The Thermic Circadian Rhythm of Dogs infected with *Babesia gibsoni*

Fujiko SUNAGA, Kazuhiro NAMIKAWA, and Yasunori KANNO

*Department of Infectious Disease, School of Veterinary Medicine, Azabu University, Fuchinobe, Sagamihara 229, Japan*

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Body temperatures are known to indicate regular periodic changes. This periodic changes of body temperatures are reported to be disturbed in cases of diseases such as cancer [7], psychopathy [5, 6] and malaria [2]. However the thermic circadian rhythm in dogs [3] is little known, and the rhythm in canine babesiasis is not examined. Therefore, in this study, we analyzed the thermic circadian rhythm in dogs infected with *Babesia gibsoni* by the moving average method [8] and Halberg’s cosinor method [1].

Two splenectomized mongrel dogs were used in this experiment. These two dogs were kept in a room temperature of 20±2°C, in light from 6:00 to 18:00, alternated with darkness, from at least two weeks before the experiments to their end. Body temperatures were taken by the telemeter; a thermic transmitter was surgically implanted in the peritoneal cavity of the animals to measure the intraperitoneal temperatures. The temperatures were recorded at intervals of one hour during this experiment. The dogs were intravenously inoculated with $1 \times 10^9$ parasitized erythrocytes (RBC).

Dog No. 1 suffered from serious anemia (RBC: $72 \times 10^6$ mm$^3$, Ht: 7%) accompanying severe parasitemia (percentage of parasitized RBC: 38.3%) and died on day 24 after inoculation. The body temperatures showed three distinct periods: a rising period from day 1 to day 6, including a transient rise on day 2, a high temperature period where temperatures continued at about 40.0°C from day 7 to day 12, and a falling period from on day 13 to the death (Fig. 1). The rhythms of body temperatures were analyzed by the moving average method, demonstrating the circadian rhythms were disturbed on days 1 and 2, and showed lower amplitudes on days 7, 8 and 10–12 than before inoculation. The acrophases from day 13 to the death were opposite to those of pre-inoculation. As the results, it revealed that each period of this experiment was possible to correspond to the respective stage, stage I (day 1–6), stage II (day 7–12) and stage III (day 13–the death), based on the differences of the amplitudes and the acrophases.

The body temperatures in each stage were also analyzed using Halberg's cosinor method to show the characteristic of each stage more clearly and to statistically examine the differences in amplitudes and acrophases between stages. In Fig. 2, the thermic circadian rhythms in pre-inoculation and stage I, II and III were expressed as an error ellipse on polar coordinates by the cosinor method, a kind of the regression method. The circadian rhythms were expressed in terms of cosine curve in order to detect the characteristics of rhythms. The direction of the arrow drawn from the polar plot to the pole of the ellipse indicates the acrophase value and its length indicates amplitude value. The angle formed by two radii drawn from the polar plot tangent to the error ellipse indicates 95% confidence arc for acrophase. The error ellipses of stage I and pre-inoculation did not overlap each other. This result suggests that the differences in acrophase between stage I (09:56) and pre-inoculation (13:40) were statistically significant and the acrophase of stage I proceeded earlier by about 4 hours than that of pre-inoculation. The error ellipse of stage II was located on the polar plot, indicating that the circadian rhythm was hardly detectable in the temperatures of stage II. The amplitude (0.17) and acrophase (00:48) of stage III indicated that the amplitude was lower and the acrophase proceeded earlier by about 13 hours than that in pre-inoculation. The differences in acrophase between stage III and pre-inoculation were statistically significant. The thermic circadian rhythm in stage III was the nocturnal.

Dog No. 2 died on day 12 after inoculation suffering from severe anemia (RBC: $242 \times 10^6$ mm$^3$, Ht: 14%) accompanying severe parasitemia (percentage of parasitized RBC: 42.5%). The body temperatures rose from day 7. The
Fig. 1. Changes of thermic circadian rhythms in dog No. 1.
- a-wave (---): body temperatures taken hourly
- b-wave (---): 24-hour moving average values of body temperatures taken hourly
- c-wave (---): 9-hour moving average values of the remainders after subtracting b-wave from a-wave
- d-wave (---): the average values of 9-hour moving average values of the remainders after subtracting b-wave from a-wave before inoculation

Fig. 2. The body temperatures of dog No. 1 summarized by cosinor: differences circadian acrophase and amplitude between body temperatures after inoculation (stage I, II and III) and those before inoculation (pre).

Rhythms of the body temperatures in dog No. 2 were analyzed by the same methods used for dog No. 1. The amplitudes were extremely lowered showing a flattened rhythm from day 3 to day 6 after a transient rise on day 2 as compared with the amplitudes of pre-inoculation. The acrophase from day 7 to the death was observed earlier than that of pre-inoculation. The result of this experiment revealed the two stages, stage I (day 1–6) and stage II (day 7–11) in different amplitudes and acrophases. By the cosinor method, the amplitude (0.03) in stage I was considerably lower than in pre-inoculation (0.26), and that (0.12) in stage II was lower than in pre-inoculation. The acrophase (06:44) proceeded earlier by about 10 hours than that in pre-inoculation. The differences in acrophase between stage II and pre-inoculation were statistically significant. The thermic circadian rhythm of stage II in No. 2 was nocturnal like stage III in No. 1.

Moroji and Takahashi [6] reported that the thermic circadian rhythms of the psychopathic patients by the cosinor method were flattened in severe chronic cases and were not detectable in some cases. Kanno and Namikawa [4] also reported the obvious acrophase displacement of the thermic circadian rhythms in severe acute cases of polypus dogs. From the study, the amplitudes of circadian rhythms in two dogs were
lower in post-inoculation than in pre-inoculation and the acrophases tended to come earlier as the condition of dogs were getting worse. The thermic circadian rhythms in the last stages of two dogs were nocturnal, i.e., the body temperatures in the night were higher than in the daytime, opposite to the diurnal rhythms in pre-inoculation.

REFERENCES


要約

*Babesia gibsoni*感染犬の体温リズム（短報）：須永藤子・並河英彦・菅野康則（麻布大学獣医学部伝染病学講座）——*Babesia gibsoni*感染犬の体温リズムを時間平均法とコサイン法を用いて解析したところ、一時的な体温上昇後にリズムが平坦化する時期と、昼間に高く、夜に高い体温を示す時期が認められ、後者は死期に近づくにつれてみられた。これら2時期の体温リズムと感染前との差は統計的に有意であった。