Spectral and Coherent Characteristics of EEG in Women during Various Phases of Menstrual Cycle

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EEG recording was performed in healthy women during various phases of menstrual cycle. Comparative study showed that the power spectrum of EEG α-waves in central and mediotemporal areas significantly decreases during ovulation. In the menstrual phase coherent characteristics of EEG α-waves increased in symmetrical occipital and intrahemispheric parieto-occipital areas.

Key Words: *electroencephalogram; spectral and coherent characteristics; menstrual cycle*

Reproductive function is regulated by CNS (up to the higher part of CNS). Study of spontaneous electrogenesis should elucidate the neurophysiological mechanisms for integration of the cortical-hypothalamic-pituitary-ovary system. Previous studies showed that some parameters of spontaneous and evoked brain activity vary during menstrual cycle in parallel with changes in hormonal status [2-9]. There are contradictory data on the type of these variations. It should be emphasized that studies of the central mechanisms of normal menstrual cycle do not take into account asymmetry of the female reproductive system. This system is characterized by lateralization of generative function in the ovaries. Despite the existence of paired ovaries and occurrence of multiple ovulation in each ovary, only one follicle in one of the ovaries usually undergoes maturation and ovulation over menstrual cycle. Published data demonstrate significant morphological and functional differences between the ovaries and predominance of the right ovary [1].

Here we studied spectral and coherent characteristics of EEG during various phases of normal menstrual cycle in conventionally healthy women of reproductive age.

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MATERIALS AND METHODS

Thirty-five women of 18-38 years were examined in various phases of menstrual cycle. The study was performed at the beginning of the menstrual cycle (day 2-3 of menstruation) and on the day of ovulation (as confirmed by the results of ultrasonography and measurement of rectal temperature). The anamnesis showed that these women were healthy and had regular menstrual cycle. Examination included ultrasound study of the size and location of the dominant follicle and EEG recording.

Recording and spectral-and-coherent study of EEG were performed using an Encephalan 131-01 hardware-software complex. Total bioelectric activity of the brain was recorded unipolarly in 16 leads according to the 10-20 system. Recording was conducted in symmetrical frontal, temporal, central, parietal, and occipital cortical areas (Fp1-Fp2, F3-F4, F7-F8, T3-T4, T5-T6, C3-C4, P3-P4, and O1-O2). The reference electrode was placed on earlobes.

During the first examination we recorded general and expanded EEG to perform a clinical study and estimate pathological features of brain activity. This approach is particularly important for subjects with neurological disorders.

Data visualization and selection of five 5-second EEG epochs without non-brain artifacts involved an application software package. For selected epochs the

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TABLE 1. Mean Power Spectrum of EEG α-Waves in Central and Temporal Areas of Women during Various Phases of the Menstrual Cycle (*M*±*m*)

Phase of cycle	Power spectrum of EEG α-waves, mkV^2			
	T3	T4	C3	C4
Menstruation	32.2±1.4	34.5±1.2	56.4±1.4	57.5±1.3
Ovulation	28.5±1.2	31.4±1.1	49.6±1.5	51.2±1.4

power spectrum and coherence were estimated by the fast Fourier transform algorithm for 16 channels in the range of EEG α-waves (8-13 Hz). The mean spectral and coherent parameters of EEG were calculated in the range of α-waves for different pairs of leads.

The significance of differences between mean values was estimated by Student's *t* test ($p<0.05$).

RESULTS

The total number of menstrual cycles was 32. Anovulatory cycles were excluded from the analysis. Ultrasound examination showed that in 23 of 32 cycles (72%), dominant follicles with a size of 15-25 mm are located in the right ovary. In 9 cycles (28%), dominant follicles with a size of 15-20 mm were revealed in the left ovary. It should be emphasized that ultrasound examination was performed 2-3 days before the estimated onset of ovulation, but not immediately before ovulation. It explains relatively small size of the dominant follicle. Our findings show that the right ovary has the main functional load.

The menstrual cycle lasted 24-30 days. Despite the existence of regular menstruations in examined women (one of the major inclusion criteria), the time of follicle maturation and onset of ovulation did not necessary correspond to 12-14 days (standard period). In some women ovulation was observed on days 9-10, while in others this process was delayed up to the 20th day. Electrophysiological parameters were evaluated taking into account the actual time of follicle maturation in each woman, but not the mean statistical length of phases in the menstrual cycle.

Comparative study showed that during ovulation the power spectrum of EEG α-waves in central and mediotemporal areas significantly decreases compared to that observed in the menstrual phase of the cycle (minimum concentration of sex hormones). The mean power of α-waves decreased symmetrically in both hemispheres (Table 1).

In women with dominant right ovary, variations in the power spectrum of EEG α-waves during ovulation were most pronounced in the left central area.

The hemisphere or brain area with low power of α-waves is characterized by greater functional activity (*i.e.*, more significant activation). Our results indicate that EEG activity in the left central area during ovulation is higher in women with dominant right ovary.

TABLE 2. Mean Values of Coherent Characteristics of EEG α-Waves in the Parieto-Occipital Area of Women during Various Phases of the Menstrual Cycle (*M*±*m*)

Phase of cycle	Pairs of leads		
	P3-O1	P4-O2	O1-O2
Menstruation	0.68±0.03	0.69±0.03	0.75±0.05
Ovulation	0.61±0.03	0.63±0.02	0.64±0.03

Coherent characteristics of EEG α-waves in symmetrical occipital and intrahemispheric parieto-occipital areas increased during the menstrual phase (Table 2).

These data show that coherence between bioelectric processes in the parieto-occipital cortical area increases during the menstrual phase of the cycle.

Our findings suggest that spectral and coherent characteristics of bioelectric activity in the brain significantly change over a normal menstrual cycle. It can be hypothesized that these parameters are sensitive to variations in the hormonal status and depend on the location of the dominant follicle. The study of EEG in various phases of the menstrual cycle will elucidate the role of central mechanisms in reproductive systemogenesis.

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