80. Parasympathetic Activity during Para-Sleep

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The sympathetic activity appears to decrease during para-sleep (PS), as indicated by the following manifestations: fall in the systemic blood pressure,1-4 decrease in sympathetic nerve discharges5 and depression of the somato-sympathetic reflex activity.6 However, little has been known as to the behavior of parasympathetic activity during PS. In the present experiments, it is aimed to count the heart rate only under the parasympathetic nervous control via vagal nerve. This was done in the cat by transecting chronically the spinal cord at the cervical level, so that the supra-spinal modulation of the heart rate via the sympathetic nervous system was eliminated.

Under pentobarbital anesthesia, the spinal cord was transected between C2 and C3 in 3 cats (high cervical transection: HCT cat), and between C6 and C7 in 5 cats (low cervical transection: LCT cat). In HCT cats, the artificial respiration was continued during whole period of their survival. The electrode implantation for recording EEG, EMG and rapid eye movements (REM) was performed as described previously.7 After recovery from anesthesia cats were laid in the thermo-regulated wooden box (45 x 55 x 30 cm) with a transparent glass window. The rectal temperature was kept at 36-38°C. During 1-2 days after the spinal transection, the extremities of cats were in the complete paralysis. The movements of head and neck were occasionally observed. The nictitating membranes were relaxed bilaterally. After 4th or 5th postoperative day, reflex movements of extremities were developed, and nictitating membranes gradually retracted again.

The experimental observation was done in 2-5th postoperative day. One period of observation lasted for 3-13 hours. The stages of sleep were classified into ortho-sleep (OS) and PS by means of the polygraphic recordings of EEG, neck muscle activities and eye movements (Fig. 1). No difference was observed as to the appearance of PS phase between HCT and LCT cats.

During OS (Fig. 1 left), heart rate was 63.0-114.9/min (average: 91.2/min) in HCT cats and 52.5-150.0/min (average 95.4/min) in LCT
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Blood pressure was at levels of 86.0–92.0 mmHg both in HCT and LCT cats. After the neck EMG began to decrease and the onset of PS was thus indicated, the heart rate gradually decreased both in HCT and LCT cats. During PS (Fig. 1 right), the heart rate was 60.0–112.2/min (average: 83.1/min) in HCT cats, and 40.5–145.5/min (average: 89.7/min) in LCT cats. The difference of the heart rate between PS and OS just before each PS was calculated in each of 12 episodes in HCT cats, and 25 episodes in LCT cats. The differences were statistically significant (P < 0.01). In LCT cats, the respiratory arrhythmia often increased during PS (Fig. 1 right). The blood pressure was slightly decreased (less than 10 mmHg) during PS. In some cases of both LCT and HCT cats, the heart rate was phasically accelerated when REM appeared briskly and continued for more than 2 seconds. Such acceleration of the heart rate was accompanied by transient elevation of the blood pressure in both HCT and LCT cats as well as the transient tachypnea in LCT cats. Thus, the heart rate was much higher (112.3% of the mean frequency during OS) during REM phase than the phase without REM (94.3%).

Atropine methylnitrate (0.3–0.5 mg/kg) was injected intravenously in 3 cases of LCT cats for the purpose of blocking vagal influences on the heart. Within a few minutes after the injection the heart rate as well as blood pressure level increased, and gradually returned in several hours. The heart rate during OS within 5 hours after the injection was 90.0–114.0/min (average: 105.0/min) and blood pressure was 104.0–135.0 mmHg (average: 120.0 mmHg). The difference in the heart rate between the two sleep stages was com-

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**Fig. 1**: Polygraphic records during OS (left) and PS (right) of a LCT cat. In this case the mean heart rate was 86.0 and 74.0/min, respiratory rate was 24.0 and 25.1/min during OS and PS respectively. Abbreviations are; EEG: electroencephalogram on the left somatosensory cortex; REM: rapid eye movement; EMG: electromyogram of neck muscle; RESP: respiratory movements monitored by the pneumograph; BP: blood pressure from the left femoral artery; CTG: cardiotachogram.
pletely abolished for more than 5 hours after the injection. These results indicate the decrease in the heart rate during para-sleep of the present preparation is resulted from the augmentation of the vagal tone.

In the present observation, the fluctuation in the systemic blood pressure which was observed in intact cats\(^1\)\(^--\)\(^4\) was eliminated by the spinal transection. Furthermore the artificial respiration was constantly maintained in HCT cats. Under these conditions, the decrease in the heart rate was invariably observed. The augmentation of the vagal tone would, therefore, be primarily originated in the central nervous system, rather than as the results of the reflex activation of the peripheral buffer mechanisms. In addition, the phasic inhibition of the elevated vagal tone is suggested during REM phase, as revealed in the phasic increase in the heart rate synchronous with REM appearance.

References

6) —---: Brain Research., 3, 381 (1967).