Clinical researches

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THE INFLUENCE OF BIOFEEDBACK SESSIONS IN CLOSED LOOP OF HEART RATE VARIABILITY AND PACED BREATHING ON SYSTOLIC BLOOD PRESSURE CONTROL DURING STANDARD DRUG THERAPY IN PATIENTS WITH ARTERIAL HYPERTENSION

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Changes of systolic blood pressure (SBP) in biofeedback (BFB) sessions with closed loop of paced breathing (PB) and heart rate variability (HRV) during standard drug therapy of arterial hypertension (AH) was studied. 275 patients with 1-3 degree of AH (143 men and 132 women, mean age 58,55 ± 7,99 years) was divided into two comparable groups: 1 - BFB (139 patients) in investigated PB loop, 2 - control group (136 patients) with BFB without PB. In both groups was performed 10 sessions of BFB. Changes of SBP depending on the stage and degree of AH, gender and age was assessed. BP was measured by the method of Korotkov's with monometer Microlife BP AG1-20 in same conditions. Data were processed by parametric and nonparametric statistics. It is proved that the use of biofeedback in the loop of PB and HRV significantly ($p < 0.01$) exceeds in efficiency an isolated drug therapy in control of SBP at any stage and degree of AH in patients of both sexes in all age groups. Extent of the effect increases with the stage and degree of the disease and not related to the sex and age of the patient. Findings allow to recommend this technique in clinical practice.

KEY WORDS: arterial hypertension, biofeedback, heart rate variability, paced breathing, systolic blood pressure

ВПЛИВ СЕАНСІВ БІОЛОГІЧНОГО ЗВОРОТНОГО ЗВ'ЯЗКУ ІЗ ЗАМКНУТИМ КОНТУРОМ ВАРІАБЕЛЬНОСТІ СЕРЦЕВОГО РИТМУ І МЕТРОНОМІЗОВАНОГО ДИХАННЯ НА КОНТРОЛЬ СИСТОЛІЧНОГО АРТЕРІАЛЬНОГО ТИСКУ НА ТЛІ СТАНДАРТНОЇ МЕДИКАМЕНТОЗНОЇ ТЕРАПІЇ У ПАЦІЄНТІВ З АРТЕРІАЛЬНОЮ ГІПЕРТЕНЗІЄЮ

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Вивчено зміни систолічного артеріального тиску (САТ) в сеансах біологічного зворотного зв'язку (БЗЗ) із замкнутим контуром метрономізованого дихання (МД) і варіабельності серцевого ритму (ВСР) на етапах стандартної медикаментозної терапії артеріальної гіпертензії (АГ). 275 пацієнтів з 1-3 ступенем АГ (143 чоловіки та 132 жінки, середній вік 58,55 ± 7,99 років) розділені на дві зіставні групи: 1 - БЗЗ (139 пацієнтів) у вивченому контурі МД і 2 - група порівняння (136 пацієнтів) з БЗЗ без МД. В обох групах виконано по 10 сеансів БЗЗ. Оцінювали зміни САТ залежно від стадії та ступеня АГ, статі та віку пацієнтів. АД вимірювалося за методом Короткова монометром Microlife BP AG1-20 в однакових умовах. Дані оброблялися методами параметричної та непараметричної статистики. Доведено, що використання БЗЗ в контурі МД та ВСР достовірно ($p < 0,01$) перевершує по ефективності ізольовану медикаментозну терапію в контролі САД при будь-яких стадіях і ступенях АГ у пацієнтів обох статей у всіх вікових групах. Ступінь вираженості ефекту зростає зі збільшенням стадії і ступеня захворювання і не пов'язана зі статтю і віком пацієнта. Отримані дані дозволяють рекомендувати методику в клінічну практику.

КЛЮЧОВІ СЛОВА: артеріальна гіпертензія, біологічний зворотний зв'язок, варіабельність серцевого ритму, метрономізоване дихання, систолічний артеріальний тиск

ВЛИЯНИЕ СЕАНСОВ БИОЛОГИЧЕСКОЙ ОБРАТНОЙ СВЯЗИ С ЗАМКНУТЫМ КОНТУРОМ ВАРИАБЕЛЬНОСТИ СЕРДЕЧНОГО РИТМА И МЕТРОНОМИЗИРОВАННОГО ДЫХАНИЯ НА КОНТРОЛЬ СИСТОЛИЧЕСКОГО АРТЕРИАЛЬНОГО ДАВЛЕНИЯ НА ФОНЕ СТАНДАРТНОЙ МЕДИКАМЕНТОЗНОЙ ТЕРАПИИ У ПАЦИЕНТОВ С АРТЕРИАЛЬНОЙ ГИПЕРТЕНЗИЕЙ

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Изучены изменения систолического артериального давления (САД) в сеансах биологической обратной связи (БОС) с замкнутым контуром метрономизированного дыхания (МД) и вариабельности сердечного ритма (ВСР) на этапах стандартной медикаментозной терапии артериальной гипертензии (АГ). 275 пациентов с 1-3 степенью АГ (143 мужчины и 132 женщины, средний возраст 58,55 ± 7,99 лет) разделены на две сопоставимые группы: 1 — БОС (139 пациентов) в изученном контуре МД и 2 — группа сравнения (136 пациентов) с БОС без МД. В обеих группах выполнено по 10 сеансов БОС. Оценивали изменчивость САД в зависимости от стадии и степени АГ, пола и возраста пациентов. АД измерялось по методу Короткова монометром Microlife BP AG1-20 в одинаковых условиях. Данные обрабатывались методами параметрической и непараметрической статистики. Доказано, что использование БОС в контуре МД и ВСР достоверно ($p < 0,01$) превосходит по эффективности изолированную медикаментозную терапию в контроле САД при любой стадии и степени АГ у пациентов обоих полов во всех возрастных группах. Степень выраженности эффекта возрастает с увеличением стадии и степени заболевания и не связана с полом и возрастом пациента. Полученные данные позволяют рекомендовать методику в клиническую практику.

КЛЮЧЕВЫЕ СЛОВА: артериальная гипертензия, биологическая обратная связь, вариабельность сердечного ритма, метрономизированное дыхание, систолическое артериальное давление

INTRODUCTION

Arterial hypertension (AH) is the most common chronic disease of the cardiovascular system in the adult population [1]. The greatest difficulty is the control of systolic blood pressure (SBP), which plays the leading role in the development of cardiovascular complications and significantly increases mortality [2].

One of the promising methods to increase the manageability of SBP can become biofeedback (BFB) in the closed loop of heart rate variability (HRV) and paced breathing (PB) [3].

Absence of data about the effectiveness of BFB in the loop of HRV and PB in the control of SBP in patients with arterial hypertension prompted us to perform this study.

The study was performed as part of research V. N. Karazin KhNU «Development and research of automatic system in heart rate variability control», № registration 0109U000622.

OBJECTIVE

The purpose of the study is to evaluate the changes of SBP in BFB sessions with the loop of HRV and PB in patients with AH.

MATERIALS AND METHODS

275 patients with AH (143 men and 132 women, mean age 58,55 ± 7,99 years) were observed. Inclusion criteria were systolic and systolic-diastolic AH in any stage and degree with the absence of systematic reception of any vasoactive medications in the past three months. Patients were excluded from the study in the case of isolated diastolic AH, acute myocardial infarction, unstable angina, stable angina with IV functional class, III stage of chronic heart failure, complex disorders of rhythm and conduction, comorbidities in others organs and systems.

In all patients blood pressure was measured by the Korotkov's method with monometer Microlife BP AG1-20 in the morning in a quiet, bright room in the sitting position after 15-minute rest. The accuracy of BP measurement is 0.5 mm Hg.

All patients were randomly assigned to two clinically comparable groups (table.): BFB group (139 patients) with the loop of PB and control group (136 patients) with BFB without MD.

Table

Clinical characteristics of patients with AH of comparable groups

Indices		Group	
		Biofeedback (139)	Comparison (136)
Sex, (n)	males	70	73
	females	69	63
Age	mean, (M ±s d)	58,23 ± 8,31	58,86 ± 7,67
	mature, (n, M ± sd)	66 (51,8 ± 4,87)	68 (53,6 ± 3,56)
	elderly, (n, M ± sd)	65 (62,5 ± 4,69)	59 (61,85 ± 3,69)
	old, (n, M ± sd)	8 (76,5 ± 1,85)	9 (79,4 ± 2,01)
AH stage, (n)	I	2	4
	II	115	110
	III	22	22
AH severity grade, (n)	Mild	14	15
	Moderate	51	62
	Severe	74	59
IHD	without	91	97
	SA	33	24
	PC	22	22
SA FC	without	106	113
	I	11	4
	II	10	9
	III	12	10
CHF stage	without	10	19
	1	59	55
	2A	57	55
	2B	13	7
CHF FC	without	10	19
	I	68	57
	II	43	42
	III	18	18

Note: IHD – ischemic heart disease; SAP - stable angina; PC - postinfarction cardiosclerosis; CHF – chronic heart failure; FC – functional class; without – patients without this indices.

BFB sessions were conducted on computer diagnostic complex «CardioLab 2009» («HAI-Medika») with built-in module «Biofeedback», which is the program-related audio-visual breathing metronome and algorithm for dynamically determining the current values of HRV parameters [4]. In both groups were performed 10 BFB sessions.

All patients were treated by the same therapy with antiplatelets, anticoagulants, beta-blockers, angiotensin converting enzyme inhibitors, calcium channel blockers, sartans, aldosterone antagonists, diuretics and statins in accordance with the recommendations for the prevention and treatment of AH from Ukrainian and European Societies of Cardiology [1, 5].

Groups of BFB and comparison were classified into subgroups depending on the stage and degree of AH, gender (women, men) and age (adult, elderly, old in classification [6]) of the patients.

In the groups and subgroups of patients the mean (M) and standard deviation (sd) of the SBP was evaluated after entering data into the Microsoft Excel table. The significance of differences between values of SBP in groups and subgroups at stages of the study was determined by using the U-Mann-Whitney-test [7] and inside groups at current stages against the values before the treatment - by using T-Wilcoxon test [8].

RESULTS AND DISCUSSION

Changes of SBP mean values in groups of BFB and comparison in stages of the study are shown in Fig. 1. At the same medication in groups systematic BFB sessions has contributed to significantly ($p < 0.01$) lower values of SBP in 9 day of the treatment.

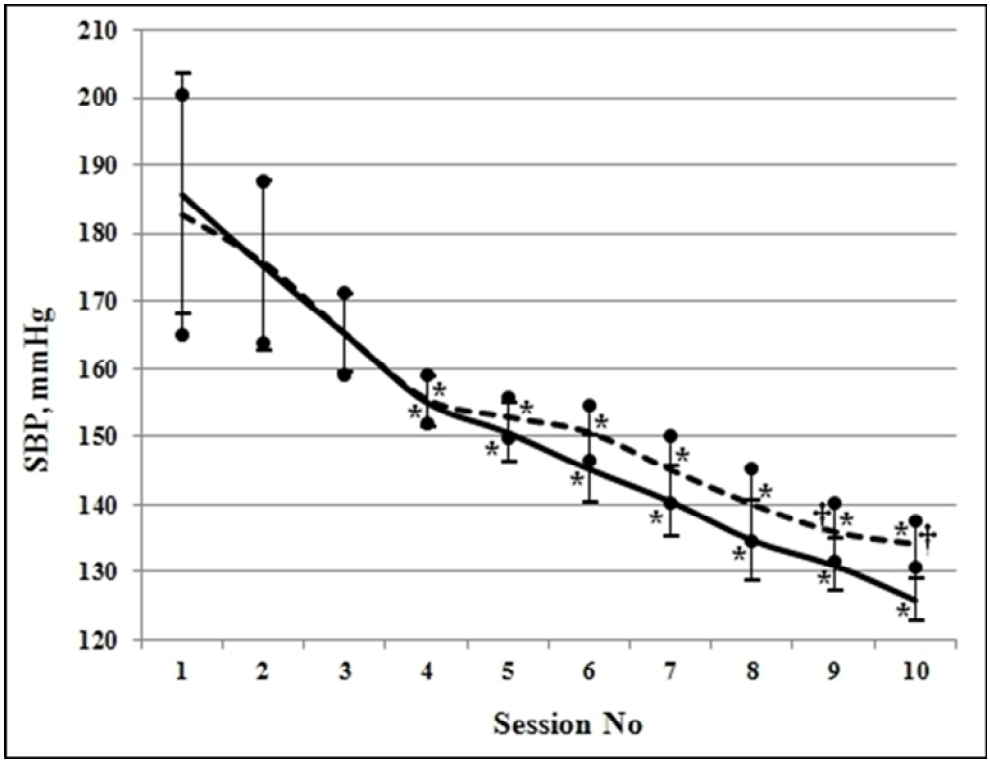
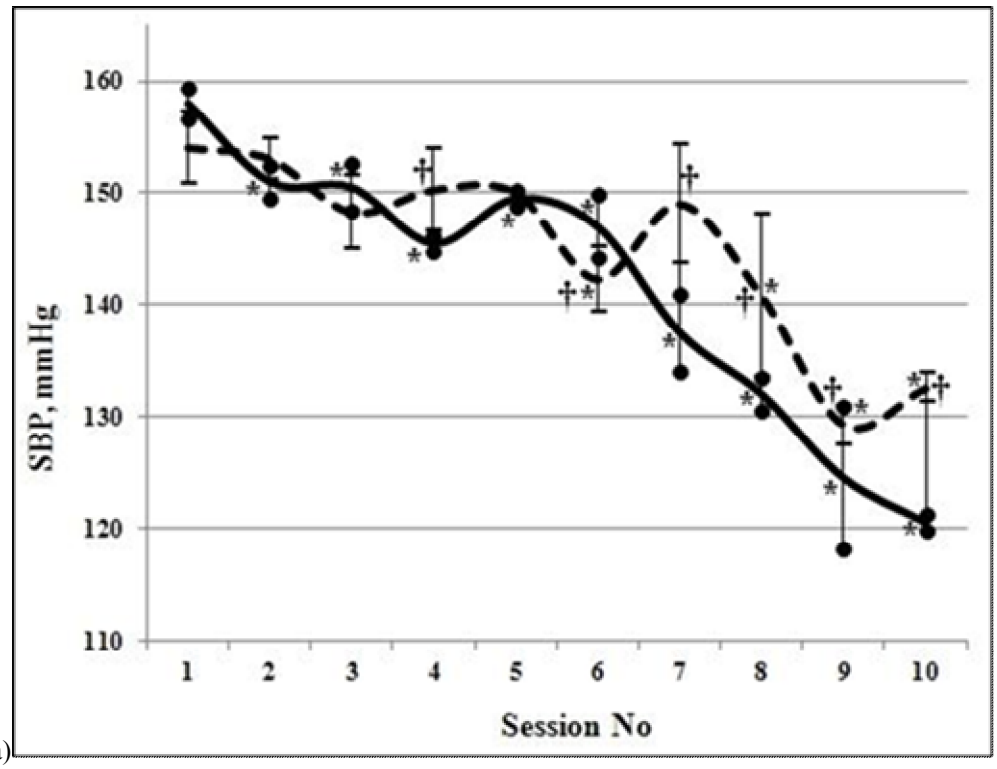


Fig. 1. Changes of SBP mean values for all patients in groups of BFB and comparison at stages of observation

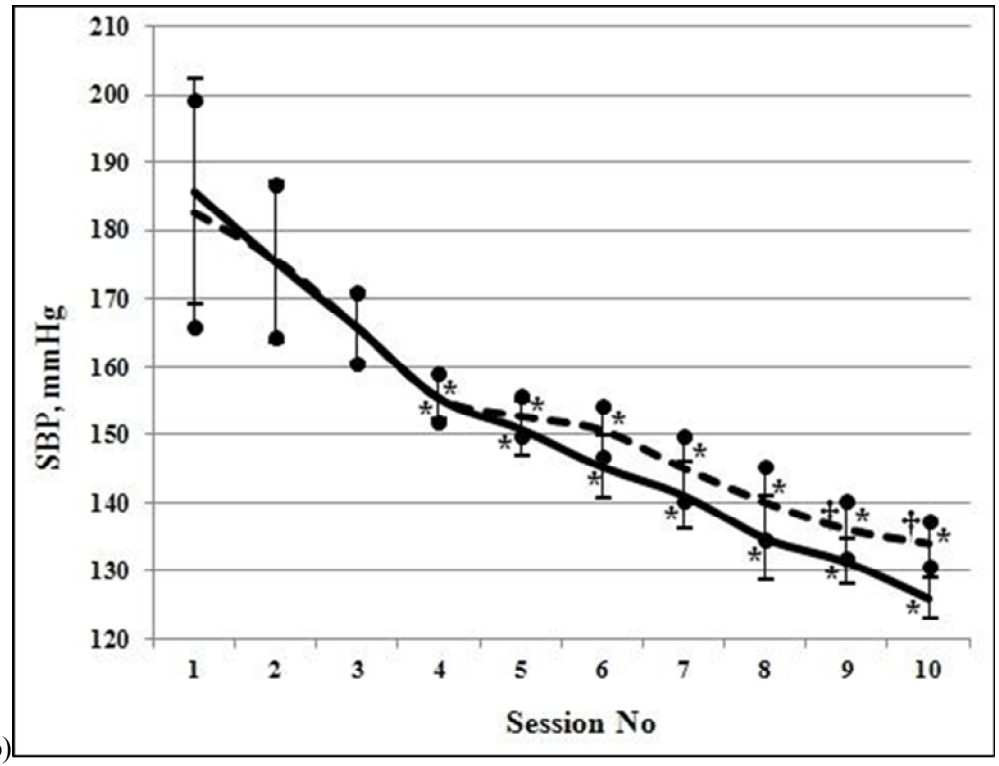
Note: ▬▬ - BFB group; ▬ ▬ - comparison group; * - P < 0,01 in the series against the baseline values; † - P < 0,01 between series on the current session.

Fig. 2 shows changes of SBP mean values at I - III stages of AH. In BFB group degree of SBP reduction were significantly ($p < 0.01$) greater in 7 treatment day at I (Fig. 2a) and in 9 day - at II (Fig. 2b) and III (Fig. 2c) stages of AH against the comparison group.

a)



b)



c)

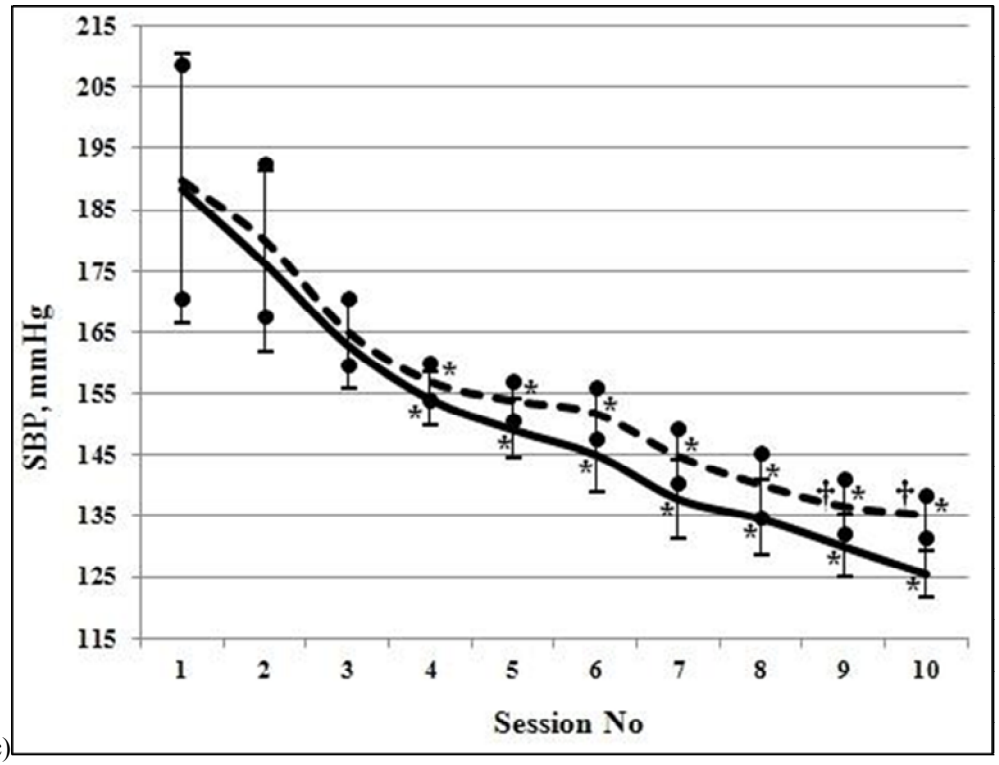
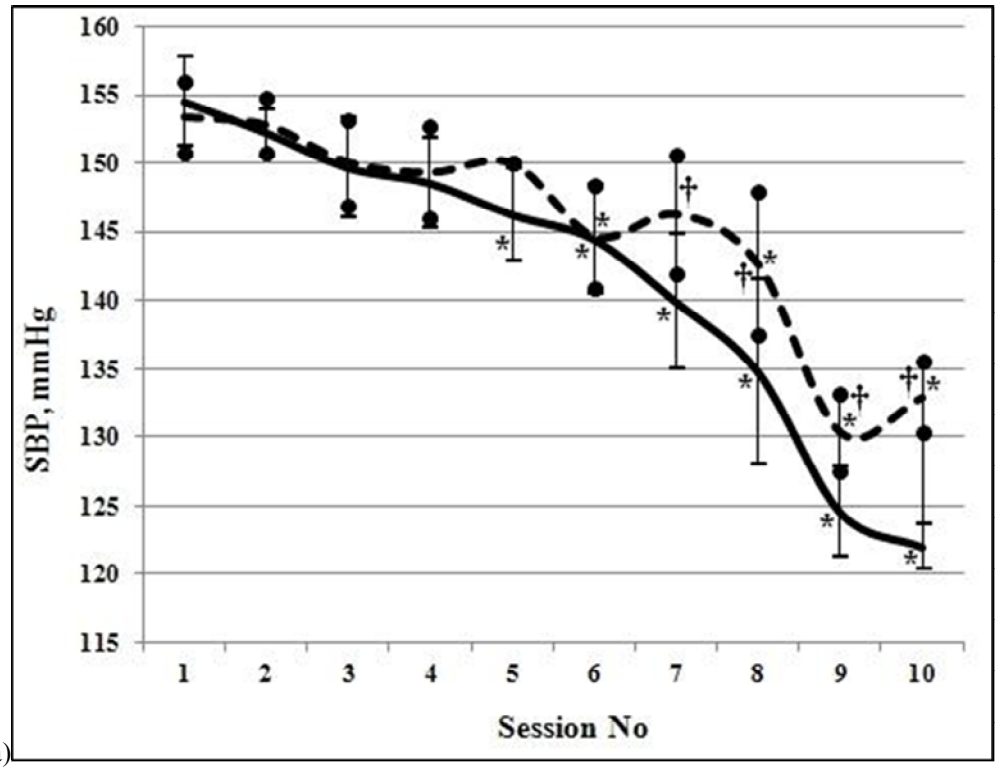


Fig. 2. Changes of SBP mean values in patients with I (Fig. 2a), II (Fig. 2b) and III (Fig. 2c) stage of AH in groups of BFB and comparison at stages of observation

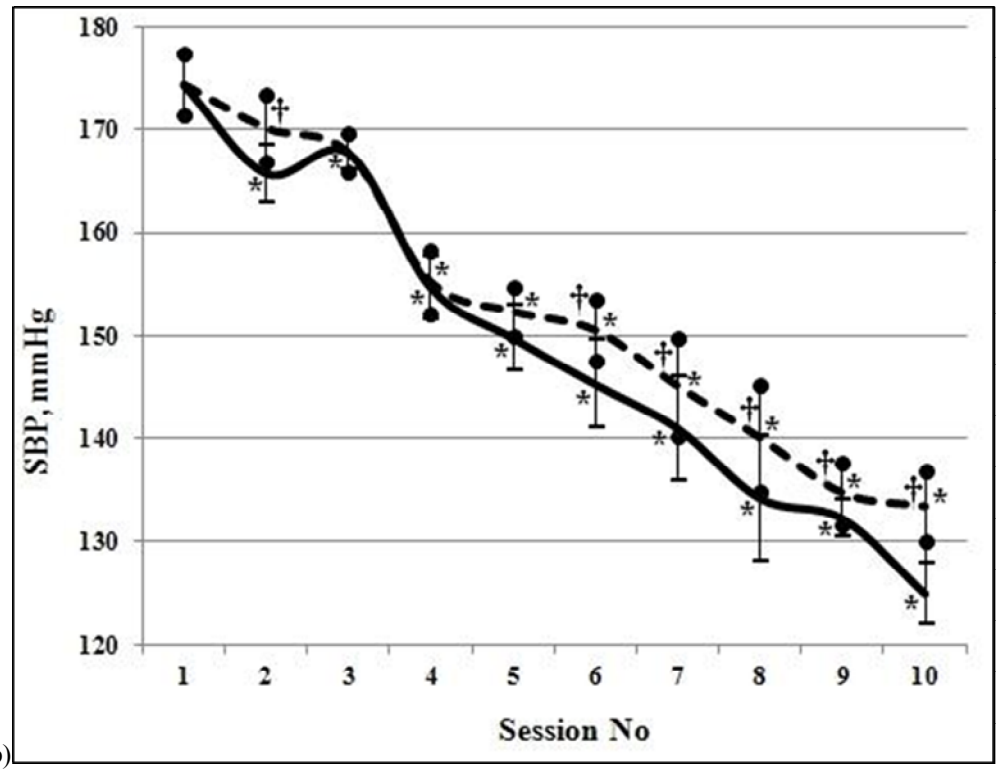
Note: ▬▬ - BFB group; ▬ ▬ - comparison group; * - P < 0,01 in the series against the baseline values; † - P < 0,01 between series on the current session.

Variability of SBP in groups of BFB and comparison depending on the degree of AH is shown in Fig. 3. Conducting of biofeedback sessions contributed to significantly ($p < 0.01$) lower values of SBP at 7 session with 1 (Fig. 3a) and at 6 - with 2 (Fig. 3b) and 3 (Fig. 3c) degrees of AH against SBP values in the comparison.

a)


160
155
150
145
140
135
130
125
120
115
SBP, mmHg
1
2
3
4
5
6
7
8
9
10
Session No

b)


180
170
160
150
140
130
120
SBP, mmHg
1
2
3
4
5
6
7
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10
Session No

c)

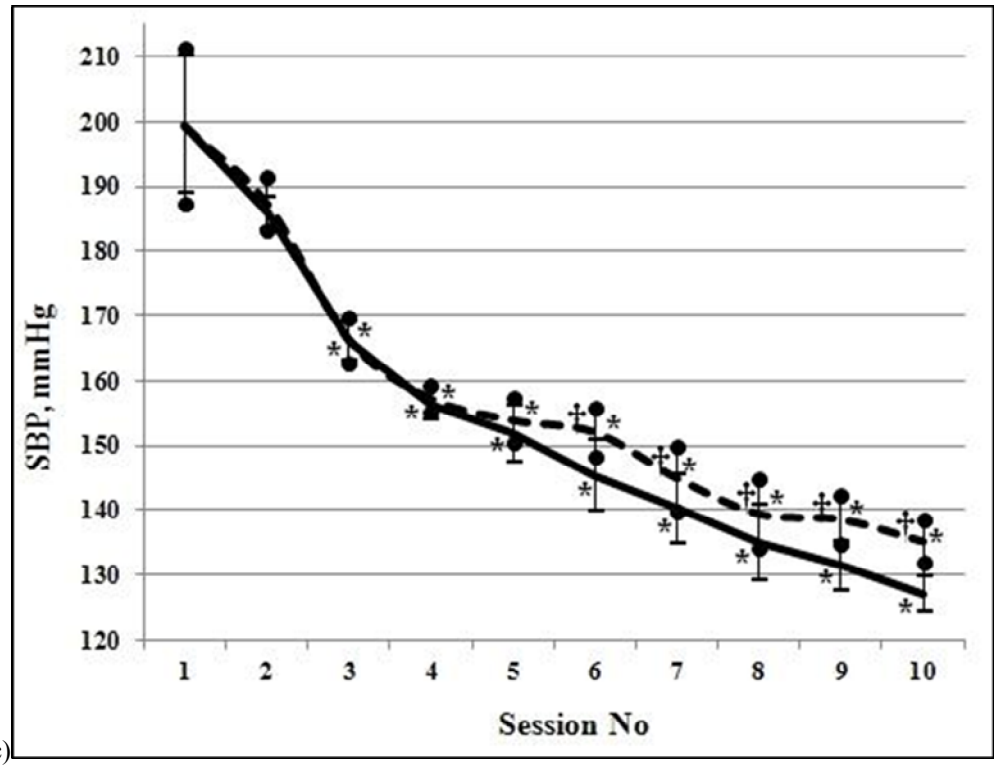
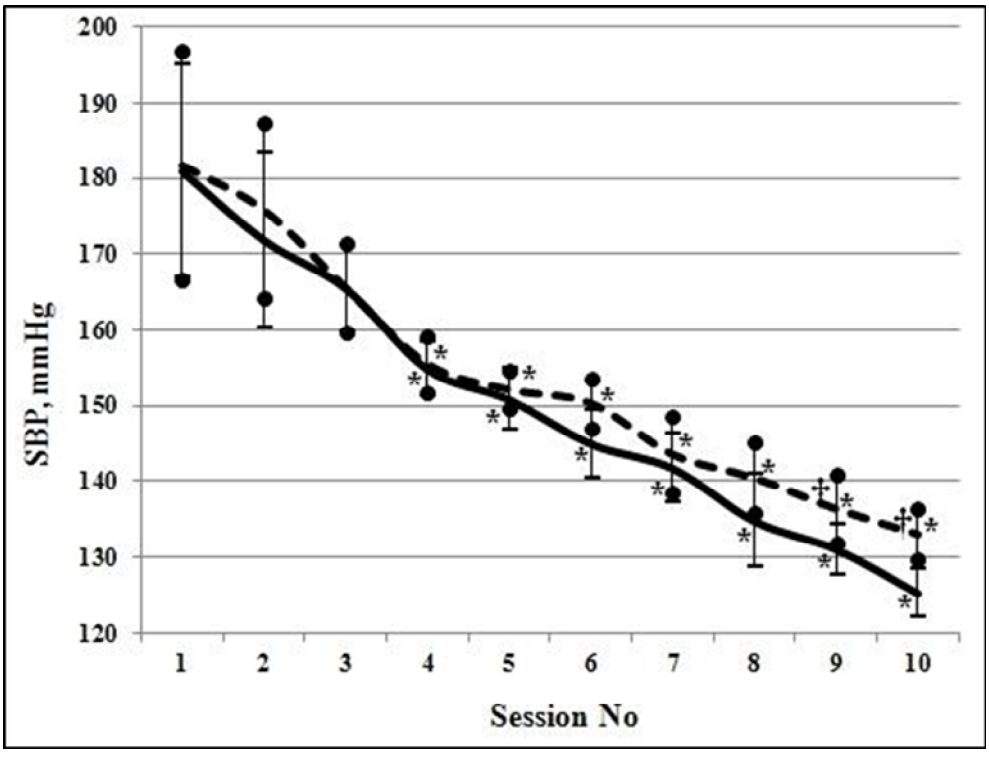


Fig. 3. Changes of SBP mean values in patients with 1 (Fig. 3a), 2 (Fig. 3b) and 3 (Fig. 3c) degree of AH in groups of BFB and comparison at stages of observation

Note: ▬▬ - BFB group; ▬ ▬ - comparison group; * - P < 0,01 in the series against the baseline values; † - P < 0,01 between series on the current session.

Changes in the level of SBP in male and female patients with AH on the stages of observation are shown in Figure 4. The biofeedback sessions have led to significantly ($p < 0.01$) lower values of SBP in female patients at 9 (Fig. 4a) and in male patients at 7 (Fig. 4b) treatment day.

a)



b)

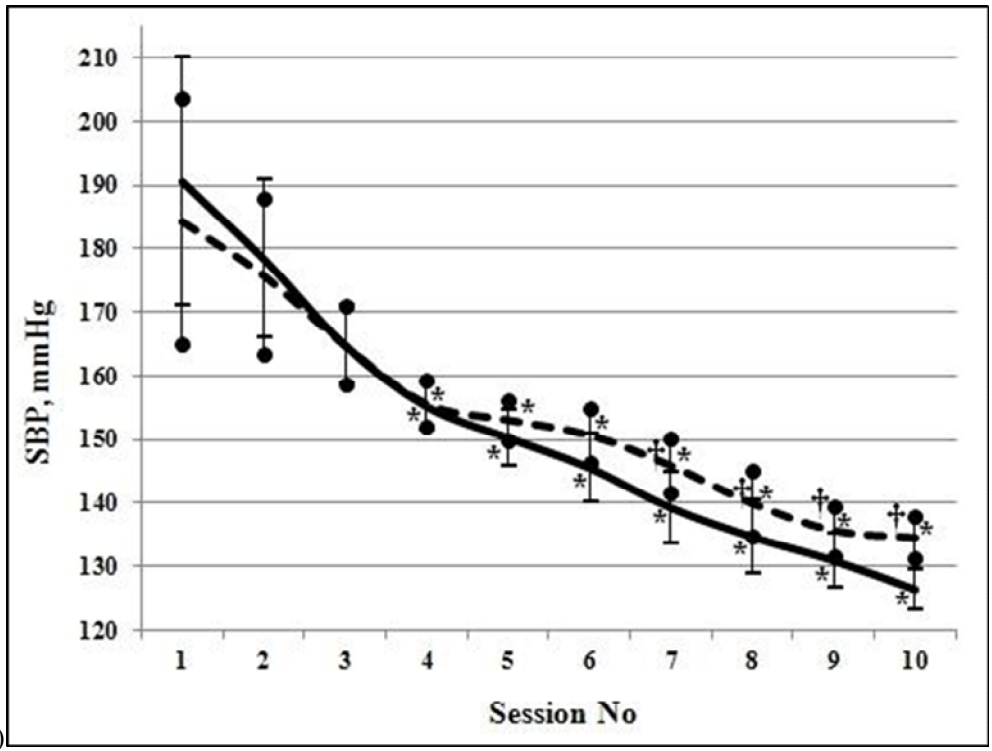
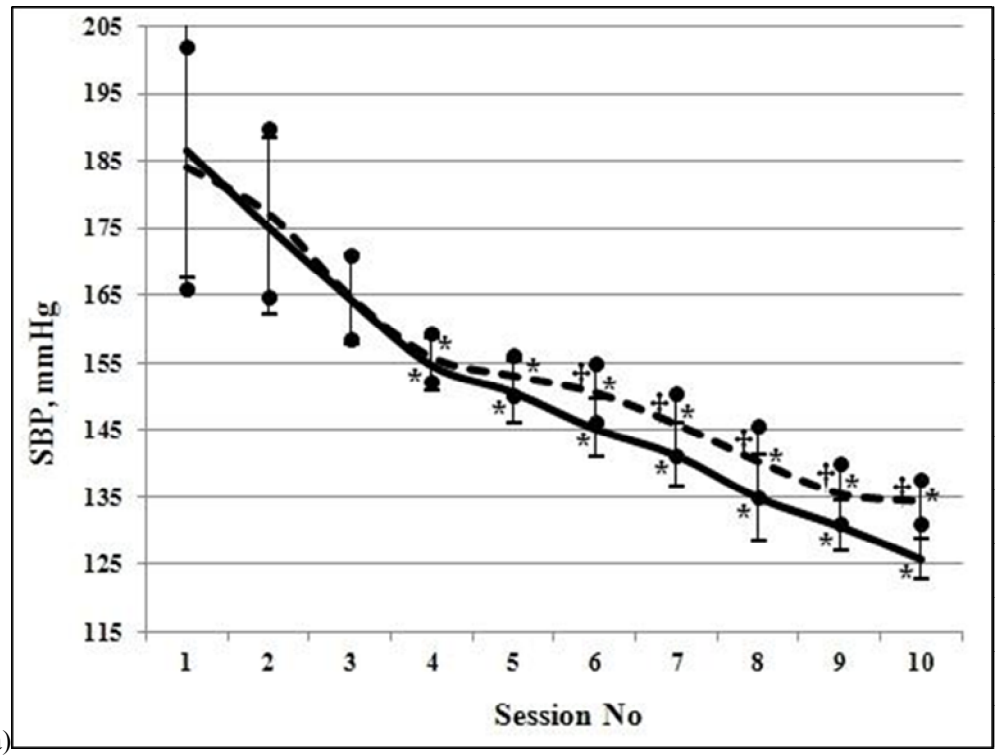


Fig. 4. Changes of SBP mean values in female (Fig. 4a) and male (Fig. 4b) patients in groups of BFB and comparison at stages of observation

Note: ▬▬ - BFB group; ▬ ▬ - comparison group; * - P < 0,01 in the series against the baseline values; † - P < 0,01 between series on the current session.

Changes of SBP in patients with AH in stages of the study in groups of BFB and comparison in different age groups are presented in Figure 5. Implementation of biofeedback sessions in the background of standard medical therapy provides significantly ($p < 0.01$) better control of SBP in patients of mature age from 6 (Fig. 5a), elderly - from 8 (Fig. 5b) and old - from 9 (Fig. 5c) session as compared with that in the control group.

a)



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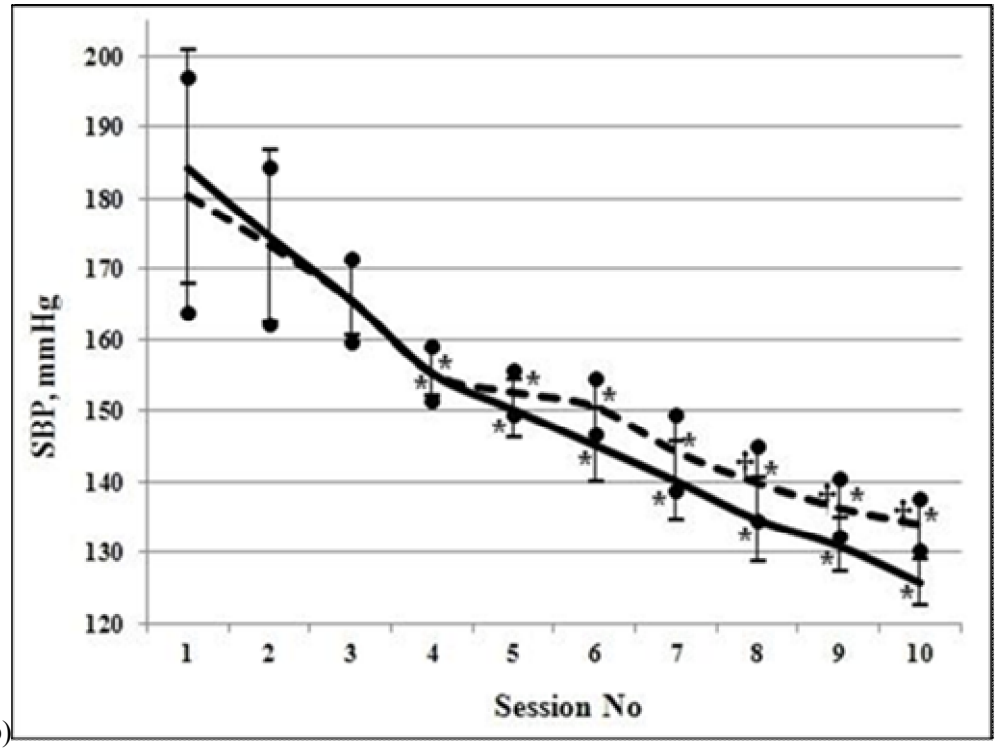

c)

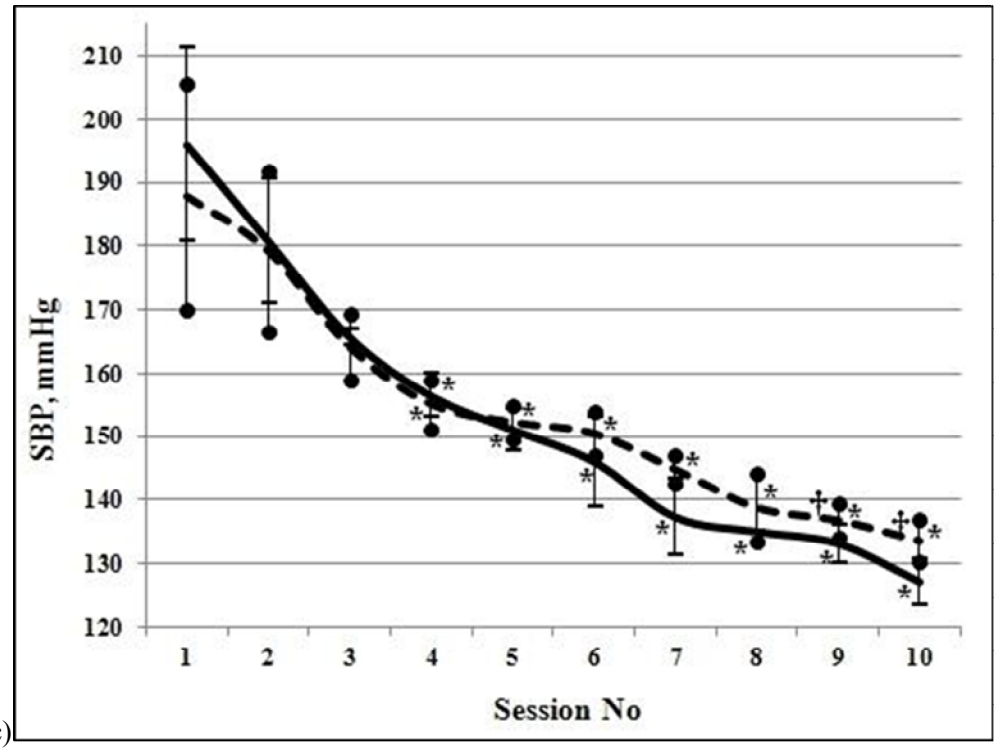

Fig. 5. Changes of SBP mean values in patients of mature (Fig. 5a), elderly (Fig. 5b) and old (Fig. 5c) age in groups of BFB and comparison at stages of observation

Note: ▬▬ - BFB group; ▬ ▬ - comparison group; * - P < 0,01 in the series against the baseline values; † - P < 0,01 between series on the current session.

Low in some patients manageability of SBP on the background of drug therapy [9] requires a search of new control methods including drug-free. BFB in the loop of PB and HRV is promising treatment for AH due to exposure to the key link of the pathological condition - sympathovagal regulation [10].

In general population standard medical therapy allowed to reduce SBP by 26.6 %,

additional BFB sessions improved this index to 32.3 %.

The degree of SBP reduction in control group was 14 % for I, 26,6 % in II and 28.8 % for III stage of AH, and in the BFB group - 23.7 %, 32 % and 33.4 %, respectively. Probably, rising with AH stage increasing sympathovagal imbalance increases the sensitivity of regulatory systems to BFB [11], which was manifested in further decrease of SBP.

As for degrees of AH in patients of comparison group SBP decreased by 13.4 %, 23.5 % and 22.2 % with 1, 2 and 3 degrees, and in the BFB group – 21 %, 28.3 % and 36 3 %, respectively.

Standard medical therapy in the degree of SBP lowering was equally effective in male and female, but more significant in the BFB group, where it fell by 33.7 % and 30.8 % against 27 % and 26.8 %.

In patients of mature, middle and old age against the background of pharmacotherapy was noted almost same reduction of SBP (27 %, 25.7 % and 28.9 %, respectively). In the BFB sessions the reaction was much better - 32.6 %, 31.8 % and 35.1 %, respectively.

Our study confirmed [12] that the inclusion of BFB with the loop of PB and HRV to the therapy of patients with AH significantly increases its effectiveness against the isolated drug therapy regardless of the stage and degree of the disease, gender and age. The effectiveness of additional BFB sessions in the loop of PB increases with the stage and degree of AH and is not associated with gender and age of the patients.

Obtained data allow to recommend this technique in clinical practice for patients with low SBP reduction during the treatment, and in AH generally as an additional therapy.

CONCLUSIONS

1. Biofeedback in the closed loop of paced breathing under the control of heart rate variability parameters can be used as a technology which increased the efficiency of the of systolic blood pressure control in arterial hypertension.
2. Efficiency of biofeedback sessions in closed loop of paced breathing under the control of heart rate variability parameters in systolic blood pressure control in arterial hypertension increases with the stage and grade of the disease and not depends on age and sex of patients.
3. Biofeedback in the closed loop of paced breathing under the control of heart rate variability parameters is especially useful in the arterial hypertension control in patients with inadequate reduction of systolic blood pressure.

PROSPECTS FOR FUTURE STUDIES

It is interesting to evaluate the effectiveness of in the closed loop of paced breathing under the control of heart rate variability parameters in control of diastolic blood and pulse pressure.

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