SPECIFIC FEATURES OF THE MECHANISMS REGULATING SYSTEMIC HEMODYNAMICS IN WOMEN OF REPRODUCTIVE AGE

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Relevance: The cardiovascular system of women from the onset of menstruation to menopause functions under conditions of continuous hormonal remodeling caused by stage-related changes in endocrine status. In modern scientific literature, this phenomenon is described by the concept of the “hormonal continuum of women’s health,” with the majority of studies focusing on the effects of exogenous sex hormones on hemodynamic parameters. At the same time, in recent years, interest in the preservation and strengthening of women’s reproductive health has significantly increased [1].Nevertheless, data on age-related features of systemic hemodynamics and its changes during different phases of the menstrual cycle in apparently healthy women remain limited. The active use of modern invasive methods for assessing reproductive potential is usually accompanied by the need for anesthetic support, which requires special attention to the safety of the procedures performed. One of the key indicators of a favorable course of anesthesia is the maintenance of stable patient hemodynamics [3].

Keywords: Women of reproductive age, systemic hemodynamics, estrogen, invasive methods.

Introduction: Systemic hemodynamics in women of reproductive age is shaped by complex and dynamic mechanisms of neurohumoral regulation. Cyclical changes in hormonal background associated with the phases of the menstrual cycle play a significant role in these processes. Sex hormones exert multilevel effects on vascular tone, myocardial contractile function, and peripheral resistance parameters. Despite the growing interest in women’s health issues, the features of systemic hemodynamic regulation in apparently healthy women remain insufficiently studied. This problem is of particular importance in the context of diagnostic and therapeutic interventions requiring anesthetic management. Therefore, the study of the specific mechanisms regulating systemic hemodynamics in women of reproductive age represents a relevant task of modern medicine.

Aim of the Study: The aim of the present study is to investigate the specific features of the mechanisms regulating systemic hemodynamics in women of reproductive age depending on the age category (21–25, 31–35, and 41–45 years).

Materials and Methods: The study was based on monitoring hemodynamic and autonomic changes in women of reproductive age during the first and second phases of the menstrual cycle, as well as in postmenopause (physiological and surgical), across different age categories. The study was conducted in 2023–2024 at the Bukhara Perinatal Center, in the Department of Gynecology.A total of three groups of women were formed according to age, with 30 participants in each group: 21–25, 31–35, and 41–45 years. The second cohort included 40 women with physiological postmenopause and 28 women with surgical postmenopause, who were also divided into age subgroups of 46–50 and 51–55 years.To assess hemodynamic parameters, the following investigations were performed: complete blood count analyzed using a MINDRAY hematology analyzer (China), and estrogen levels determined by enzyme-linked immunosorbent assay (ELISA). Blood tests were conducted in the laboratory of the Bukhara Perinatal Center. Additionally, all participants underwent electrocardiography with heart rate variability analysis, peripheral vascular rheovasography, spectral analysis of hemodynamic signals, continuous noninvasive blood pressure monitoring, and respiratory wave recording.

Results: The analysis of systemic hemodynamic regulation in women of reproductive age revealed pronounced age-related and phase-dependent differences.In the 21–25-year age group, during the second phase of the menstrual cycle compared with the first phase, an increase in volumetric regulation parameters (stroke volume and cardiac output) by an average of 10–15% was observed, along with an increase in heart rate of approximately 8–12%. At the same time, the power of respiratory waves in the microvasculature decreased by 10–20%. Up to 60–65% of the increase in total spectral power of pulse amplitude and heart rate during the second phase occurred in the slow-wave range (P1–P2), reflecting humoral–metabolic regulatory mechanisms. Simultaneously, a compensatory increase in the activity of high-frequency cardiac regulators (P4, P3%) by 15–20% was observed, indicating enhanced autonomic influence.In women aged 31–35 years, the second phase of the cycle was characterized by a reduction in the power of respiratory waves in the aorta and peripheral vessels by an average of 15–25%, accompanied by a 20–30% increase in the total spectral power of aortic pulsation. Up to 70% of the increase in spectral activity of cardiac output, the aorta, and heart rhythm was attributed to the slowest frequency range (P1), indicating the maximal expression of humoral–metabolic regulation in this age group. In the baroregulatory range (P3), normalized indices decreased by 20–30%, whereas the contribution of the high-frequency range (P4) increased by 15–25%, reflecting enhanced parasympathetic and respiratory regulation.In the 41–45-year age group, the second phase of the menstrual cycle showed the greatest number of statistically significant shifts, affecting more than 75–80% of the analyzed parameters. A decrease in arterial blood pressure by 5–10%, an increase in heart rate by 10–15%, and an increase in volumetric pulsation in the central and peripheral circulation by 20–30% were observed, along with a simultaneous

reduction in respiratory waves of the aorta and microvessels by 25–35%. Overall regulatory spectral activity (S, Power) increased by more than 30%; however, the distribution of power across frequency ranges was less organized.Comparative analysis demonstrated that in women aged 41–45 years, absolute and spectral hemodynamic parameters in both phases of the cycle were on average 20–40% higher than those in younger age groups, accompanied by a 25–30% reduction in the proportion of slow-wave humoral–metabolic oscillations and an increased contribution of sympatho-parasympathetic regulation. Oscillatory activity of the microvasculature in women aged 41–45 years was characterized by lower variability and less pronounced phase-dependent differences compared with women aged 21–25 years.

Conclusion:The conducted study made it possible to identify pronounced age-related and phase-dependent features of the mechanisms regulating systemic hemodynamics in women of reproductive age. It was established that the menstrual cycle has a significant influence on the nature of hemodynamic responses, with the most pronounced changes recorded during the second (luteal) phase of the cycle. In women aged 21–25 years, the second phase of the menstrual cycle is characterized by a predominantly balanced adaptive response, manifested by a coordinated increase in volumetric circulation parameters, heart rate, and total spectral power of oscillations. Slow-wave humoral–metabolic mechanisms play a dominant role in hemodynamic regulation in this group, while preserved autonomic nervous system activity indicates a high level of functional reserves of the cardiovascular system.In the 31–35-year age group, the maximal expression of slow-wave regulation reflecting humoral–metabolic adaptive mechanisms was observed. During the second phase of the cycle, women in this age group demonstrated the most orderly redistribution of regulatory influences, with reduced baroreflex activity and compensatory enhancement of parasympathetic and respiratory components. This indicates an optimal level of adaptive capacity and the most physiological pattern of systemic hemodynamic regulation during this age period.In women aged 41–45 years, a decrease in the coherence of regulatory mechanisms and a reduction in the contribution of slow-wave humoral oscillations were identified, accompanied by enhanced neural sympatho-parasympathetic regulation. During the second phase of the menstrual cycle, the greatest number of multidirectional and less organized changes in hemodynamic parameters were recorded, which is likely associated with an age-related decline in sex hormone levels and a reduction in their regulatory influence on the cardiovascular system. Comparative analysis showed that with increasing age, spectral differences between menstrual cycle phases become less pronounced, absolute hemodynamic parameters increase, and the regulatory balance shifts toward high-frequency mechanisms. This reflects a gradual decline in humoral–metabolic control and an increasing role of neural regulatory influences.Thus, the identified features confirm the biological nature of phase-dependent adaptation of systemic hemodynamics in women of reproductive age and emphasize the necessity of considering both age

and the phase of the menstrual cycle when assessing the functional state of the cardiovascular system, as well as when planning diagnostic and therapeutic interventions, especially those requiring anesthetic management.

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