UDC 612.172.2:612.216:615.22:616-07:004.38

SPIRONOLACTONE IN BIOFEEDBACK SESSIONS IN THE LOOP OF PACED BREATHING AND HEART RATE VARIABILITY IN HEALTHY VOLUNTEERS

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In 7 conditionally healthy volunteers, aged from 19 to 21 years (average age is 19,53 ± 1,55 years), influence of spironolactone on alterations of regulatory systems state of the organism combined with biofeedback (BFB) sessions in the loop of paced breathing (PB) and heart rate variability (HRV) parameters was evaluated. All volunteers were conducted 2 series of everyday BFB sessions in analyzed loop for 5 days with a 3 months interval between them, 2nd series of sessions were conducted 6 hours after oral application of 25 mg spironolactone. The data was analyzed using non-parametric statistical methods. Optimization of regulatory systems state under influence of BFB sessions in the loop of PB and HRV parameters was found. Spironolactone in studied dose had no significant effect on optimization of regulatory systems state.

KEY WORDS: biofeedback, paced breathing, heart rate variability, regulatory systems of the organism, spironolactone

СПІРОНОЛАКТОН В СЕАНСАХ БІОЛОГІЧНОГО ЗВОРОТНОГО ЗВ'ЯЗКУ З КОНТУРОМ МЕТРОНОМІЗОВАНОГО ДИХАННЯ ТА ВАРІАБЕЛЬНОСТІ СЕРЦЕВОГО РИТМУ У ЗДОРОВИХ ДОБРОВОЛЬЦІВ

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На 7 умовно здорових добровольцях у віці від 19 до 21 років (середній вік – 19,53 ± 1,55 років) оцінили вплив спіронолактону на якість біологічного зворотного зв'язку (БОС) в контурі метрономізованого дихання (МД) і параметрів варіабельності серцевого ритму (ВСР). Всім добровольцям проведено по 2 серії щоденних сеансів БОС у досліджуваному контурі протягом 5 днів з інтервалом у три місяці між ними, у 2-й серії сеанси проводили через 6 годин після перорального прийому 25 мг спіронолоктона. Дані оброблялися методами непараметричної статистики. Встановлена оптимізація стану регуляторних систем під впливом БОС з контуром МД і ВСР. Спіронолактон в дослідженій дозі не робив істотного впливу на якість оптимізації регуляторних систем.

КЛЮЧОВІ СЛОВА: біологічний зворотний зв'язок, метрономізоване дихання, варіабельність серцевого ритму, регуляторні системи організму, спіронолактон

СПИРОНОЛАКТОН В СЕАНСАХ БИОЛОГИЧЕСКОЙ ОБРАТНОЙ СВЯЗИ С КОНТУРОМ МЕТРОНОМИЗИРОВАННОГО ДЫХАНИЯ И ВАРИАБЕЛЬНОСТИ СЕРДЕЧНОГО РИТМА У ЗДОРОВЫХ ДОБРОВОЛЬЦЕВ

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На 7 условно здоровых добровольцах в возрасте от 19 до 21 года (средний возраст – 19,53 ± 1,55 лет) оценили влияние спиронолактона на качество биологической обратной связи (БОС) в контуре метрономизированного дыхания (МД) и параметров вариабельности сердечного ритма (ВСР). Всем испытуемым проведено по 2 серии ежедневных сеансов БОС в исследуемом контуре в течение 5 дней с временным интервалом в три месяца между ними, во 2-й серии сеансы проводили через 6 часов после перорального приёма 25 мг спиронолоктона. Данные обрабатывались методами непараметрической статистики. Установлена оптимизация состояния регуляторных систем под

влиянием БОС с контуром МД и ВСР. Спиронолактон в изученной дозе не оказывал существенного влияния на качество оптимизации регуляторных систем.

КЛЮЧЕВЫЕ СЛОВА: биологическая обратная связь, метрономизированное дыхание, вариабельность сердечного ритма, регуляторные системы организма, спиронолактон

INTRODUCTION

The function of human circulatory system is controlled by neurohumoral regulatory systems [1]. Chronic distress cause its overstrain, which forms the base for development and manifestation of diseases [2].

One of perspective ways of optimization of regulatory systems state is biofeedback in the loop of paced breathing and heart rate variability (HRV) parameters [3-6].

Spironolactone, a competitive aldosterone antagonist, inhibits aldosterone-regulated exchange of sodium to potassium ions at collective tubules and distal canaliculi of nephron, providing moderate diuretic and mild antihypertensive effects [7].

Considering the above, it is interesting to evaluate spironolactone influence on the organism in combination with biofeedback sessions in the loop of paced breathing and HRV parameters at one contingent of volunteers.

The study is conducted as a part of research project of V.N. Karazin Kharkiv National University «Development and Research of Automatic Control of Heart Rate Variability», registration No. 0109U000622.

OBJECTIVE

To evaluate spironolactone influences on alterations of regulatory systems state of the organism in combination with biofeedback sessions in the loop of paced breathing and HRV parameters at one contingent of volunteers.

MATERIALS AND METHODS

The study involved 7 conventionally healthy volunteers aged from 19 to 21 years (average age is $19{,}53 \pm 1{,}55$). Inclusion criteria: acute and chronic diseases absence, pernicious habits absence, heart rate above 60 bpm at rest, blood pressure above 100/60 mmHg.

Biofeedback sessions were conducted using computer diagnostic complex «CardioLab 2009» («KhAI-Medica») with special «Biofeedback» module that contains programmatically connected aural-visual breathing metronome and algorithm of HRV parameters estimation.

In compliance with research objective, volunteers were conducted 2 series of everyday biofeedback sessions in studied loop for 5 days with a 3 months interval between them [8]. Second biofeedback series were conducted 6 hours after oral intake of 25 mg spironolactone. Before second biofeedback series all volunteers took similar dose of spironolactone for 2 days to reach significant pharmacological effect [7].

During biofeedback session, initialization of adaptation algorithm of biofeedback module was conducted in first 2 minutes, while volunteer breathed in his normal rhythm. After that for each following minute exact frequency of paced breathing was set through frequency rearrangement of aural-visual breathing metronome. Adaptation algorithm consisted in automatic seeking of such frequency, when current sympathovagal and neurohumoral values were maximally approximate to optimum zone [5].

Regulatory systems state was estimated based on HRV parameters. HRV parameters were estimated in slide buffer for 1 minute through dynamic spectral decomposition by fast Fourier transform of R-R intervals sequence of lead I ECG records with 1000 Hz digitization frequency during 7-minute biofeedback session [4]. Powerfulness of very low (VLF, ms^2), low (LF, ms^2) and high (HF, ms^2) frequencies of HRV domain spectrum were estimated, then they were transformed into two-dimensional coordinate space with LF/HF and VLF/(LF+HF) axes, which correspond to powerfulness of sympathovagal and neurohumoral balances of regulation [9].

Biofeedback quality estimation was based on optimality (O, estimation of farness of regulatory systems from optimal state during whole period of session), sensitivity (S, estimation of receptivity of regulatory systems to paced breathing), effectiveness (E, estimation of approaching range of HRV parameters to optimal physiological state during execution of optimal bioreverse control

algorithm) parameters both for whole regulatory system (D) and its parts, and also on BQI integral index (parameter that reflects all qualitative changes of biofeedback process) [9]. Estimation of all values was carried out using PTC MathCad software.

Statistical analysis of the results for each subject was carried out using Microsoft Excel. Average values (M) and standard deviation (sd) of O, S, E parameters for D, LF/HF, VLF/(LF+HF) indicators of all records of each series of all subjects were put down in spreadsheet. The differences reliability of each parameter between sessions and in each session was determined by Wilcoxon signed-rank test.

RESULTS AND DISCUSSION

O, S, E parameters values for D, L/H, V/(L+H) indicators of 1st and 5th sessions of 1st and 2nd biofeedback series in conventionally healthy volunteers are shown in the table. According to the data, biofeedback series in the loop of paced breathing under HRV parameters control optimize regulatory systems state. However, adding spironolactone to biofeedback series has no significant influence on alterations of O, S, E parameters values for D, LF/HF, VLF/(LF+HF) indicators.

Table

O, S, E parameters values for D, LF/HF, VLF/(LF+HF) indicators of 1st and 5th sessions of 1st and 2nd biofeedback series

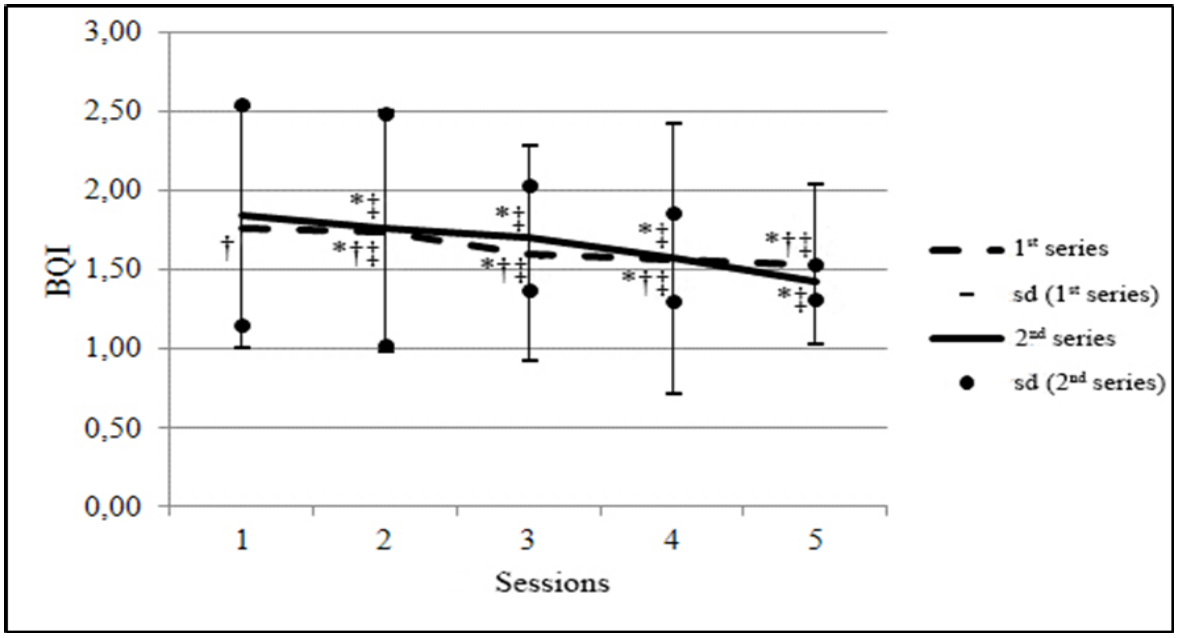
Parameters		1st series		2nd series	
		1st session	5th session	1st session	5th session
D	O	-4,09±7,12	1,07±2,60 †	-1,59±2,49 *	-1,14±2,55 *†
	S	0,76±0,41	0,77±0,33 †	1,05±0,37 *	0,80±0,47 *†
	E	0,05±0,08	0,22±0,25 †	0,00±0,17 *	0,10±0,23 *†
LF/HF	O	-28,47±61,56	-3,88±8,11 †	-7,53±6,67 *	-5,57±3,89 *†
	S	4,97±1,60	5,78±1,82 †	6,62±2,75 *	6,16±0,59 *†
	E	0,82±0,40	0,98±0,02 †	0,99±0,00 *	1,00±0,01 *†
VLF/(LF+HF)	O	-2,15±1,04	-1,85±0,98 †	-5,90±2,04 *	-2,99±0,53 *†
	S	0,41±0,26	0,40±0,26 †	0,05±2,95 *	2,05±0,03 *†
	E	0,07±0,06	0,18±0,13 †	0,03±0,41 *	0,40±0,05 *†

Notes: * – p > 0,05 on same session against base series;
† – p > 0,05 on sessions against base values of one series.

BQI values alterations of 1st and 2nd biofeedback series in every volunteer are shown on the picture. Systematic biofeedback series in the loop of paced breathing and HRV parameters lead to approximation of BQI value to optimal level. Adding spironolactone to biofeedback series bring no additional alterations to BQI value.

These results show optimization of regulatory systems of the organism by conducting systematic biofeedback series that proofs the data [3-6, 8].

Absence of spironolactone influence at 25 mg dose on regulatory systems in biofeedback series should be explained by short, predominantly local effect of the drug outside system alteration of neurohumoral regulation [7].



Pic. BQI values alterations of 1st and 2nd biofeedback series in every volunteer for 5 sessions.

Notes: * – p > 0,05 on sessions against base values;
† – p > 0,05 on same session against base series;
‡ – p > 0,05 on adjacent sessions of same series.

CONCLUSIONS

1. Systematic biofeedback sessions in the loop of paced breathing under HRV parameters control optimize regulatory systems state of the organism.
2. Adding spironolactone to biofeedback series has no significant influence on optimization of regulatory systems state.
3. Spironolactone in 25 mg dose has predominantly local and short pharmacological effect.

REFERENCES

1. Rhoades R. A. Medical Physiology: Principles for Clinical Medicine. 4th ed. / R. A. Rhoades, D. R. Bell. – Baltimore, MD: Lippincott Williams & Wilkins, a Wolters Kluwer business; 2013. – P. 311–325.
2. Grippo A. J. Stress, depression and cardiovascular dysregulation: a review of neurobiological mechanisms and the integration of research from preclinical disease models / A. J. Grippo, A. K. Johnson // Stress. – 2009. – № 12 (1). – P. 1–21.
3. Schwartz M.S. Biofeedback: A Practitioner's Guide. 3rd ed. / M.S. Schwartz, F. Andrasik. – NY: Guilford Press; 2003. – 930 p.
4. Schwartz M.S. Biofeedback: A Practitioner's Guide. 3rd ed. / M.S. Schwartz, F. Andrasik. – NY: Guilford Press; 2003. – 930 p.
5. Belal S.A.S. Sravnenie Algoritmov Poiska Optimal'noj Chastoty Metronomizirovannogo Dyhanija Pri Starte S Fiziologicheskoj Normy I So Svobodnogo Dyhanija U Zdorovyh Dobrovol'cev Na Osnovanii Ocenki Kachestva Biologicheskoj Obratnoj Svjazi. / S.A.S. Belal, K.I. Linskaja, A.L. Kulik [i dr.] // Variabel'nost' Serdechnogo Ritma: Teoreticheskie Aspekty I Prakticheskoe Primenenie: Materialy V Vseross. Simp. / otv.red. R.M. Baevskij, N.I. Shlyk, Izhevsk: Izd-vo «Udmurtskij Universitet», 2011. – S. 25–30.
6. Kulik O. L. Implementation of Biofeedback in a Closed Loop of Heart Rate Variability and Paced Breathing in Patients with Arterial Hypertension / O. L. Kulik, O. J. Schmidt, S. A. S. Belal, I. A. Rank // Journal of V.N. Karazin KhNU, series «Medicine». – 2014. – No. 1108. – p. 10–15.
7. Spironolactone [электронный ресурс]. / FDA Professional Drug Information database. // Access mode: http://www.drugs.com/pro/spironolactone.html.

8. Belal S. A. S. Vosproizvodimost' Biologicheskoj Obratnoj Svjazi U Zdorovyh Dobrovol'cev V Algoritme Metronomizirovannogo Dyhanija Pod Kontrolem Parametrov Variabel'nosti Serdechnogo Ritma. / S.A.S. Belal, A.L. Kulik, A.V. Martynenko, N.I. Jabluchanskij // Vestnik Aritmologii: Materialy 10-Go Jubilejnogo Kongressa «Kardiostim-2012» 16–18 Fevralja 2012 G. (Sankt-Peterburg). – 2012. – Prilozhenie A. – S. 81.
9. Jabluchanskij N.I. Variabel'nost' Serdechnogo Ritma V Pomoshh' Prakticheskomu Vrachu [electronic resource]. / N. I. Jabluchanskij, A. V. Martynenko // Access mode: http://dspace.univer.kharkov.ua/handle/123456789/1462.