

EEG Characteristics in Women During Normal and Complicated Pregnancy

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Keywords: electroencephalogramme, functional interhemispherical asymmetry, gestational dominant, pregnancy.

Abstract: Clinical and spectral EEG analysis of 230 women on different gestational periods was carried out. The presence of morpho-functional asymmetries was found in the peripheral (placental localization) and central (gestational dominant) links of functional system “mother-placenta-fetus”. It has been shown, that functional interhemispherical asymmetry of the brain is the sensible parameter of normal and complicated gestation. It was found that the prevailing activation is characteristic for normal pregnancy in central and temple areas of the brain contralateral to the side of placental localization in uterus. The development of threat of fetus wastage accompanied by the inversion of interhemispheric asymmetry of EEG activation.

Zusammenfassung: *EEG-Charakteristika bei Frauen während normaler und komplizierter Schwangerschaft.* Es wurden bei 230 Frauen klinische und Spektral-EEG-Analysen zu verschiedenen Zeitpunkten der Schwangerschaft durchgeführt. Im funktionalen System „Mutter-Plazenta-Fötus“ wurden morpho-funktionale Asymmetrien zwischen Peripherie (Plazentalokalisation) und dem zentralen Nervensystem (schwangerschaftstypische Dominanzmuster) gefunden. Es konnte gezeigt werden, daß die Art der funktionalen Interhemisphärische Asymmetrie im Hirn ein sensibler Parameter für normalen und komplizierten Schwangerschaftsverlauf ist. Es wurde festgestellt, daß vorherrschende Aktivierung im zentralen Bereich des Hirns und im Schläfenbereich auf der kontralateralen Seite zum Sitz der Plazenta im Uterus charakteristisch für eine normale Schwangerschaft ist. Die Entwicklung zu einer drohenden Fehlgeburt war von einer Umkehr der interhemisphärischen Asymmetrie der EEG-Aktivierung begleitet.

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Introduction

At present time the demographical situation in Russia is critical because the death rate is twice larger than the birth rate. In these conditions, the searches of new

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methods of prognosis and diagnostics of obstetrical pathology, allowing decreasing perinatal complications and the death rate are rather important.

During the pregnancy new and biologically unique functional system “mother-placenta-fetus” (FSMPF) is formed in the woman’s organism, within the limits of which the purposeful integration of regulatory mechanisms of mother and fetus is realized [1, 2, 10]. The introduction of the systemic approach in the perenatology characterizes qualitatively new stage of development of this science: a step has been done from the discussion of separate mechanisms towards the study of their intersystem integration. Term “system” presumes the existence of the central-peripheral integration. According to the present ideas, the integrative centers of FSMPF are highest structures of central neurotic system (CNS) or “gestational dominant” [1, 13]. Gestational dominant is temporally predominant joining of cortical and subcortical formations in brain, possessing an increased excitability, capability towards the summation of the excitement, inertness of the induction of inhibition in the surrounding structures. Gestational dominant directs and concentrates the energy of neurotic excitement for the realization of the most meaningful physiological process for the organism in the present moment. Gestational dominant determines during the whole period of pregnancy not only the visceral, but also the behavioural reactions of the mother’s organism. The experimental and clinical observations indicate that the highest compartments of CNS participate in the regulation of FSMPF. It was shown that rhythmic skin irritation of fetuses is accompanied by the distinct reaction of desynchronization of the EEG of mother’s organism [8]. But the reverse influence of diencephalon structures of CNS on the state of placental hemodynamics was also proved [7]. Touching upon the clinical parallels, it is possible to indicate that pathological processes, affecting diencephalon structures of CNS, lead to the different complications of pregnancy [17], down to premature fetus wastage, that, according to A. Arshawskii [1], is the consequence of inhibition of gestational dominant.

At the basis of the developing by us model underlie the data, indicating the existence of asymmetry mechanisms of central-peripheral integration of FSMPF. So, in the number of investigations it is shown that the placenta may be set asymmetric relatively to the sagittal uterus cavity [12]. It is also shown, that the weight of fetuses under the right-sided placental disposition is bigger and the duration of delivery under the left-sided placental disposition is less [21]. According to the data, found in literature, it is possible to consider, that the asymmetric content of sex steroids in myometrium may be the mechanism determining the beginning of asymmetry of afferent uterus impulsation. It is known that under the influence of estrogens increases the activity of afferent uterus systems. Therefore, asymmetry of sex steroids content in myometrium may be the reason, that the afferent impulsation reaching the highest compartments of CNS will be also asymmetric. Therefore, it is possible to speak about the existence of lateralization of transplacental linking channels between mother and fetus and to presume the existence of factors determining this lateralization. It is necessary to underline that the asymmetry of reproductive apparatus during the pregnancy is formed within the limits of individual lateral phenotype, i.e. interconnected by visceral, somatic and brain asymmetry.

The significant achievement in this sphere was the detection of morpho-functional asymmetry in the central (gestational dominant) and peripheral (placental lateralization) links of functional system “mother-placenta-fetus”, and also the peculiarities of their spatial relation as the condition of normal and pathological passing of pregnancy [5, 9, 19, 24].

It is known that work of brain's systems, providing adaptation and regulative mechanisms of various reactions and states passing on the different levels of CNS, is reflected in the characteristics of bioelectrical brain's activity. At the same time, the data of EEG that exist today – observations of pregnant women during normal and complicated pregnancy – are very contradictory [3, 6, 10, 14, 16, 20, 22, 23], and the main thing is the lack of comparison of encephalographic indexes with the direction of morphofunctional asymmetry of uterine-placental complex.

The aim of this investigation was the study of brain's bioelectrical activity during the physiological and complicated pregnancy.

Methods

Observation and examination of 230 pregnant women from 18–31 years were carried out on the basis of Research Institute of Obstetrics and Pediatrics (Russia, Rostov-on-Don). US-scanning, obstetric-gynecologic survey, registration and analysis of bioelectrical brain's activity were carried out in pregnant women at terms of 10–12, 23–24, 35–36 weeks.

Registration and spectrum analysis EEG were conducted with the help of firmware complex “Entsefalan 131-01” (Russia, Taganrog). Bioelectrical brain's activity was registered monopolar according to the system “10-20” in the symmetrical frontal, temporal, central, parietal and occipital areas. Independent electrode was placed on the lobes of the ear. The record of EEG of the pregnant women was realized at the state of rest with the open and close eyes for 4–6 minutes with the quantization frequency of 150 Hz and with the pass band from 0,1 to 30 Hz. The visualization of the obtained information and the selection of containing no artifacts of uncerebral origin of buckets (five 6-seconds EEG-epochs) were realized with the help of application programs on IBM “Pentium”. The account of power spectrum for the epochs, selected by this way, was conducted according to the algorithm of Fast Fourier Transform for 19 channels in the range of the EEG basic rhythms. Besides, the average amplitude, dominant frequency and intensity index of every rhythm were calculated. All data were transformed into the electronic worksheet “Excel-2000”, in which the reprocessing was conducted. So, the coefficients of interhemispheric EEG asymmetry (CIA) were calculated in every derivation pair for alpha rhythm for every woman. $CIA = \frac{R-L}{R+L} \times 100\%$, where MR the meaning of alpha rhythm power on the right and ML the meaning of alpha rhythm power on the left.

The analysis of encephalographic data was conducted taking into account the lateral placental location and the presence of threat of fetus wastage, with the help of statistical packet processing – Statistica 4.3 and with the usage of algorithm of two-factor dispersing analysis ANOVA. The side of placental location was determined by the US-scanning (devise – Toshiba SAA 340-A). According to our investigations, the overwhelming majority of women at terms of gestation 10–

12 weeks had the full-blown and well controlled in the sagittal plane miometrium hypertrophy. Taking into consideration the data about the influence of estrogens and progesterone on the miometrium, the obtained results give grounds to consider, that the onset of retroplacental miometrium hypertrophy may be viewed as effective morpho-functional criterion of placental formation. In doubtful cases, in the determination of placental lateralization in the first trimester of pregnancy, we oriented on this very criterion. In the second and third trimesters the placental thickness was evaluated on the right and on the left of sagittal uterus plane. Placental thickness on the one side is not less than in 1,5–2 than on the opposite one allows to speak about its lateralization. The side of the going of umbilical cord was also taking into consideration.

From total amount of examined pregnant women according to clinical evidence and US data, two groups of women were selected. The group “normal” (72 women) consisted of those women who had no threat of fetus wastage till the whole period of gestation. The group “risk” consisted of 46 women who had the diagnosis of “threat of fetus wastage” on every stage of investigation. Spectral EEG indexes and the meaning of CIA averaged by the chosen groups of women (“risk” and “normal”). The reliability of distinctions of the middle group indexes was estimated according to Student’s T-criterion.

Results

The conducted dispersing analysis was the evidence of statistically reliable compatible influence of two factors (laterality of placental location and threat of fetus wastage) on the interhemisphere asymmetry of alpha rhythm in the central and temporal derivations (Table 1).

Table 1. The results of two-factor dispersing analysis of variability of parameters of interhemispheric functional asymmetry of EEG.

CIA	Fisher’s Criterion (F)	Stage of significance
Front temporal areas	9,35	0,0012
Middle-temporal	22,44	0,0009
Back-temporal	10,58	0,0007
Central	10,08	0,0006

The meanings of integral CIA for the groups “risk” and “normal” in pregnant women at terms of 35–36 gestational weeks with the different placental lateralization are represented on the Fig. 1. The similarity is shown in the groups of pregnant women with the right-sided and ambivalent placental lateralization. In women of these placental groups, under the absence of gestational disturbances the evident bilateral asymmetry with the prevalence of alpha-rhythm power of EEG on the right is found. The given mechanism was more evident in temporal and central brain’s areas. In women with threat of fetus wastage the higher meanings of power’s spectrum of alpha rhythm of EEG were seen in the left interhemisphere. In the group of left-placental pregnant women the dependence had the reverse character.

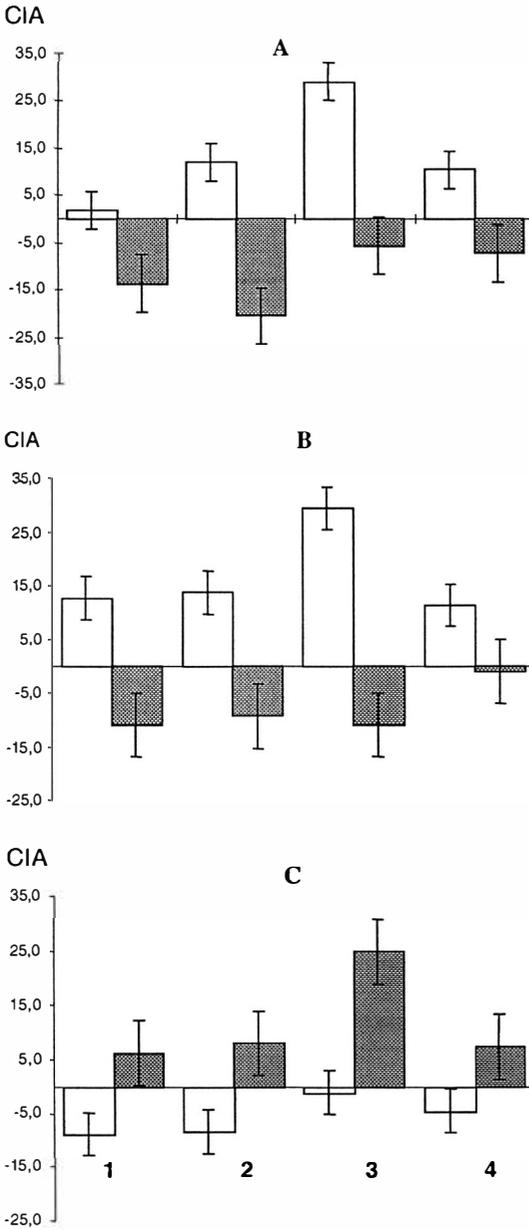


Fig. 1. Intergroup differences of EEG-power asymmetry of alpha rhythm at pregnant women.

CIA – coefficient of the interhemispherical asymmetry (%).

□ – Normal, ■ – Risk.

Derivations: 1 – front-temple, 2 – middle-temple, 3 – back-temple, 4 – central.

A – Right-side placenta.

B – Ambilateral placenta.

C – Left-side placenta.

In EEG of the examined group “normal” dominated the alpha rhythm with maximum in the parietal or occipital derivations. The basic rhythm was of sinusoidal shape, modulated by the amplitude of 40–60 mv and 9–10,5 Hz was characterized by the high regulatory range, absence of hypersynchronization and well or weakly changed amplitude gradient on the areas. Topographic picture of EEG of those women was characterized by legibly expressed bilateral asymmetry of all cortex areas. Spectral indexes of power of alpha rhythm were not high and on average constituted $65,4 \pm 12,3 \text{ mv}^2$. The desynchronized EEG type with the power of alpha rhythm 25–30 mv and the absence of regional difference was seen in 5 persons of this group. Besides, the comparative stability of picture in all three trimesters was peculiar for EEG of this group.

The group “risk” according to EEG characteristics was heterogeneous and actually consisted of three groups. In the first group (26 women) – alpha rhythm was vividly expressed by the amplitude to 100 mv, under the preservation of bilateral skewness, in 40% of cases the displacement of the maximum of alpha activity into the parietal-central area was seen. The spectral power of alpha rhythm was characterized by the considerable value and was equal on average by the subgroup $105 \pm 20,5 \text{ mv}^2$. The second subgroup (15 women) consists of pregnant women with absence of interhemispheric asymmetry on the reliable level of significance. In EEG of this group of women the smoothed regional differences were marked, both against the background of high activation, and in cases of registration of synchronized according to alpha rhythm of EEG. The third subgroup (5 patients) consists of women, in the EEG of which the different forms of epileptomorphic activity (adhesions, sharp waves, discharges, etc.) occupied more than 40%.

It is necessary to note that in pregnant women of the group “risk” the considerable intensity of the slow activity in the range of theta-rhythm was seen, especially in the central areas (to 25%). And it didn't exceed the amplitude of the dominating rhythm according to the index. Besides 75% of all pregnant women were established to have the considerable increase of low frequency (to 20Hz) high-amplitude (to 30 mv) beta activity in the symmetrical front region of brain.

Discussion

The obtained data indicates about unequal lateralization of EEG-activation in pregnant women, depending upon the side of placental location. In the context of the existing ideas in electrophysiology, the more functionally active (the bigger level of activation) is considered to be this hemisphere (or brain's area), in which the power of alpha frequency is lower. During the noncomplicated pregnancy the prevalence of activation in the temporal and central areas of the left hemisphere was found in women with right-sided and ambilateral placental location. In pregnant women with the similar placental lateralization and signs of threat of fetus wastage, the higher level of activation of temporal and central cortex department was determined, on the contrary, in the left hemisphere. The opposite situation was observed in women with the leftlocalized placenta: right-sided cortical activation of temporal areas combined with the favorable course of pregnancy; larger activation of the left hemisphere or the absence of reliable asymmetry of this sign was connected with the signs of threat of fetus wastage.

It was shown, that the left-sided placental lateralization increases the possibility of obstetrical pathology [10]. This is explained by the predominant dextrality of phenotype in the population, that, in its turn, conditions the higher functional activity of the right ovary, the prevalence of hemodynamic resources of the right vascular uterus circuit, the prevailing implantation of fetal ovum on the codirectional with the dominant ovary uterus half. There are some data in literature about lateralized influence of sex hormones on the functional interhemispheric asymmetry of the neurotic system structures, connected with the sexual behavior of people and animals [4, 18]. It was shown, that gestational hyperestrogenia promotes the activation of the left hemisphere. Against this background the afferent impulsation with the uterus mucous, under the right-sided placental lateralization causes the appearance of gestational dominant exactly in the left hemisphere. It was also found that in healthy pregnant women the character of correlational EEG relations reflects prevailing level of integration of bioelectrical processes in the left hemisphere [11]. During the late gestational toxicosis the authors have showed the pathological inversion of intrahemispheric correlations occurring at first due to disorganization of integrative processes of the left hemisphere. According to some authors [3] the prevailing of the left hemisphere activation during the II and III trimesters reflects an optimal formation of gestational dominant, while leveling of interhemispheric asymmetry correlates with rough disturbances and complications of gestation. It was also shown that the growth of symmetry is accompanied by the reduction of functional state, resistance to stress and adaptability [9]. Examination of the obtained results in the context of the given data allow to make the conclusion, that one of the most important factors, determining high resistance of the functional system “mother-placenta-fetus” is the spatial coordination of its central and peripheral links. Just the situation “right placenta – left-sided cortical activation in the temporal and central areas” is the maximal favorable prognostic sign of gestation. As is well known, the main mechanism of interhemispheric interrelations in general and of functional asymmetry in particular, is the combined, summation-reciprocal mechanism or physiological dominant [4]. Therefore the onset of gestational asymmetry occurs under the participation of dominant mechanism of interhemispheric relations, and this circumstance let us view the results of the conducted investigations as one more confirmation of gestational dominant existence.

Besides, the presence of high-amplitude, inclined to the hypersynchronization alpha rhythm was characteristic to EEG of women with constant threat of fetus wastage. Some authors [14] connect this with the initial dysfunction of brain's activity, which was manifested in period of pregnancy in connection with the increase of organism tendency to disadaptation.

We observed the increase of theta rhythm power in the central derivations, besides the inversion or absence of the above mentioned EEG-signs of gestational dominant, in all women with threat of fetus wastage, irrespective of the placental side of localization. Such redistribution of power of cortex's spontaneous electrogenesis in favor of slow frequency is connected with the regulational disturbance from side of diencephalon structures that are subcortical projection of uterus-placental complex. According to K.Sudakov [15] these changes accompanied by the decreased homeostasis level and disadaptation on the organism level, and also

by the stable psychogenic tension. It is possible to suppose that under the threat of fetus wastage diencephal activation has an excess character with the subsequent transition to the beyond cut off inhibition of cortical areas. Obviously, this is one of the compensating mechanisms of CNS appearing in extreme conditions. In the context of a given investigation, the obtained results allow to assert that high power meanings of slow frequencies may be the evidence of pathological passing of gestation. It is necessary to stop on discussing one more interesting mechanism. Comparative analysis of indexes of local synchronization of bioelectrical brain's activity showed the increase of high-amplitude, low frequency beta-activity in the symmetrical frontal areas at late gestational terms. It is possible to suppose that the given peculiarities of spectral EEG characteristics reflect the state of readiness, an optimal level of "preluanch" state.

Thus, spontaneous bioelectrical brain's activity of pregnant women is an extremely sensible index of the normal and pathological gestational passing. The investigations of central regulation mechanisms by the gestational processes, in our opinion, enlarge the method set of prediction and diagnostics of obstetrical-gynecological pathology.

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