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**VEGETATIVE AND HEMODYNAMIC RESPONSES TO STRESS IN ADOLESCENTS WITH
CONSTITUTIONAL-EXOGENOUS OBESITY AND VASCULAR DYSTONIA OF HYPERTENSIVE TYPE**

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We studied the characteristics of central hemodynamics and autonomic responses to cold and psycho-emotional test in adolescents with obesity and vascular dystonia of hypertensive type. Various options for the autonomic responses accompanied by changes in central hemodynamics as a function of body weight have been identified.

Keywords: *obesity, adolescents, blood pressure, cold test, psycho-emotional test*

Изучены особенности центральной гемодинамики и вегетативной реакции на холодовую и психоэмоциональную пробу у подростков с ожирением и с вегето-сосудистой дистонией по гипертоническому типу. Выявлены различные варианты вегетативной реакции, сопровождающиеся изменениями центральной гемодинамики в зависимости от массы тела.

Ключевые слова: *ожирение, подростки, артериальное давление, холодовая проба, психоэмоциональная проба*

Introduction

Obesity is one of the leading risk factors for arterial hypertension (AH) [1,2]. It is shown that tracking of the initially high blood pressure in children and adolescents and its transformation into arterial hypertension in adult life are associated with overweight and obesity [3]. Metabolic disorders, as well as autonomic dysfunction and closely associated with it chronic psycho-emotional stress lay at the heart of the development of arterial hypertension in children and adolescents with obesity. The effect of stress on the prognosis of cardiovascular disease in adolescence has been studied poorly. Excess reactivity to stress is an important marker of onset and progression of hypertension [4]. It is essential that 17-25% of «teenage» arterial hypertension and cases of «high blood pressure» goes into the category of «adult» pathology [3]. It is generally accepted that autonomic changes during stress are the predominance of tonus of the sympathetic nervous system over the parasympathetic and hemodynamic changes as secondary shifts caused by changes in autonomic regulation [5,6]. The possible predominance of activity of parasympathetic part of autonomic nervous system to stress has been noted [5,7]. Vagotonic reaction to stress is a pathological form of psycho-vegetative syndrome, the reaction of disintegration [5,6].

The goal: to study features of the clinic, mental status, changes in blood pressure, central hemodynamics and autonomic responses to cold and psycho-emotional stress in adolescent with obesity in combination with vascular dystonia (VVD) of hypertensive type.

Materials and methods

The study involved 88 adolescents, aged 15-17 years. Group I, the main, contained teens with constitutional-exogenous obesity of I — IV degree and (VVD) of hypertensive type (14 boys and 16 girls); II group, group of comparison — teens with (VVD) of hypertensive type and normal BMI (20 boys and 10 girls); III group, the control — relatively healthy adolescents (14 boys and 14 girls). The examination program included the use of a complex of methods: clinical (medical history, anthropometry with kaliperometry and the percentage of fat mass by Shkerly formula); to study the psychological status of adolescents we used Spielberger-Hanin scale to determine the level of personal anxiety, Eysenck test — to determine the personal characteristics of adolescents. Study of central hemodynamics was carried out with tetrapolar thoracic rheography with the definition of index of peripheral vascular resistance (IPVR, $\text{din.sm}^5 \text{ c}^{-1} / \text{m}^2$); the average blood pressure according to the formula $\text{BP aver.} = \text{Systolic BP} \times 0.42 + 0.58 \times \text{Diastolic BP}$. We used the method of variation intervalometry to study the function of the autonomic nervous system defining: the mode amplitude (Amo,%), variation range (VR), coefficient of monotonicity (CM), which was calculated using the formula: $\text{CM} = \text{Amo} (\%) / \text{VR}$, index of stress (IS), calculated by the formula: $\text{IS} = \text{Amo} / \text{Mo} \times \text{VR}$, reflecting the activity of the sympathetic nervous system. The survey was conducted at rest and during stress tests: cold and psycho-emotional. Statistical processing has been carried out with the program «Statistica 6.0»

Results of the study and discussion

Clinical examination showed that all the teenagers of I and II group had the numerous complaints, often associated with neurovegetative disorders: headaches, increased blood pressure, weakness, fatigue, unstable mood, pain in heart. Adolescents with obesity complained on overweight, shortness of breath, abdominal pain, thirst, sweating, irritability, frustration with the body. Medical history revealed that mothers of adolescents as the main group and comparison group are equally often have pathology of pregnancy and childbirth: 90% and 80%, respectively. Complications of pregnancy and birth were preeclampsia, threatened abortion, prolonged or precipitated labor in more than half cases; third of the examined newborns had hypoxia or asphyxia at birth, birth trauma. Among healthy adolescents unfortunate course of ante- and perinatal period was noted in 25% of observations, $p < 0.05$. Hereditary predisposition to obesity has been noted in virtually 100% of cases among adolescents of group I that prevailed through the maternal line: obesity in 90% of mothers and in 60% of fathers. In the comparison group and in healthy adolescents obesity in bloodlines took place only in 33.3% and 7.1%, $p < 0.05$. Relatives of teen groups I and II in comparison with healthy adolescents had significantly more diseases of the cardiovascular system: coronary artery disease (33.3%, 56.7%, 7.1%, $p < 0.05$), arterial hypertension (83.3%, 76.7%, 7.1%, $p < 0.05$) and diabetes mellitus of type I and II (I — 33.3%, II — 6.1%, $p < 0.05$). In relatives of healthy adolescent diabetes has not been detected.

Attention has been attracted to harmful habits such as smoking and alcohol using among adolescents of groups I and II. Smoking occurred almost 2 times more frequently in adolescents of II group — 76.7% of cases, against 33.3% of adolescents with obesity and 7.1% in adolescents of group III ($p < 0.0001$). Alcohol abusing has been found significantly more frequently in adolescents of comparison group — 46.7% than among adolescents and the main control group (23.3% and 14.3%), $p < 0.0001$.

Objective examination of all major groups of teenagers showed that all adolescents have constitutionally-exogenous obesity complicated by secondary diencephalic syndrome, while I degree of obesity was found in 26.7%, II — in 20% and more often III — IV degrees — in 53.3% of cases, $p = 0.0001$. The average value of BMI in the group I was 32.04 ± 5.19 and was significantly higher than in group II and III — $(21.37 \pm 2.3$ and 21.44 ± 2.4 respectively), $p = 0.0001$. The average value of body fat percentage (BFP) in the main group of teenagers was 30.93 ± 9.6 . In adolescents with complicated obesity abdominal fat depositing has been defined in 83.3% of patients. It is important to emphasize that both adolescents with obesity and adolescents of comparison group had signs of dysembriogenesis as twisted little fingers and toes, sandal-type incision of toes, anthelix, low growth of hair, hypertelorism and others, which are indirect indication of fetopathy. Frequency of comorbidity of ENT organs (chronic tonsillitis, sinusitis) is high among adolescents of groups I and II — more than in 2/3 of adolescents (76.6%, 83.3%), $p > 0.05$.

Among the personal characteristics in adolescents with obesity introverted character of the person significantly prevailed — 60%, in the comparison group — 30%, in the control group — in 17.9%, $p < 0.05$; frustration with own appearance — in 66.7%, 33.3% and 7.9% respectively, $p < 0.05$, low self-esteem — in 73.3%, 43.3% and 10.7% respectively, $p < 0.05$. The high level of personal anxiety was diagnosed in 53.3% and 20% of the patients of I and II groups, $p < 0.05$ and in 10.7% of adolescents of the control group. Family analysis revealed that examined adolescents with obesity were significantly more frequently in single-parent families (the vast majority were without fathers) — in 43.3%, in the comparison group — in 26.6%, in the control group — 3.6%, $p < 0.05$. 26.6% of adolescents of study group lived in destructive families and significantly more often adolescents of the comparison group — in 40.0%, $p < 0.05$. Healthy adolescents grew mainly in harmonious families (75%). The main type of parenting in families of adolescents of groups I and II is erratic style with emotional rejection (6.7% and 20%), $p > 0.05$, coniving hyperprotection — in 23.3% and 26.6%, $p > 0.05$. Patologizing types of parenting in families of the control group were significantly less and in total amounted to 28.5%. Correlation analysis of psychological indicators of adolescents with obesity revealed statistically significant higher feedback of level of personal anxiety to the level of self-esteem ($r = -0.83$; $p < 0.001$) and feed-forward with high directivity of introverted personality and the type of family relationship (TFR): ($r = 0.84$ $p < 0.001$, and $r = 0.93$; $p < 0.001$). There was substantial significant inverse correlation between self-esteem and level of introvertivity of person ($r = -0.91$; $p < 0.001$). Adolescent self-esteem as a characteristic of personality which is influenced by microsocial environment has highly reliable direct connection with TFR ($r = 0.71$, $p < 0.001$) and TFE (the type of family education) ($r = 0.79$, $p < 0.001$). It is worth to note correlations of anthropometric and psychological indicators among adolescents of the main group. It was revealed that body weight has reliable feedback with self-esteem ($r = -0.79$ $p < 0.001$) and expressed feed-forward with TFR and TFE: ($r = 0.91$, $p = 0.001$; $r = 0.94$, $p = 0.001$); BMI has expressed feed-forward with TFE and TFR: ($r = 0.98$, $p = 0.001$; $r = 0.93$, $p = 0.001$) and feed-back with self-esteem ($r = -0.71$; $p = 0.001$). BFP significantly depends on all observed psychological symptoms. In addition to significant feed-forward of BFP with TFR and TFE: ($r = 0.48$, $p = 0.05$; $r = 0.50$, $p = 0.001$) significant feed-forward has been noted between BF and personal anxiety ($r = 0.74$, $p < 0.001$), significant feedback of BFP with self-esteem ($r = -0.58$; $p < 0.05$) has been revealed. There is reliable inverse correlation of waist /hip circumference and adolescent self-esteem ($r = -0.83$, $p < 0.001$) and expressed feed-forward with TFR and TFE ($r = 0.87$, $p < 0.001$; $r = 0.83$, $p < 0.001$).

Initial autonomic tonus was determined by the adapted version of the sign table of Wayne A. et al (1981). All teens of I and II groups had vegetative-vascular dystonia of sympathetic type, which clinically manifested in cephalgia and cardialgia of varying degrees of severity, arterial hypertension, weakness, irritability, distraction, mood variability, pale skin, white and pink dermatographism, tendency to tachycardia and temperature increase in infectious dis-

eases, atonic constipation, restless, short bed. Changes in the cardiovascular system in adolescents with obesity were characterized by muted heart sounds, systolic murmur; regardless of body weight in half of the adolescents we observed cardialgia of medium intensity, aching nature, lasting from minutes to hours, occurring usually after psycho-emotional situations. Headaches, dizziness combined with the manifestation of «general maladjustment syndrome» occurs after emotional or physical strain, and significantly more common in adolescents with obesity (90% of cases) and in 46.7% of adolescents of comparison group, $p < 0.0001$. Increased blood pressure was diagnosed in all adolescents of main and comparison group.

Our research revealed three types of reactions of blood pressure to cold stress test (CST) — increase, decrease, and the lack of response. Increasing BP_{aver.} on 5% or more was found in 10% of adolescents in both I and II groups and on 7.1% in the control group. BP_{aver.} reduction on 5% or more was noted more frequently in adolescents of I and II groups compared to III — 56.7%; 43.3%; 17.9% respectively, $p < 0.005$. No reaction of BP_{aver.} to cold stress was detected in 75% of healthy adolescents and less frequently in adolescents of groups I and II (46.7% and 33.3%), $p < 0.005$. It was noted that blood pressure reduction in the examined adolescents occurred due to reduction of IPVR on 10% or more in all groups, but significantly more frequent in group I (33%) compared with control one (7.1%), $p = 0.001$. There were significant differences in the frequency of changes in pulse pressure (PP) between groups during cold test: increasing of PP was significantly more frequent in group I compared with III — 36.7% and 21% respectively, $p < 0.05$. Reduction of PP in both main and comparison group was significantly more often than in III (53.3%, 56.7%, 25%), $p = 0.001$; no changes of PP have been detected in the control group — 54% compared with groups I and II (10% and 20%), $p < 0.005$. At the same time in groups I and II PP during CST tended to increase than in the control and was ΔPP (I gr. = 3.62%, I II gr. = 1.68%), while in the comparison group we observed opposite direction of the reaction PP to cold stress — at average PP decreased on 5.03%.

The autonomic response to cold stress in all groups of surveyed has been studied. Surveyed patients were divided according to changes of tension index (TI) to cold stress into groups of sympathoadrenal response to cold stress (with increase of TI on 10% and more) and parasympathetic response to cold stress (with decrease of TI on 10% or more). Activation of the sympathoadrenal system during cold stress test was significantly more frequent in group III (46.4%) compared with group I (28%), $p < 0.002$. Differences in the severity of the changes of TI in adolescents with predominance of sympathetic activity during cold stress among groups have been detected (ΔTI I gr. = 15.74%, ΔTI II gr. = 23.66%, ΔTI III gr. = 20.01%, $p > 0.05$). Parasympathetic autonomic response to cold stress was identified in all three groups, but in group I it was significantly more often than in control group — 44% and 28.9% respectively, $p = 0.027$. Reduction of TI in adolescents with parasympathetic autonomic responses was most significant in group I — ΔIS I gr. = -51.96%, ΔIS II gr. = -20.22%, ΔIS III gr. = -20.52%, p I-III < 0.005 , p I-II < 0.005 .

The relationship between the changes of autonomic parameters to cold stress and level of anxiety, introverted nature of person, self-esteem has been studied. In group I high level of anxiety was identified in 53% of cases, of which vagotonic reaction to cold stress was in 56,3% of adolescents; in group II high level of anxiety was registered in 20% of cases and was accompanied by vagotonic response to cold stress in 83%; in group III — in 10,7%, but these adolescents did not have vagotonic reaction to cold stress ($p = 0,0001$). Introverted character of person have been identified in groups I and II in 60% and 30% of adolescents; vagotonic reaction to the cold stress was met with the same frequency — in 44.4% of observations. In healthy adolescents introverted character of the person have been identified only in 17.9% of cases, however vagotonic reaction to cold stress have not been observed. Low self-esteem have been found in adolescents of group I in 73.3% of cases, group II — in 46.2%, group III — in 10.7%, $p < 0.05$. Vagotonic response to cold stress have been encountered in groups I and II in 40.9% and 30%. In healthy adolescents with low self-esteem vagotonic reaction to cold stress have not been identified. During carrying out the Spearman correlation analysis we revealed high significant correlation between anxiety level and the development of vagotonic reaction in I and group II ($r = 0.53$; $p = 0.03$), ($r = 0.9$; $p = 0.014$), respectively; significant correlation between introverted character of person and vagotonic reaction in the study group ($r = 0.64$; $p = 0.03$); and correlation in the comparison group ($r = 0.35$; $p = 0.006$); low correlation between low self-esteem and vagotonic reaction of group II ($r = 0.27$; $p = 0.03$).

Adolescents of all groups have three variants of BP_{aver} changes and autonomic changes with predominance of sympathetic over parasympathetic responses to the psycho-emotional test (PET) as well as for cold stress. Increasing of BP_{aver} on 5% or more occurred with equal frequency (in 36.7% cases), both in the study group and comparison group; in the control group increasing of BP_{aver} on 5% or more has been found in 17.4%, which is significantly less than in groups I and II, $p = 0.002$. Decreasing of BP_{aver} occurred in all groups, but it was less in the main group (3.3%) than in control one — 14.3%, $p = 0.011$. BP_{aver} on 5% or more in the comparison group was comparable with the control group (16.7% and 14.3%, respectively), $p > 0.05$. No changes BP_{aver} to psycho-emotional test in group I had no significant differences (60% and 67,9%, respectively), $p > 0,05$ in comparison with group III. In group II no changes in BP_{aver} occurred less frequently (in 46.7%) than in group III, $p = 0.004$; significant difference from I group have been identified, $p = 0.089$.

Autonomic response to the psycho-emotional test (PET) in all the groups of surveyed has been studied. Analysis of TI changes revealed that activation of the sympathoadrenal system (increase on 10% or more) to PET have been detected in all three groups and no significant differences between groups were received (60%, 57%, 46.6%), $p > 0.05$. While the change of TI on average was ΔTI I gr. = 141.6%, ΔTI II gr. = 118.3%, ΔTI III gr. = 56.32%, $p < 0.05$ and was more pronounced in group I than in group II and control group. In all three groups parasympathetic autonomic response to PET was identified, but in group I and group II it was diagnosed more frequently

(in 36.7% and 40% of cases) than in control (a 17.9%), $p < 0.005$. Change of TI in adolescents with parasympathetic autonomic responses to PET averaged — ΔTI I gr. = -45.44%, ΔTI II gr. = 38.56%, ΔTI III gr. = -32.9% and significant differences did not matter, $p > 0.05$.

Conclusions

1. Adolescents aged 15-17 with obesity and VVD of hypertensive type had: hereditary predisposition to obesity (100%), high frequency of psychosomatic disorders in relatives — CHD (33.3%), arterial hypertension (83.3%), diabetes of type I and II (33.3%); pathology of pregnancy and delivery among mothers of probands (90%); diseases of ENT organs (76.6%), prevalence of III-IV degrees of obesity (53.3%) with abdominal fat depositing (83.3%).

2. Analysis of the psychological characteristics and microsocial environment of children with obesity reveals significant presence and significant correlation between: a high level of personal anxiety, low self-esteem, the predominance of introverted orientation of the person, change the type of family relationship (destructive families) and family education (prevalence of unstable parenting style with an emotional rejection of the child, conniving hyperprotection).

3. In adolescents with obesity and VVD of hypertensive type in comparison with healthy adolescents during cold stress test we met more often marked vagotonic reaction to stress, accompanied by decrease in blood pressure and IPVR, which is indicator of maladaptation of autonomic and hemodynamic support of stress.

4. After psycho-emotional test in adolescents with VVD of hypertensive type regardless of body weight we observed parasympathetic autonomic reactions that were significantly more often than in healthy adolescents.

5. Adolescents with VVD of hypertensive type have high frequency and significant correlation of vagotonic reaction with high level of anxiety in adolescents, regardless of body weight, and significant correlation between introverted personality and vagotonic response in adolescents with obesity.

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