Pathogenetical Peculiarities of Arterial Hypertension with Weight Increasing on Psychological Stress Background

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Abstract — The article examines the pathogenetic features of the rearrangement of body functional state, against the background of psychological stress. At the present time the steady increasing of flow of information and emotional stress lead to load increase of the central nervous system. It is necessary to increase the nutrient substrate – glucose and, for its aerobic catabolism the necessary amount of oxygen, to meet the intensification of the activity of the central nervous system. The increasing of energy costs of the central nervous system is accompanied by anticipation, which leading to change in eating behavior, and turning on a stress-hunger-food mechanism. Above mentioned factors lead to body weight increasing, and respectively, to increasing of the absolute circulating blood volume. At the same time, the relative circulating blood volume (ml/kg body weight) decreases, which leads to a shortage of blood coming to vital organs, including the central nervous system. Blood deficiency compensated by centralizing blood circulation, which is achieved by peripheral vascular spasm. In addition, there is psychological stress affect human body, that is constantly present in the modern lifestyle. Chronic psychological stress, leading to permanent activity of the sympathetic-adrenal system, is a concomitant factor of peripheral vascular spasm. Against this background, the conditions for the development of hypertension are created.

Keywords — pathogenesis, anticipation, psychological stress, obesity, hypertension.

I. INTRODUCTION

A distinctive feature of the modern way of life is the change in the relationship between the changed factors of the external environment and the human body. First of all, this was due to an avalanche-like stream of information and psychoemotional tension, leading to a reorganization of the functional state of the organism and the development of various pathological conditions [1]. At the same time, the totality of the increasing information flow and psychoemotional tension is a psychological stress (PS), which is accompanied by a change in eating behavior, violation of lipid, carbohydrate, protein, mineral metabolism, including against the background of energy costs of the central nervous system (CNS) and depletion of its resources And raschvitis of nutritional obesity (AO), insulin resistance, and then hyperglycemia (type 2 diabetes mellitus – DM-2), arterial hypertension (AH) [2].

AH, together with AO, hyperlipidemia (GLE) and CD-2 is part of the widespread, currently metabolic syndrome (MS) [3–9].

It should be noted that MS is considered as a combination of symptoms, each of which aggravates the course of other independent pathological conditions that make up its composition.

In our opinion, it is advisable to consider MS from the viewpoint of a consistently developing cascade of manifestations of a single pathological process, the starting
factor of which is psychological stress (PS) [1]. This will allow us to approach the interpretation of the laws of the development of hypertension and other components of the MC, from the new positions, and, accordingly, the development of a strategy for its treatment.

II. MATERIAL AND METHODS

Our research is based on the results of analysis of published research results and their interpretation from the position of the development of the body's response to the PC and the consequences of these reactions for its functional state.

The principle of the dominant [10, 11], the principles of the regulatory function of the central nervous system aimed at maintaining homeostasis, formulated in the theory of functional systems [12, 13] and the regularities of endogenization of pathological processes were taken as a basis.

The principle of the dominant is that with the emergence of a priority focus of excitation in the central nervous system, the main resources are directed at satisfying the demands in the energy and plastic substrate of this dominant excitation focus. The remaining parts of the brain are provided by the residual principle [1, 11].

At the same time, for the emergence of this priority focus of excitation in the central nervous system, it is necessary to receive information about an intensive request to the body, that is, the effect of a stressor leading to changes in homeostasis. That is, the response to the stressor, aimed at preserving homeostasis, is vitally important for the body.

Thus, under the influence of external factors, a functional state changes at the cellular, organ, tissue level (Fig. 1). The information on this on afferent conducting ways arrives in the central nervous system. In parallel, there is a release of biologically active substances into the blood, which, due to humoral transport, also ensures the transfer of information. That is, the transfer of afferent information occurs both in a nervous and humoral way.

![Fig. 1. Principles of the regulatory function of the central nervous system in maintaining homeostasis](image)

The information arriving in the CNS is analyzed and then the response is simulated - responses to the received and analyzed information, a model of the desired result is synthesized, a functional system is formed, with the involvement of the sought-for organs, systems and body resources to achieve the desired result. At the same time, the modeling of the response takes place taking into account the coping strategies of the organism, acquired during the previous life experience and the psychoemotional state due to afferent information.

Efferent information about the response, directed at obtaining the final positive result – preservation of homeostasis, is transferred neurohumoral to the effector organs, the excitation or inhibition of which leads to a certain result.

On the principle of feedback, the preliminary result obtained is tested in the analytical department of the central nervous system for compliance with the desired model - preservation of homeostasis. In the absence of compliance, new body resources are attracted and a new functional system is formed with the inclusion of additional organs and systems to preserve homeostasis.

It should be noted that the body reacts to the stressor in the on-line regime, without taking into account the consequences of the responses for its functional state. In this case, prolonged exposure to stressors, even with moderate intensity, can lead to persistent changes in the functional state of the organism, its organs and systems. Moreover, these changes aimed at an adequate response to external influences can in fact be pathological in nature for the whole organism, but necessary to optimally respond to stress.

That is, the newly acquired functional state of the body, based on vital activity in conditions of chronic stress, despite the consequences of reactions to stress, becomes physiological for the new conditions. At the same time, reactions to long-term stressors, when implemented, initially solve the priority task, create prerequisites for the development of pathological conditions from intact organs and systems not involved, or indirectly involved in responding to stress.

Accordingly, in substantiating the pathogenetic features of the development of hypertension with increasing weight against the background of the PS, we considered:

- reaction to the SS from the position of the main target, for the impact of the stressor and energy satisfaction of the response to stress;
- as a reaction to PS promotes weight gain;
- as a reorganization of the functional state of the organism with chronic PS leads to the development of hypertension.

III. RESULTS AND DISCUSSION

A. Features of the central nervous system under the influence of the PS

PS has become an integral part of the modern way of life, the intensity of which is steadily growing. In this case, the main target for the effect of the PS is the central nervous system, sensory organs, conductive nerve impulse and endocrine organs involved in the stress response, which
provides a neurohumoral regulation of the response to external influences.

Under the increasing impact of psychoemotional stress and information flow, the intensity of the CNS activity sharply increases. This is confirmed by an increase in oxygen consumption from 20–25 to 50–70% of the amount used by the whole organism. In parallel, the intensity of volumetric blood flow increases by 30–50% from the resting state (15% of the total volume blood flow of the whole organism).

The main, almost the only energy substratum that provides the vital activity of the central nervous system are carbohydrates, primarily glucose.

Despite the fact that there is an opinion that, regardless of the state of rest or intensive brain activity, the brain spends 5–6 g of glucose per hour [14], an increase in brain oxygen consumption indicates exactly a sharp increase in energy costs due to aerobic catabolism of glucose.

At the beginning of the day, the supply of glucose is due to the storage of glycogen stored in the liver.

However, during the day, against the backdrop of intensive cognitive activity against the background of psychoemotional tension, the demand for carbohydrates increases, which is not possible to provide due to glycogen stores in the liver. That is, the intake of easily digestible carbohydrates from outside with food is necessary.

Against this background, eating behavior changes with a priority increase in the intake of carbohydrate-rich foods throughout the day.

It should be noted that against the backdrop of automation of production and the introduction of new technologies, changes in physical activity characterized by hypodynamia dramatically reduce the energy expenditure of the vital activity of the organism. In this case, only the vital activity of the central nervous system is accompanied by a sharp increase in energy consumption.

B. Features of weight gain on the background of PS

The chronic effect of PS leads to the fact that for a long time, due to changes in eating behavior, there is an increased consumption of carbohydrates during the day. Against this background, a model of metabolism is formed with an emphasis on the use of glucose catabolism as the main form of energy supply for the vital activity of the organism.

The duration of chronic PEIS, whose target is the central nervous system contributes to the activation of compensatory-adaptive mechanisms, in particular, preventive adaptation - anticipation. That is, for the energy supply of the previous intensive CNS activity, the consumption of carbohydrates increases not in on-line mode, but in advance. This is achieved by increasing the consumption of carbohydrates, not only in the course of intensive CNS activity, but also at rest. As a matter of fact, "stress seizure" will be noted, as the implementation of the previously formed coping strategy of the organism, its eating behavior in response to the stressors.

It should be noted that in oxidative phosphorylation of metabolites of anaerobic stage of glucose catabolism, fatty acids, glycerin, amino acids, oxidative phosphorylation occurs in the mitochondria, resulting in the formation of pyruvate, citrate, a-ketoglutarate and acetyl-Co A (acetylcouoenzyme A).

The presence of common metabolites assumes the commonality of the metabolism of glucose, fatty acids and amino acids the possibility of their mutual transformation. Exceptions are essential amino acids.

Of particular note is the fact that the anabolism of glycogen in the liver occurs only to the initial level, without increasing its reserves, taking into account the expected intensive use of glucose during the future intensive CNS activity.

Accordingly, acetyl-Co A and other metabolites of the anaerobic stage of catabolism of surpluses received due to the excision of carbohydrates, after restoration of the initial level of glycogen in the liver, will be used for the synthesis of alternative energy carriers - free fatty acids. The release of free fatty acids into the blood will be accompanied by the activation of adipocytes, in which their deposition will occur. This creates the prerequisites for accumulation of lipids in adipocytes and increase in body weight.

C. The development of hypertension with weight gain on the background of PS

In this section we carry out the justification for a single axis of the PS - AO - AG, as successively developing stages of a single pathological process (Fig. 2).

Under the influence of chronic psychoemotional and information stress, the response of body provides for the permanent activation of the sympathetic-adrenal system. At the same time, the intensity of the stressor is much less than with acute stress, which helps maintain its compensatory capabilities for a long time.

An increase in the activity of the sympatho-adrenal system will contribute to the development of a long peripheral angiospasm. That is, prerequisites are created to reduce the capacity of the circulatory bed and increase blood pressure.

It should be noted that even Reaven (1996) drew attention to the role of the sympatho-adrenal system in the development of AH in MS [15].

However, due to the low intensity of the stressor, a persistent increase in blood pressure in such situations will not be detected.

Against the backdrop of intense CNS activity accompanied by a change in eating behavior and an increase in carbohydrate intake, there will be an increase in body weight.

In parallel with the increase in weight, the absolute volume of circulating blood (BCC) will also increase, which, in turn, will lead to an increase in the burden on the heart.

It should be noted that against the background of an increase in the absolute BCC, the relative BCC - the volume of blood per unit of body weight, will decrease, which creates a circulatory deficit in all organs and tissues of the body.
Over time, under the influence of PEIS and the reaction to it in the form of "seizing stress" will increase the weight gain and absolute BCC. In this case, the deficit of relative BCC will increase, which will be compensated for by centralizing blood circulation to ensure the vital activity of vital organs and, in the first place, the central nervous system.

Fig. 2. Pathogenetic features of the arterial hypertension development with increasing weight against the background of psychoemotional stress

D. The role of psychological stress in the formation of eating behavior during pregnancy and the first year of life

There is close attention paid in the study of the functional state of the mother-placenta-fetus complex, because it determines the development of the fetus during pregnancy.

The great attention is paid in the issue of the development of the fetus and newborn during the first transaction period in psychology. The first transaction period starts from the moment of conception and lasts for the first year of baby's life. Functional, emotional and somatic state is transmitted to the child through the mother-placenta-fetus system.

It is affect the physiological and psychological development of the fetus. Strategies for responding learning to external stimuli take the place by this way.

The child intuitively learns the behavioral characteristics of pregnant mother, who is affected by psychological stress and hormonal changes.

Our study is focused on the response features of pregnant woman to a psychological stressor and the impact of PS on the formation of eating behavior in the first transactional period. In this regard, we paid special attention to study these issues.

The fetus is not able to objectively assess the features of a particular stressful situation, and its importance as a life-threatening factor. Therefore, it is not able to choose a strategy to respond to this stressful situation.

The reaction of the pregnant mother can be the only one available source of information about specific stress to the fetus. Biochemical composition of the blood changes due to incoming of stress hormones, primarily of adrenaline, in response to the stress.

Incoming of adrenaline and other stress hormones to the blood is happen at the cognitive level. Therefore, the reaction to stress occurs at the level of unconditional reflexes and instincts of the mother. Taking information comes to the fetus, and limited by the habitat of the fetus – functional state of uterus and placental blood flow.

Thus, physiological reactions of the fetus is determined by the role of PS to the mother's body.

Repeated stressful situations and a typical reaction of the mother's body to them during pregnancy will form a stable relationship between the biochemical changes in placental blood and the functional state of the organs and systems of the fetus.

The impact of PS does not depend on our desire and occurs in a constant mode. Therefore, even during conception there is remain the impact of psychological stressors to the woman's body.

The awareness of pregnancy for the woman in itself will be stressful, regardless whether the pregnancy was planned or not. Also, the features of psychological stress in case of unplanned pregnancy will depend on whether it was desired or not.

Moreover, from the moment of conception and awareness of pregnancy, stressors in their emotional color and orientation begin to change (Fig. 3)

Fig. 3. The role of psychological stress in pregnant women in the formation of eating behavior

It should be noted, in case of wanted pregnancy, it is does not matter if it was planned or not. The main stressor will be fear and anxiety, which is associated with a possible pathology of pregnancy, congenital malformations and the threat of its termination.

In the early stages of pregnancy, the most common is uterine hypertonicity, and its complication can be premature termination of pregnancy. At a later period, often develops gestosis, and then pregnancy may be terminated.

In case of unwanted pregnancy, especially if the pregnancy occurred outside of marriage, the main psychological stressors is:

a) waiting for the first conversation with a partner;
b) fear of partner’s reaction to the news of the pregnancy;

c) waiting for the first conversation with a parents;

d) fear of parents’ reaction to the news of pregnant daughter.

Prolonged period of making decision about termination or preservation of pregnancy has a great importance. There is a high probability of a fairly long period of doubt about the appropriateness of these conversations, and consideration of an alternative option – termination of pregnancy while maintaining secrecy.

A negative external reference from a partner and/ or parents to pregnancy can be assessed as a long-term psychological stressor. It can be manifested in the form of periodic episodes of discussion about the timeliness of pregnancy, reproaches for the rashness of the decision to maintain pregnancy.

Along with it, just as important the fact of absence of stable acceptable material security. Its associated with fears about the availability of financial opportunities, sufficient to bring pregnancy and, after that, to raise a child.

In addition, constant everyday stressful situations are accompanied by the effect of psychological stressors associated with pregnancy. Which means that its will be mutually amplified and aggravated by changes on the hormonal background of the woman.

Together, this will lead to unconscious anxiety and fear, which can be permanently stable or situationally amplified. The features of the formation of eating behavior strategies will be determined by permanent or situational increasing impact of psychological stressors.

Thus, the basic needs of the fetus and newborn will be life support and safety from the moment of conception and during the first year of life. These needs are perceived and realized at the level of unconditional reflexes and instincts.

Therefore, the role of PS of pregnant woman on the formation of eating behavior of fetus and newborn it should be considered as a consequence of the development of general adaptation syndrome.

The impact of psychological stress, accompanied by the activation of the sympathoadrenal system. This leads to the catecholamines entry into the blood, which have vasospastic action.

Angiospasm of the uterine vessels, increases the tone and the contractile function of the myometrium develop against this background. The combined development of angiospasm and hypertonicity of the uterus leads to a decrease of uterine blood flow and compression impairment of blood transport through the placenta.

Thus, the incoming blood containing elevated level of catecholamines and stress mediators to the fetus, combined with a decrease in placental blood flow, leads to hypoxia and nutrient deficiency. This will create conditions for the formation of the connection "stress (catecholamines)-hypoxia-hunger”.

“Stress (catecholamines) -hypoxia-hunger” connection realization will be fixed in one or another alternative form of eating behavior.

Thus, the strategy of “stress-hunger-emotional eating” will be formatted in case of situational effects of psychological stressors, even with their high intensity. It will manifest by taking more than usual food, rich with carbohydrates in stressful situations.

Conversely, permanent angiospasm, hypoxia and hunger will be associated by long-term violation of transport through the placenta to the fetus of blood in condition of chronic stress. Blood flow deficient leads to insufficient supply of oxygen and nutrients for the life support of the fetus. Formation of alternative variant of eating behavior: “stress-hypoxia-hunger- self-consumption” creates in the conditions prolonged oxygen and nutrients deficient.

The reason for this will be anticipation of prolonged hypoxia and the plastic and energy substrate deficient in condition of placental blood flow decreasing. It is used the accumulated energy carriers of their own resources, with the exception of the most energy- consuming processes in the body against this background. One of the energy- consuming processes is digestion.

After childbirth, the child’s reaction to any discomfort, i.e. stressful situation for him is standard – he begins to cry.

At this situations, mother’s reaction often standard too – it is feeding.

"Stress- emotional eating” eating behavior is established, in combination with the nutritional behavior formed during pregnancy. This reaction begins to be realized without such additional elements as "hypoxia-hunger”.

Thus, the frequency and intensity of PS steadily increases in the modern way of life. Along with it "stress- emotional eating” behavior if formed and fixed as the reaction to the stress, during pregnancy and breastfeeding during the first year. Among young population this creates a stable tendency of increasing of alimentary obesity.

Thus, in cases of stress usual eating behavior is "stress-emotional eating”. Emotional eating is brings to the increasing of food intake, which brings to increasing of frequency and rejuvenation of alimentary obesity.

At the same time, the negative impact of psychological stress leads to the formation of stress eating consumatory behavior among pregnant women and during the first year. That is, the psychological stress is a predisposing risk factor for hypertension in alimentary obesity for pregnant women and the newborn of the first year of life.

IV. CONCLUSION

Thus, the response to PEIS in the form of peripheral angiospasm on the background of activation of the sympathoadrenal system; An increase in the absolute BCC and an increase in the load on the heart; In parallel with the centralization of blood circulation, as a compensatory-adaptive reaction of the organism in response to a decrease in the
amount of blood per unit of body weight, in aggregate, will lead to hypertension.

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