EXPERIMENTAL BIOLOGY

Biological Rhythms of Tissue Basophils in Various Sites of Rat Dura Mater

A. V. Laryushkina and V. M. Chertok

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 129, No. 1, pp. 96-99, January, 2000
Original article submitted May 27, 1999

Changes in the components of biorhythms of functionally active basophils were studied in the frontal, parietal, and occipital areas of the dura mater of adult rats in the circadian and ultradian ranges. Spectral analysis revealed differences in rhythm parameters in each area of the dura mater, synchronized for 24-h period.

Key Words: *tissue basophils; dura mater; circadian rhythms*

Functional activity tissue basophils (TB) in the dura mater (DM) varies over 24-h period in accordance with certain time-synchronized regularities [2,7]. Rhythmic fluctuations in the structural arrangement of these cells were studied under the effects of drugs [2], noise and vibration [7], laser [9], but specific features of TB localization in DM have never been examined. However, variations in the TB functional activity depending on their location in DM were noted [8].

We examined local differences in the time organization of TB in rat DM.

MATERIALS AND METHODS

Dura mater from samples 108 adult non-inbred albino male rats were examined. The animals after birth were kept under the same day/night regimen with the same feeding, drinking, humidity, and temperature conditions. The study was carried out during the autumn equinox (September 22-24). The material was collected every 2 h (3 animals per point) during 3 days. The rats were decapitated, the dura mater was isolated and stained with 0.5% methylene blue (pH 5.3).

Functional activity of TB was assessed by their number per standard area (population area) of DM individually for the frontal, parietal, and occipital parts and by the ratio of intact to degranulated TB. Local biorhythms of TB in DM were studied by the spectral analysis algorithm for nonequivalent observations with plotting a periodogram (curve reflecting rhythmic oscillations); oscillation parameters and their confidence intervals were estimated, and true course of the rhythm curve was approximated [1,3].

Department of Human Anatomy, Vladivostok Medical University

RESULTS

Tissue basophils in the dura mater are located mainly along blood vessels; their size is 9-20 μ. The shape of cells is determined by their function. Intact cells are usually round with regular even contour. As the functional activity of TB increases, they acquire an oval or spindle-like shape, clear-cut contour disappears, and multiple secretory granules appears around them. Estimations revealed local specificities in the functional activity of TB in the studied areas of DM. The highest values were detected in the frontal DM; the number of TB in the parietal and especially in the occipital DM was significantly lower (68 and 56%, respectively, $p<0.01$); degranulated cells in these areas constitute 79 and 68%, respectively.

The results of mathematical processing of chronobiological data on degranulated TB in all studied

0007-4888/00/0001-83$25.00

areas of DM and parameters of harmonics with the critical significance level above 0.95 are summed up in Table 1. The observation was carried out for 3 days, but we detected no infradian component in the rhythm of TB functional activity (28-60 h). Circadian (20-28 h) and ultradian (period less than 20 h) components in the spectra of these cells were found. The rhythms of degranulating frontal TB possess only a highly potent circadian component. Similar, but less potent component was noted in the rhythms of occipital DM. Functionally active parietal TB showed not only circadian but also 8- and 12-h ultradian components in their rhythmic spectra. However, because of low potency of both ultradian components, 24-h component of TB rhythm dominates in all DM areas, and the pattern of rhythmic wave is more complex than regular sinusoid. Since the period of ultradian components is divisible by 24 h, the cycle in the parietal area is completed every 24 h. Ultradian rhythms are most often attributed to local fluctuations in biochemical processes [7,11]; they also can be involved in adaptation processes. For example, simple spectra often attest to exhaustion of adaptation potential in individual structures or whole organ [3,4].

Pronounced local differences in the mean number of degranulated TB (mesor) in various areas of DM over 24 h were detected (Table 1). The amplitude in the frontal area are 3.8 times higher than in the parietal and more than 4-fold higher than in the occipital area ($p<0.001$). The relative amplitude of the 24-h component is similar in all three areas of DM.

Rhythms of functional activity of TB in all cases possess a potent 24-h component; in other words, rhythm parameters return virtually to the initial level every 24 h (Fig. 1). Approximation traced the true course of the wave of circadian rhythmic oscillations [1,3]. In the frontal area the wave approximated a sinusoid and the values smoothly increased from 0.00 to 6.00, decreased from 6.00 to 18.00, and increased again till 6.00. In the parietal area the wave was not sinusoidal, despite the extreme values were recorded at the same time as in the frontal area. The values increased rapidly and dropped smoothly. In the occipital area the count of degranulating TB gradually increased from 0.00 to 6.00, most rapidly from 2.00 to 6.00, after which the wave course was slower; the lowest values were observed at 18.00-20.00, after which they gradually increased again. It is noteworthy that acrophases of the circadian rhythm component of TB functional activity in all three areas of DM were recorded at 5.00-6.00, *i.e.*, the rhythm parameters increased during daytime and dropped in the dark time of the day, with the minimum about 18.00. Analysis of the acceleration curves (Fig. 2) showed phase inversion with respect to the main process: in all DM areas the zero values

TABLE 1. Rhythm Parameters of Tissue Basophil Degranulation in Various Dura Mater (DM) Areas in Adult Rat (X±Sx)

Parameter	DM area		
	frontal	parietal	occipital
Mesor, arb. units	8.0±0.8	20.2±0.8	18.4±0.5
Period, h	23.8054+0.5951-0.4761	24.1894+1.5723-1.2895	8.1398±0.5291	11.5795+2.3159-1.0422	23.8054+1.1903-1.0712
Potency	0.9669	0.7619	0.0901	0.0654	0.8101
Total potency	0.9669	0.7619	0.8420	0.9074	0.8101
Amplitude, arb. units	64.920±1.164	20.214±1.109	6.569±0.2153	5.870±0.2181	13.933±0.653
Relative amplitude	-0.7377±0.0197	1.0007±0.0946	0.3252±0.0219	0.2906±0.0223	0.7572±0.0561
Acrophase, grad	95.2743±1.0229	97.4±3.1314	241.9029±18.0971	206.04±20.1543	79.0571±2.6742
Acrophase, rad.	1.6673±0.017	1.7045±0.0548	4.2333±0.3167	3.6057±0.3527	1.3835±0.0468
Sin component	68.618	20.038	-5.830	-2.625	13.690
Cos component	-6.252	-2.695	-3.028	-5.250	-2.594

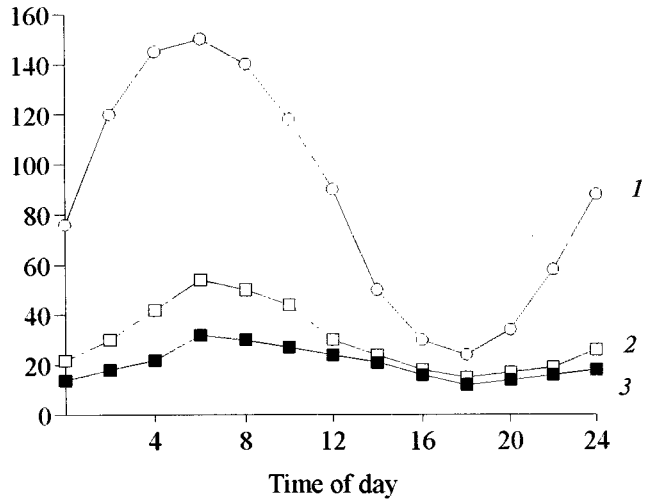

Fig. 1. Circadian oscillations of tissue basophil functional activity in various dura mater areas in rats. Ordinate: number of degranulating cells. Here and in Fig. 2: *1*) frontal; *2*) parietal; *3*) occipital area.

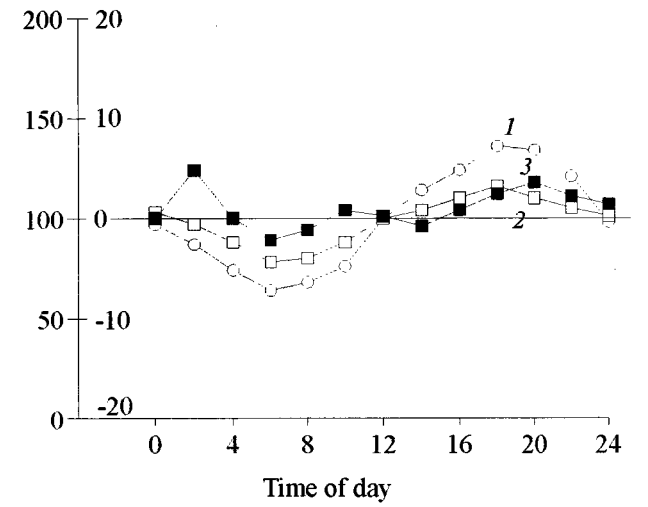

Fig. 2. Acceleration of circadian oscillations of tissue basophil functional activity in various dura mater areas in rats. Ordinate: double smoothened acceleration.

of the parameter occurred at 0.00 and 12.00 and the maximum at 6.00. The highest values of positive and negative acceleration were observed in the frontal area. The presence of different rhythms in all DM areas is most probably explained by the presence of several (not one) oscillators in DM. At least, phase inversion with increase in parameters during the light phase and decrease during the dark phase indicate [5,6] the presence of a "day" (direct) and "night" (inverted) circadian oscillators.

Hence, a potent 24-h circadian rhythm of TB activity was detected in all studied areas of rat DM; the parietal area possesses additional ultradian components in the rhythm of TB degranulation, which little modify the wave course, due to their low power [3,10]. Parameters of circadian rhythms have pronounced local differences: the highest mesor values were observed in the frontal TB rhythm and the lowest in the occipital area. The oscillations were the greatest in the parietal area and the acrophase in the frontal area. The course of rhythmic wave approximated a sinusoid only in the frontal area and was not sinusoidal in the parietal and occipital areas, where it was characterized by other rates of wave course deceleration and acceleration.

REFERENCES

1. V. P. Karp and G. S. Katinas, *Methods of Estimation in Chronobiology and Chronomedicine* [in Russian], St. Petersburg (1997).
2. V. S. Karedina, T. V. Dovbysh, and T. A. Kozhevnikov, *Byull. Eksp. Biol. Med.*, **90**, No. 9, 356-357 (1980).
3. G. S. Katinas and N. I. Moiseeva, *Ecological Physiology of Man. Part II. Adaptation of Man to Different Climatic Conditions* [in Russian], Leningrad (1980).
4. G. S. Katinas, S. I. Ryabov, and A. Sh. Kurumshieva, *Urol. Nefrol.*, No. 6, 35-40 (1991).
5. A. N. Kubynin, G. S. Katinas, V. V. Mikheev, and Yu. D. Ignatov, *Byull. Eksp. Biol. Med.*, **125**, No. 6, 695-698 (1998).
6. K. S. Pittendrikh, *Biological Rhythms* [in Russian], Moscow (1984).
7. D. S. Sarkisov, A. A. Pal'tsyn, and B. V. Vtyurin, *Adaptive Rearrangement of Biorhythms: Electron Radiographic Study* [in Russian], Moscow (1975).
8. V. M. Chertok and A. E. Kotsyuba, *Morfologiya*, No. 1-2, 40-49 (1993).
9. V. M. Chertok, A. E. Kotsyuba, and A. V. Laryushkina, *Byull. Eksp. Biol. Med.*, **108**, No. 10, 493-495 (1989).
10. V. M. Chertok, A. V. Laryushkina, and A. E. Kotsyuba, *Ibid.*, **111**, No. 4, 410-411 (1991).
11. T. Pavlidis, *J. Theor. Biol.*, **33**, 319-338 (1971).