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ROLE OF THE MEDIAL PREOPTIC AREA IN THERMAL PREFERENCE OF RATS

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Abstract : This study was conducted to find out whether the medial preoptic area (mPOA) plays a role in the selection of ambient temperature by rats. Adult male Wistar rats were kept in an environmental chamber having three interconnected compartments, maintained at three different temperatures (18°, 24° and 30°C) in which the animals could move freely from one compartment to the other. Normal rats preferred to stay at the chamber maintained at 24°C for most of the time, during day and night. The temperature preference shifted to 30°C after the mPOA of these rats had been lesioned by local administration of 5 µg of N-methyl D-aspartic acid (NMDA) in 0.2 µl distilled water. The results of the study suggest that the mPOA acts as a fine tuning center for homeostatic regulation of thermal balance, including selection of appropriate thermal environment. It is proposed that after the mPOA lesion, the animal cannot assess properly the energy status of the body and thereby prefers a higher ambient temperature.

Key words : thermal preference, ambient temperature, medial preoptic area, rectal temperature, NMDA, neurotoxic lesion

INTRODUCTION

Behavioral and physiological thermoregulatory mechanisms ensure that the body temperature is maintained within a narrow limit in homeotherms. Behavioral thermoregulation in animals includes selection of appropriate ambient temperature. Normal rats prefer an ambient temperature (T_{amb}) of 24°C (1). The preoptic area (POA) plays an important role in thermoregulation (2, 3). Lesion of this area produces hyperthermia and deficit in thermoregulation (4). Some studies have shown that the behavioral thermoregulation is not affected after the POA lesion in rats, as they still possess the ability to escape from heat stress (5). But, on the other hand, on the basis of some indirect evidences, it was suggested that some component of behavioral thermoregulation is altered, as the mPOA lesioned rats prefer a lower T_{amb} (6). This assumption is based on the amount of sleep observed in rats, before and after

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the mPOA lesion. Assuming that the total sleep time (TST) is maximum at the thermoneutral zone (7), it was shown that the normal rats had maximum sleep at 30°C, and after the mPOA lesion, they showed maximum sleep at 24°C. On the other hand, the normal cats had maximum sleep at 23°C and after the POA lesion, they slept maximally at 33°C (8).

The findings of these two studies on the effects of T_{amb} on the amount of sleep after the lesion are contradicting each other. Moreover, no direct studies have been conducted to find out the thermal preference of rats before and after lesion of the mPOA.

METHODS

Experiments were performed on adult male Wistar rats weighing between 200 and 250 g. The animals were housed in separate plastic cages in a room having an ambient temperature of 25 ± 1°C and light-on period from 5:00 to 19:00 h. Food and water were given *ad lib.*

The thermal preference study was conducted in an environmental chamber, which had three interconnected compartments (each having dimensions of 40 × 35 × 45 cm). The compartments were interconnected through openings of 12 × 8 cm at ground level in the partitioning walls between the chambers. The chambers were maintained at 18°, 24° and 30°C with the help of thermal sensors and feedback regulation. There were separate heating and cooling arrangements for each compartment. Food and water were provided in all the three compartments.

Rats having higher (30% or more) locomotor activity at night than during the day were selected with the help of a photoactometer. The animals were first trained to move freely in the environmental chamber. Not more than one rat was kept in the chamber at a time. The rats were left in the chamber undisturbed for two hours (i.e. at 10:00–12:00 h and 18:00–20:00 h) before the recording of the temperature preference. Rectal temperature was also noted before putting the animals inside the chamber. Those rats, which did not explore all the three compartments, were discarded. The duration of stay of the rats in each chamber was noted by stop watches for two hours each during day (12:00–14:00 h) and night (20:00–22:00 h) for five days. The temperature in each of the compartments on different days was changed randomly, to ensure that the rats selected the chamber because of the temperature in it, and not because of its location. After the control recordings, the mPOA of these animals were lesioned under sodium pentobarbitone anesthesia (40 mg/kg bw i.p) by intracerebral injection of NMDA (5 µg/ 0.2 µl) procured from Sigma Chemical Co., USA, at stereotaxic coordinates of A 7.8, L 0.6, H–1.5, as per De Groot atlas (9). Recordings were repeated on the third, seventh and fourteenth days after the lesion. The study was conducted on six rats.

At the end of the experiment, the animals were deeply anesthetized with sodium pentobarbitone (45 mg/kg, bw i.p) and perfused with 0.9% saline followed by 10% formalin solution. The brains were removed and kept in formalin until sectioned. The sections were stained with

0.25% cresyl violet solution, for histological confirmation of the lesion.

The duration of stay of all the rats in each compartment during the five prelesion days and three post lesion days (both during day and night) was noted. The durations of stay of the six animals for five days in the chamber having 24°C were compared with their stay at 18° and 30°C, by using Student's *t* test. Two-way ANOVA was used to find out the animal variation and time dependent variation among the five pre-lesion days. As no significant variation was found, the pooled mean data of five days in each temperature were taken as the pre-lesion value, for comparison with the post-lesion recordings. Then two-way ANOVA was again employed for finding out the significant variation between the pre-lesion average and post-lesion values. Student's *t* test was then done between the pre-lesion average and post-lesion values, in those cases where it had shown significant difference in two-way ANOVA. The rectal temperature data were also subjected to same type of statistical analysis.

RESULTS

All the six rats had shown bilateral destruction of the neurons of the mPOA, and mostly glial cells were present in the lesioned areas. The rats had spent maximum time, both during day and night, in the chamber having a temperature of 24°C. The average duration of stay of the rats in the chamber maintained at 18°C and 30°C was significantly low on all the pre-lesion days (Table I). There was no change in the duration of stay of the animals in any

TABLE I: The time (in percentage) spent by the rats in the three compartments maintained at 18°, 24° and 30°C, before and after the lesion of the mPOA.

Chamber Temp.		*Before lesion (Days)*					*Before lesion average*	*After lesion (Days)*		
		1	*2*	*3*	*4*	*5*		*3*	*7*	*14*
18°C	Day	13.20±12.82^{+++}	12.50±9.53^{+++}	13.35±10.12^{+++}	17.95±12.73^{++}	15.34±11.49^{++}	14.46±5.07	12.88±15.41	28.77±30.33	12.83±9.35
	Night	8.33±2.98^{+++}	12.38±11.47^{+++}	12.38±11.47^{+++}	12.69±10.09^{+++}	19.05±10.52^{+}	12.77±3.44	10.88±15.63	4.47±4.68	3.12±2.42
24°C	Day	78.94±12.21	74.61±11.66	81.00±10.47	77.24±13.78	68.83±9.94	76.13±6.13	64.80±27.97	58.90±28.50	22.39±11.64***
	Night	80.76±9.22	76.04±5.85	77.64±12.69	76.47±12.00	58.16±26.46	73.81±9.61	65.59±26.12	24.65±28.21*	16.33±15.07***
30°C	Day	7.28±5.40^{+++}	10.97±1.72^{+++}	5.19±3.74^{+++}	4.26±2.10^{+++}	15.20±8.52^{+++}	8.58±1.66	19.19±18.39	11.80±7.24	64.51±12.52***
	Night	9.83±10.05^{+++}	11.19±4.10^{+++}	9.51±9.57^{+++}	10.51±6.30^{+++}	10.91±3.28^{+++}	10.39±4.95	22.95±22.86	70.52±28.63**	79.95±16.28***

*P<0.05, **P<0.01, ***P<0.001 compared to pre-lesion average
$^{+}$P<0.05, $^{++}$P<0.01, $^{+++}$P<0.001 compared to respective 24°C reading of the same day

TABLE II: The mean rectal temperature (°C) of the six rats during day and night, before and after the lesion of the mPOA.

	Before lesion (Days)						*After lesion (Days)*		
	1	*2*	*3*	*4*	*5*	*Mean ± SD*	*3*	*7*	*14*
Day	36.45±0.39	36.60±0.38	36.68±0.44	36.64±0.30	36.44±0.41	36.55±0.30	37.45±0.49**	37.15±0.77	37.05±1.01
Night	36.77±0.36	36.76±0.58	36.88±0.90	36.70±0.68	36.56±0.30	36.73±0.44	37.83±0.37***	37.26±0.12*	36.93±0.39

*P<0.05, **P<0.01, ***P<0.001 compared to pre-lesion average

particular chamber on the third day following the lesion of the mPOA with NMDA. There was an increase in the time spent by the rats in the chamber maintained at 30°C, on the seventh and fourteenth day during night, and on the fourteenth day during day, after the lesion. Simultaneously, there was a decrease in the duration of their stay in 24°C on the fourteenth day during day, and on seventh and fourteenth day during night, after the lesion. The duration of stay in the chamber maintained at 18°C was very short even before the lesion, and it remained low even after the mPOA lesion (Table I).

The rectal temperature of the rats was elevated after the mPOA lesion on the third and seventh days at night, and on the third day during the day (Table II).

DISCUSSION

The study shows that the normal rats preferred an ambient temperature of 24°C, and the preference shifted towards a higher temperature, i.e. 30°C after the neurotoxic lesion of the mPOA, if given a choice of selecting from among 18°, 24° and 30°C.

The thermal preference of 24°C by the normal Wistar rats (before lesion) in this study is nearly similar to that reported in Sprague-Dawley and Fischer strains (1). Though it was assumed in the earlier study on cats (8), that the change in sleep after the POA lesion is related to a change in the temperature preference of the animals, the present study provides, for the first time, direct evidence to show that the thermal preference of the rats change to a higher temperature after the mPOA lesion. But this study contradicts the earlier report on rats (6) in which the thermal preference had shifted to a lower temperature zone after electrolytic lesion of the mPOA. This could be due to the use of the electrolytic lesion technique in that study, wherein not only the cell body, but also the fibers of passage would have been destroyed.

Hyperthermia observed during the first week after lesion in this study supports few earlier reports (10, 11). Absence of significant increase in rectal temperatures on the fourteenth day after the mPOA lesion is in contrast to some reports (8), though it is in agreement with some others (10). Body temperature in homeothermic animals is

well regulated by a physiological component made up of heat production and heat loss mechanisms and a behavioral component, which includes selection of appropriate ambient temperature (4). Lesions of the POA had produced hyperthermia in rats (2, 5). So, it was assumed that the lesion of the POA abolishes heat loss responses in an organism. But, later studies showed that the lesioned rats had the ability to escape from heat stress. That observation showed that the POA lesions spare the behavioral thermoregulation which could help the animal to escape from the heat stress (5). Again, recent chemical lesion studies have shown that the animals with mPOA neuronal destruction do maintain their body temperature even when exposed to high T_{amb} (12). So, it is necessary to correct the earlier concept that the hyperthermia is due to a failure of the thermoregulatory response. Rather, certain thermoregulatory responses do persist, even after the POA lesion, which actively contribute towards maintaining the Tb and also reset it at a higher level (13). The present findings further support this view, because the rats actively selected a higher temperature zone after the POA lesion. This is an altered behavior introduced by the lesion. But it is difficult to assume that this selection of higher temperature was responsible for the hyperthermia, as the hyperthermia was mostly significant on those days when the thermal preference had not changed.

The rats were maintained at the same atmospheric temperature 24 ± 1°C before and after the lesion (6, 8) in those studies which showed an increase in wakefulness after the mPOA neuronal destruction. So, it could be argued that 24°C, which was the preferred temperature of normal rats, had become an uncomfortable zone of temperature after the mPOA lesion. The placement of the rats in this uncomfortable zone of temperature may have contributed towards the decrease in sleep and increase in wakefulness in the mPOA lesioned rats.

So, it may be hypothesized that, the mPOA acts as a fine tuning center for all the components of energy balance, and it must be regulating thermoregulation to maintain the body in an energy conserving state. In the absence of this fine tuning mechanism, after the lesion of the mPOA, the animals tend to select a higher T_{amb}, as they cannot make a proper assessment and regulation of their energy balance.

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REFERENCES

1. Gordon CJ. Relationship between preferred ambient temperature and autonomic thermoregulatory function in rat. *Am J Physiol* 1987; 252: R1130–R1137.

2. Nagel JA, Satinoff E. Mild cold exposure increases survival in rats with medial preoptic lesion. *Science* 1980; 208: 301–303.

3. Sherwood C, Massopust LC, McCrum WR, Buchanan AR. The effect of hypothalamic lesions upon maintenance in the albino rat while in cold

environments. *J Neuropath Exp Neurol* 1954; 13: 191–208.

4. Boulant JA. Hypothalamic neurons regulating body temperature. In Fregly MJ, Blatteis CM, eds. Handbook of Physiology, Section 4: Environmental Physiology. New York: Oxford University Press, 1996 pp 105–126.
5. Lipton JM. Effects of preoptic lesions on heat-escape responding and colonic temperature in the rat. *Physiol Behav* 1968; 3: 165–169.
6. Szymusiak R, Satinoff E. Ambient temperature dependence of sleep disturbances produced by basal forebrain damage in rats. *Brain Res Bull* 1984; 12: 295–305.
7. Schmidek WR, Hoshino K, Schmidek M, Timo-Iaria C. Influence of environmental temperature on the sleep-wakefulness cycle in the rat. *Physiol Behav* 1972; 8: 363–371.
8. Szymusiak R, Danowski J, McGinty D. Exposure to heat restores sleep in cats with preoptic anterior hypothalamic cell loss. *Brain Res* 1991; 541: 134–138.
9. De Groot J. The rat forebrain in stereotaxic coordinates. *Trans R Neth Acad Sci* 1959; 52: 1–40.
10. John J, Kumar VM. Effect of NMDA lesion on the medial preoptic neurons on sleep and other functions. *Sleep* 1998; 21: 585–597.
11. Sallanon M, Denoyer M, Kitahama C, Aubert N, Gay N, Jouvet M. Long lasting insomnia induced by preoptic neuron lesions and its transient reversal by muscimol injection into the posterior hypothalamus in the cat. *Neuroscience* 1989; 32: 669–683.
12. Kumar VM, Khan NA. Role of the preoptic neurons in thermoregulation in rats. *Arch Clin Exp Med* 1998; 7: 24–27.
13. Szymusiak R, DeMory A, Kitrell EMW, Sationff E. Diurnal changes in thermoregulatory behavior in rats with medial preoptic lesions. *Am J Physiol* 1985; 249: R219–R227.