Interhemispheric EEG Asymmetry in Patients with Insomnia during Nocturnal Sleep

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Sleep EEG was recorded and analyzed in patients with neurotic insomnia. It was found that interhemispheric asymmetry in the same individual can vary during sleep from right-hemispheric to left-hemispheric. Interhemispheric EEG asymmetry is closely related to the stage of sleep. The development of left-hemisphere or right-hemisphere asymmetry is mainly determined by activity of the right hemisphere. The development of interhemispheric asymmetry during wakefulness, stages 1 and 2 sleep, and delta sleep is mediated by common mechanisms.

Key Words: *sleep; interhemispheric EEG asymmetry; insomnia*

Adaptive function of the sleep is associated with combined influence of hypnagogic structures in nonspecific brain systems of the right and left hemispheres. The mechanisms for interhemispheric electroencephalographic (EEG) asymmetry, sleep-related variations in asymmetry, and role of each hemisphere in the development of asymmetry remain unknown [1,2]. This study is based on the assumption that right-hemisphere activation during sleep is the major system of organization in patients with insomnia.

Here we studied the mechanisms of interhemispheric EEG asymmetry in patients with insomnia.

MATERIALS AND METHODS

We examined 10 right-handed patients with neurotic insomnia (5 men and 5 women). The mean age of patients was 39.8 years. The duration of insomnia was 4.3 years.

Polysomnographic technique suggested simultaneous recording of EEG, electromyogram (EMG), and electrooculogram (EOG). The stages of slow sleep and rapid sleep were estimated by international criteria.

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Night sleep EEG was analyzed by means of spectral compression with the fast Fourier transform algorithm. EEG activity was estimated by the absolute power of δ-, τ-, α-, and σ-waves in leads C_3 and C_4. The absolute power of EEG waves was measured in various stages and cycles of sleep. EEG epoch was 1 min. We analyzed continuous segments of various sleep stages and within-sleep wakefulness periods not containing artifacts and presented by stable recordings with a length of more than 3 min. EEG power was measured 3 times in sleep stage segments of maximum duration (at the beginning, middle, and end of each segment). The frequency of measurements during sleep varied in individuals and depended on the number of segments in EEG sleep stages and count of cycles. The mean number of epochs analyzed in each patient was 45. In total, 452 epochs of various stages and phases of sleep were analyzed in 10 patients.

The results were analyzed by parametric Student's t test.

RESULTS

Predominance of EEG activity in one hemisphere is not a constant parameter. Over night, predominance of the total EEG power changed several

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times from the right to the left hemisphere and vice versa (Table 1). We recorded the incidence of power predominance in one hemisphere in each patient (Table 1).

In some patients predominance of the EEG power was observed (in the right hemisphere in patient 1 or in the left hemisphere in patient 5). In some patients the increase in activity was more often revealed in the right or left hemisphere (*e.g.*, patient 8).

We compared the incidence of predominance of power spectra in the right or left hemisphere during various stages of sleep independently on individual changes in sleep-related asymmetry. The epochs were divided into 2 groups according to the stage of sleep (including wake) and EEG spectrum. Groups 1 and 2 consisted of segments that were characterized by power predominance in the right and left hemisphere, respectively (Table 2).

Predominance of power characteristics for any spectrum in one of the hemispheres was accompanied by predominance of other EEG frequency components. For example, predominance of the α-wave power in the right hemisphere was accompanied by predominance of other power spectra in the same hemisphere. These results show that predominance of any spectrum in any hemisphere results in an increase in the power of all spectra in this hemisphere.

Characteristics of wakefulness asymmetry were similar to those observed in stage 1 sleep (the same organization of σ-wave asymmetry). Besides this, we revealed the same characteristics of stage 2 sleep and delta sleep (power of τ- and α-waves). Fast sleep had intermediate characteristics. Characteristics of σ-waves in fast sleep did not differ from those in wakefulness and stage 1 sleep. Asymmetry of α-waves in fast sleep was similar to that in delta sleep and stage 2 sleep.

Our results indicate that during wakefulness and stage 1 sleep, σ-wave asymmetry is determined by the power spectrum of the right hemisphere ($p<0.05$). The right-hemisphere power predominance is accompanied by an increase in activity in the right hemisphere. The left-hemisphere power predominance is accompanied by a decrease in activity in the right hemisphere. The power spectrum of σ-waves in the left hemisphere practically does not depend on the site of its relative predominance. Predominance of σ-wave activity in the left hemisphere results in a decrease in the power spectrum of σ-waves in the right hemisphere, but not in an increase in the power spectrum of σ-waves in the left hemisphere. Asymmetry of δ-, τ-, and α-waves is determined by activity of the right and left hemisphere.

During stage 2 sleep and delta sleep, the power spectrum of δ-waves in the right-hemisphere group is higher than in the left-hemisphere group. δ-Wave asymmetry in the analysis epoch depended on the power spectrum in the right and left hemisphere.

Asymmetry of τ-, α-, and σ-waves was determined by the power spectrum in the right hemisphere. Activity of the left hemisphere remained unchanged within this range.

Study of δ-wave asymmetry during fast sleep revealed variations in the power spectrum of both hemispheres in various periods. Asymmetry of α- and δ-waves was determined by the power spectrum distribution only in the right hemisphere. It should be emphasized the power spectrum of these waves in the left hemisphere remained practically unchanged in various groups.

δ-Activity in the right and left hemisphere was unspecific for various stages of sleep, including

TABLE 1. Incidence (Number) of Total EEG Power Predominance in the Right or Left Hemisphere of Patients

Patient	Total power predominance		Number of measurements over sleep
	right	left	
1	32	3	35
2	32	22	54
3	7	25	32
4	26	10	36
5	3	32	35
6	42	3	45
7	5	23	28
8	16	18	34
9	15	5	22
10	30	14	44

TABLE 2. Comparison of Wave Powers in Various Stages

Sleep stage	EEG spectrum	Power in hemispheres				Reliability ($p<0.05$)			
		group 1		group 2					
		right	left	right	left	1-2 r	1-2 l	I	II
1	δ	75.1	59.1	79.4	86.2				
1	τ	32.1	26.9	22.3	24.2			+	+
1	α	24.1	20.4	17.3	19.6			+	+
1	σ	8.9	7.6	5.1	6.3	+		+	+
2	δ	142.7	123.4	90.3	110.4	+	+	+	+
2	τ	45.6	38.0	31.6	35.0	+		+	+
2	α	26.9	22.7	17.6	20.5	+		+	+
2	σ	12.7	10.9	10.8	12.5			+	+
3+4	δ	371.5	300.8	211.4	241.9	+	+	+	+
3+4	τ	63.9	54.9	49.5	54.2	+		+	+
3+4	α	27.2	22.8	20.0	21.9	+		+	+
3+4	σ	10.4	9.3	9.9	11.0			+	+
FS	δ	56.8	48.7	57.2	63.7			+	+
FS	τ	29.8	26.7	25.9	31.4			+	
FS	α	18.7	14.9	12.3	13.8	+		+	+
FS	σ	7.6	5.0	4.2	4.9	+		+	+
Wk	δ	89.6	76.1	49.3	52.8			+	+
Wk	τ	41.9	37.8	21.1	22.5			+	+
Wk	α	58.4	52.3	51.4	58.2			+	+
Wk	σ	12.6	10.7	6.4	7.2	+		+	+

Note. Group 1, epochs of analysis when power predominance in the right hemisphere was accompanied by the appearance of power in the right and left hemispheres. Group 2, epochs of analysis when power predominance in the left hemisphere was accompanied by the appearance of power in the right and left hemispheres. 1-2 r, comparison of right-hemisphere power in groups 1 and 2. 1-2 l, comparison of left-hemisphere power in groups 1 and 2. I, characteristics of the right and left hemisphere in group 1. II, characteristics of the right and left hemisphere in group 2. Stages of sleep: 1, stage 1; 2, stage 2; 3+4, delta sleep; FS, fast sleep; Wk, within-sleep wakefulness. Spectrum: specified spectra. Power characteristics estimated by means of spectral compression with specified spectra are expressed in μV^2.

wakefulness (from the viewpoint of its effect on the development of interhemispheric asymmetry). Asymmetry of the power spectrum in various stages of sleep was determined by activity of the right and left hemisphere.

Interhemispheric asymmetry of τ-, α-, and σ-waves (right-hemisphere or left-hemisphere asymmetry) was primarily determined by activity of the right hemisphere. The absolute power remained practically unchanged in the left hemisphere.

Our results indicate that interhemispheric asymmetry in the same right-handed patient with insomnia can vary from right-hemisphere to left-hemisphere asymmetry during various periods of sleep. Each stage of sleep is characterized by specific features of interhemispheric asymmetry. Study of the EEG spectrum showed that the development of left-hemisphere or right-hemisphere asymmetry is mainly determined by activity of the right hemisphere, which can increase or decrease. However, activity in the left hemisphere remained practically unchanged. The development of interhemispheric asymmetry during wakefulness, stage 1 sleep, stage 2 sleep, and delta sleep is mediated by common mechanisms.

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REFERENCES

1. J. A. Hobson, R. Lydic, and H. A. Baghdoyan, *Behav. Brain Sci.*, **9**, No. 3, 47-53 (1986).
2. S. Daan, D. G. Beersma, and A. A. Borbely, *Am. J. Physiol.*, **246**, No. 2, Pt. 2, R161-R183 (1984).