Regulatory and Adaptive Capacities of Human Body in Pain Syndrome Caused by Pulpitis

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In the study including 46 patients we found reduced regulatory and adaptive status defined by the parameters of cardiorespiratory synchronism, in patients experiencing pain caused by acute pulpitis. Significant inverse correlation was detected between the intensity of pain and the index of regulatory and adaptive status which was restored to normal after effective elimination of the pain.

Key Words: *pain; regulatory and adaptive status; cardiorespiratory synchronism; acute pulpitis*

Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage [10]. In pulpitis, nerve endings in the pulp are injured due to an increase in pulp volume and bacterial metabolites (toxins) that causes severe pain [1,8,9]. Intense and exhausting pulpal pain makes eating impossible. The nocturnal pain disturbs sleep and impairs working efficiency causing a state of stress [3,5].

Pulpitis is an ideal natural model to study the effects of pain on the regulatory and adaptive capacities of the organism.

For objective assessment of the overall human condition by his regulatory and adaptive capacities, the test for cardiorespiratory synchronism (CRS) was developed and widely used [6]. CRS is a phenomenon, when at respiratory rates usually exceeding the initial heart rate, each heartbeat corresponds to one respiratory cycle. CRS is the result of reproduction by the heart the rhythm of signals coming to the heart via the vagus nerves. Multilevel system of structures and mechanisms of the nervous system (from the cortex to the medulla oblongata) and the heart are involved in implementation of the CRS. This allows us to quantify the pain effects on the entire system of adaptive responses. We analyze the reaction of two major autonomic functions (breathing and heart) in their interaction, which is the basis of autonomic support of adaptive response. This is a principal difference between CRS and usual approaches, which are based on the reaction of just one autonomic function (heart rate variability, Kerdo-index, *etc*.).

Here we quantitatively evaluated the effect of pain on the regulatory and adaptive capacities of the human body.

MATERIALS AND METHODS

We observed 46 individuals of different age groups, patients of dental health service institutions suffering from acute pain caused by acute pulpitis. In all patients before and after treatment, the regulatory and adaptive capacities of the organism were determined by analyzing CRS. The most informative parameters were: the test for CRS; range of synchronization of cardiac and respiratory rhythms; duration of synchronization at the minimum border of the range. The relationship between these parameters quantifies the regulatory and adaptive capacities of the organism through the index of regulatory and adaptive status (IRAS) [6]:

$$IRAS=SR/DS_{min}\times 100,$$

where SR is synchronization range, DS_{min} is duration of synchronization at the minimum border of the range. The

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higher is IRAS, the better is the functional state of the organism as a whole, characterizing its ability to adapt the external and internal environment.

To carry out the test for CRS, we used a mobile automated system of CRS acquisition and analysis in humans [7]. Hardware and software complex comprising the system allows us to perform the test in the automatic mode and to correct its course. The system stores all the graphics and records of all the samples in its database and all CRS parameters are recorded in protocols.

In all patients, electric pulp test was carried out before and after treatment. Pulp electroexitability was evaluated using a Dentometr DM-1 device. Intact teeth respond to the following amperage: single rooted teeth, 2-20 μA; multi-rooted teeth, 10-25 μA. In acute pulpitis, pulp electroexitability increased to 40-60 μA.

In all patients, pain severity was determined by visual analogue scale (VAS) and digital rating scale (DRS) [2,4]. According to VAS, 0-20 points corresponded to the absence of pain; 20-40 points to very mild pain; 40-60 points to mild to moderate pain, 60-80 points to pain of medium severity; 80-100 points to severe pain. DRS is a horizontal line, which left edge corresponds to the pain-free state, and right, the most severe pain. The patient should set a vertical line perpendicular to the specified horizontal one in that place which, in his opinion, best describes the intensity of pain. The results of the study were interpreted as follows: 0 points no pain; 1-3 points weak pain; 4-6 points moderate pain; 7-10 points severe pain.

RESULTS

All patients in the study exhibited marked changes in the most relevant parameters characterizing the intensity of pain; regulatory and adaptive capacities were reduced (Table 1).

Reduced regulatory and adaptive status of patients with acute pulpitis and pain syndrome was confirmed by the following changes in CRS parameters: decreased width of the synchronization range; increased duration of the synchronization at the minimum border of the range, and reduced IRAS, which can be attributed to the main complaint of patients in acute pulpitis, toothache. This inversely correlated with pain intensity, range of CRS, and index of regulatory and adaptive status and directly correlated with the duration of synchronization at the minimum border of the range.

The regulatory and adaptive status of patients increased significantly after effective pain relief, as was seen from CRS parameters (Table 1).

Thus, pain syndrome in pulpitis had a negative impact on the regulatory and adaptive capacities of the organism, assessed by IRAS, and effective pain elimination restored the regulatory and adaptive status.

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TABLE 1. CRS, Pain Intensity, Threshold of Electroexitability, and Regulatory and Adaptive Status in Patients with Acute Pain Caused by Pulpitis (*M*±*m*)

Parameter	Before treatment	After treatment
Baseline heart rate per minute	77.6±0.2	78.7±0.4
Baseline respiratory rate per minute	18.2±0.1	17.9±0.1
$RSCRC_{min}$, per minute	80.4±0.3	78.9±0.2
$RSCRC_{max}$, per minute	85.9±0.3	87.9±0.2*
RSCRC, per minute	5.5±0.1	9.0±0.1*
DS_{min}	27.0±0.1	16.1±0.2*
IRAS	20.3±0.1	55.9±0.1*
Regulatory and adaptive capacities of the organism	Low	Good
Pain intensity by VAS, score	66.4±2.2	0
Pain intensity by DRS, score	7.4±0.2	0
Threshold of pulp electroexitability	38.9±0.6	3.5±0.3*

Note. RSCRC, range of synchronization in cardiorespiratory cycles; $RSCRC_{min}$, $RSCRC_{max}$, minimum and maximum of the range of cardiorespiratory synchronization cycles, respectively; DS, duration of synchronization at the minimum border of the range in the cardiac cycles. *p<0.001 compared with the parameter before treatment.

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