 3,5

SI	-17 ± 33**	-52 ± 83	-46 ± 94*	-70 ± 43
VLF, ms^2	**364 ± 1213***	184 ± 375**	**402 ± 537**	478 ± 530

In Table 2 * also denotes the studied parameters whose variation in relation to their original value is maximal, ** - whose variation in relation to their original values is minimal.

As can be seen from Table 2, 15-20 min after the intervention, in general the trend has continued. However, the long-term effect showed enhanced central action of various types of electrodes on an arbitrarily chosen area.

Physical activity produces the same effect on the brain metabolism as the electrodes do but with a substantially greater load on the cardiovascular system, i.e. with larger changes in the HR.

We used the same method to assess the effect of different types of electrodes on the ANS functional state. Below are some of these results.

1. Being at rest for a time commensurate with the exposure duration.

In the absence of external action at rest, an increase in the **TP** total spectrum power and a gradual increase in the **LF** spectral component are observed. The **LF/HF** ratio increases. Stress index periodically decreases and increases. The average **SI** value remains the same, which indicates maintenance of the same level of tension in regulatory systems (Fig. 4).

According to the data of RISTA-EPD investigation, in the long-term period the average electric conductivity was at about the initial level.

Stress Index

Fig.4

2. **Treating the zones recommended by RISTA-EPD with a standard device's electrode**.

During the treatment of recommended zones, the response to the SCENAR action manifested itself as an increased part (participation) of HF-component of the HRV spectrum (decreased LF/HF ratio) with a simultaneous increase in the total spectral power TP.

At the end of treatment and in the aftereffect, VLF increased, and so did the LF-component of oscillations (LF/HF increased).

Stress index increases at the beginning of exposure, decreases during the exposure and becomes lower than the initial value in the in the aftereffect (Fig. 5).

This indicates a decreased tension of regulatory systems as compared to the initial state.

According to the data of RISTA-EPD investigation, in the aftereffect the average electric conductivity decreased by 5 - 10 units, the ANS functional activity was either normal or moderately decreased, with eutonia or parasympathicotonia, which was in line with the data obtained from the HRV investigation.

Stress Index

Fig.5

3. Treating periorbital zones with the ophthalmologic electrode.

The response was different.

The normal response consisted in a short-term increase followed by a decrease in stress index and heart rate during the treatment. In the course of treatment TP total spectral power increased, the part of HF spectral component also increased.

However, in the long-term period the stress index may fall as well as rise.

The best effect was achieved in the initial state with a sufficiently high spectral power (500 -

1500), the average values of SI (90 - 262) and balanced tone - LF/HF (0.9 - 2.5).
In the initial functional state of ANS, when the total spectral power was reduced to 200-500, treatment of the periorbital areas did not improve the initial state of ANS.

For treatments that were classified as effective, according to the investigation results provided by RISTA-EPD, in the long-term period the average electrical conductivity decreased by 5 to 10 units, ANS functional activity was normal or moderately decreased, with eutonia or parasympathicotonia, which was in line with the data obtained from HRV investigation.

For treatments that were classified as ineffective, according to the investigation results provided by RISTA-EPD the average electrical conductivity varied by less than 4 units, the initial tone did not change.

4. **We used the same procedure to assess the effect of different types of electrodes in the lumbar-sacral region.**

4.1 The response was evaluated as the time interval from the beginning of exposure until the SI reached the highest value. At this point, from HRV assessment, the ANS turns into a new stable functional state that is distinguished from the initial state by broader limits of physiological changes in the brain metabolism.

4.2 When treated with a **standard device's electrode**, there was a slight decrease in the heart rate, some increase in LF and HF components and total spectral power. After the treatment, the power and the part of the LF-component increase. Stress Index increases for a short time during the treatment and then decreases. The response time averaged about 130.

4.3 When treated with an add-on 'rotating' zonal electrode with SCENAR-DE device, there was an increase in the total spectral power, decrease in the heart rate (by 10 units in case of initially high HR), growing LF spectral component in case of initially low level of HF.
The response time was longer than in case of standard SCENAR device and was about 160.

4.4 When treated with a 12-segment electrode (also called multiple electrode) with **SCENAR-DE**, the response developed even longer, which, however, proceeded typically: a short-term increase in the stress index followed by its decrease. Total spectral power increased at the beginning of treatment and then decreased. LF/HF ratio decreased during the treatment but

increased in the aftereffect. When treated with a multiple electrode, total spectral power increased more than threefold, whereas treatment with a standard SCENAR caused a 30% increase at most.
The response time was the longest and amounted to about 330.

4.5 The effect of Kuznetsov multipin applicator, in general, recalls that of SCENAR. Stress index increases for a short time, and then decreases, but in the long-term period all parameters recovered to the initial values. In a relatively normal state, no expansion of the limits of physiological change in brain metabolism was established. The response time was really short and amounted to about 30 seconds.

4.5. When exposed to heat (electric heating pad), no changes in the ANS functional state were according to HRV data.

Summarizing the results of the research, the following practical conclusions can be made:

1. Irrespective of treatment zone location, a single 10-15 minute SCENAR-session extends the limits of the brain metabolism physiological change in both directions – expanding and narrowing.
2. Maximum extension of the limits of brain metabolism physiological change after a single session is achieved provided that the zones used for treatment are those recommended by RISTA-EPD
3. Using dynamic electrodes for treating the lumbosacral zone provides a stronger effect on brain metabolism as compared with that from treating the zone with a standard device's electrode by application method.
4. The effect of the ophthalmologic electrode on the ANS functional state can be either neutral or positive. Therefore to provide the effectiveness of stimulation, before using the electrode, a 5-10 minute treatment of the lumbosacral area is recommended, for example, with a 'rotating' zone or multiple (12-segment) electrode.