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SUPERIOR CERVICAL GANGLIONECTOMY LEADS TO DAMPENING OF AMPLITUDE OF TEMPERATURE RHYTHM IN RATS

S. BHATKAL, G. SUNDARESAN, R. MATHUR AND U. SACHDEVA*

Department of Physiology,
All India Institute of Medical Sciences,
New Delhi – 110 029

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Abstract : The circadian rhythm of body temperature (CRT) is a robust marker of the endogenous pacemaker function and is one of the most frequently studied rhythms. Melatonin, the main secretion of the pineal gland seems to have more of a thermomodulatory role in controlling the body temperature than having a direct role in thermoregulation. The sympathetic innervation to the pineal via the superior cervical ganglion determines the melatonin secretion, and superior cervical ganglionectomy (SCGx) decreases the secretion of melatonin. The present study was conducted on the Wistar rats (n = 12) to determine the role of melatonin in modulation of CRT. Adult male rats were either ganglionectomised (n = 6) or sham ganglionectomised (n = 6). Rectal temperature was recorded for CRT analysis. Cosinar analysis of the temperature record was done to get the acrophase, amplitude and mesor. Our results show that SCGx decreases the amplitude to the rhythm but has no effect on the mesor of the rhythm. Our study confirms that melatonin has little role to play in the thermoregulation and its role is mainly in thermomodulation.

Key words : body temperature pineal innervation
superior cervical ganglionectomy rats

INTRODUCTION

The circadian rhythm of body temperature is a robust marker of the endogenous pacemaker function and there is considerable relationship between temperature rhythm of rats and other rhythms like locomotor activity, plasma corticosterone (1), sleep (2), melatonin and other hormonal rhythms.

Efferent from suprachiasmatic nucleus (SCN), the circadian pacemaker project to the pineal via the superior cervical ganglion and control melatonin synthesis and release (3, 4, 5). Bilateral superior cervical ganglionectomy (SGCx) abolishes the circadian rhythm of corticotropic hormones and melatonin (6, 7, 8). This strongly supports the notion that sympathetic nervous system plays an important role in

*Corresponding Author : Prof. of Physiology, College of Mecidine and Medical Sciences, Arabian Gulf University. Post Box 22979, Baharain

the regulation of pineal function. The present study was performed to examine the role of superior cervical ganglion on the circadian rhythm of temperature in rats. To this effect, the main neuronal supply to the pineal, the superior cervical ganglion was bilaterally excised and the effect of the same on the temperature rhythm was studied.

METHODS

The study was conducted on adult male Wistar rats in the weight range of 200–250 grams. They were first acclimatized to laboratory conditions for 2 days in L/D cycle of 12:12 at an ambient temperature of 24 ± 2°C, before subjecting them to experimental conditions. Throughout the period of experiment the rats were provided with ad libitum food and water. Temperature rhythm of the rats was screened for two days and only those rats with good rhythm were selected for the study. The study was conducted on 12 rats and these were divided into sham operated control (n = 6, Group I) and superior cervical ganglionectomised rats or experimental group. (n = 6, Group 2).

The rectal temperature rhythm recording was started at 2000 hours on day one. Four hourly temperature was recorded for 3 days which was taken as basal temperature rhythm recording. The rectal temperature was measured at every four-hour interval for a period of 3 days. A digital thermometer (OMRON Corpn., Japan) was used which has a dependable accuracy of ± 0.1 °F. Care was taken to assure that the animal was not aroused by placing the animal in a restrainer (20 × 10 × 8 cms), which was big enough to offer small movement so as to prevent stress while limiting the larger activities. The light-dark conditions were strictly followed at the time of measurements as well. The rats were kept fasting on the night of the 3rd day. On the fourth day, bilateral superior cervical ganglionectomy (SCGx) of the rats was done (9, 10). The control rats underwent sham SCGx wherein the ganglions were approached but not removed. After recovery from the anesthesia the rats were observed for the success of the procedure. Only those rats with bilateral ptosis were continued with the study and the others were discarded. After the surgery the rats were given 4 days of post operative recovery period. In this period the rats were watched for any infection of wound and also their temperature was checked to rule out infection. After the post operative recovery 3 more days of rectal temperature recording was done 4 hourly, starting at 2000 hours. This was taken as post SCGx temperature rhythm.

Statistical analysis

In the present study, the circadian rhythm analysis was done by using the cosinar analysis (11). The acrophase (ACR). mesor (ME) and amplitude (AMP) values obtained for individual rats on total 6 days were grouped into control and experimental groups and the mean of each day was taken for comparison. Intra-group comparisons for unpaired observations were made by one way ANOVA. Inter group paired comparisons were made by two sample 't' test.

RESULTS

The basal 3-day values of ACR, AMP and ME did not differ significantly, the average of these 3 days was taken as basal temperature rhythm. Similarly, the average of the 3 post SCGx/sham days was taken for comparison. Table I shows the values in sham operated rats while Table II shows the same for SCGx rats. The basal AMP of the non ganglionectomised group (0.47 ± 0.12) did not differ from either the basal AMP of the ganglionectomised group (0.49 ± 0.12) or the post operative AMP of the non ganglionectomised group (0.41 ± 0.11). But after ganglionectomy, the AMP decreased significantly ($P<0.05$) in the ganglionectomised group (0.33 ± 0.09) (Fig.

TABLE I: Amplitude, acrophase and mesor of the temperature rhythm in the non ganglionectomised rats (Group I). The 3 days of basal and 3 days of post operative values are given with their average values.

	Control							
	Basal				*Post operative*			
	Day 1 Mean (SD)	*Day 2 Mean (SD)*	*Day 3 Mean (SD)*	*Avg. Mean (SD)*	*Day 1 Mean (SD)*	*Day 2 Mean (SD)*	*Day 3 Mean (SD)*	*Avg. Mean (SD)*
AMP (°C)	0.54 (0.28)	0.36 (0.1)	0.52 (1.14)	0.47 (0.12)	0.43 (0.09)	0.47 (0.14)	0.35 (0.18)	0.41 (0.11)
ACR (hrs)	21.65 (1.14)	20.74 (1.7)	21.80 (1.02)	21.39 (1.16)	21.98 (0.81)	21.25 (1.56)	21.77 (1.05)	21.66 (0.74)
ME (°C)	37.35 (0.19)	37.21 (0.1)	37.15 (0.06)	37.24 (0.09)	37.33 (0.19)	37.33 (0.14)	3734 (0.20)	37.33 (0.12)

TABLE II: Amplitude, acrophase and mesor of the temperature rhythm in the non ganglionectomised rats (Group II). The 3 days of basal and 3 days of post operative values are given with their average values.

	Experimental							
	Basal				*Post operative*			
	Day 1 Mean (SD)	*Day 2 Mean (SD)*	*Day 3 Mean (SD)*	*Avg. Mean (SD)*	*Day 1 Mean (SD)*	*Day 2 Mean (SD)*	*Day 3 Mean (SD)*	*Avg. Mean (SD)*
AMP (°C)	0.58 (0.29)	0.39 (0.11)	0.49 (0.12)	0.49 (0.12)	0.31 (0.07)	0.33 (0.21)	0.34 (0.14)	0.33 (0.09)
ACR (hrs)	20.76 (1.41)	20.79 (1.03)	19.98 (1.15)	20.51 (0.87)	17.48 (2.77)	22.21 (2.43)	20.19 (5.94)	19.96 (3.48)
ME (°C)	37.28 (0.24)	37.4 (0.19)	37.37 (0.15)	37.35 (0.13)	37.46 (0.24)	37.41 (0.29)	3746 (0.22)	37.44 (0.2)

1). The basal as well as the post operative ME values of the control and the experimental groups did not differ from each other. In both the groups there was no change in the ME values after the operation (Fig. 2). The acrophase did not show any significant change after SCGx or sham operation (Fig. 3).

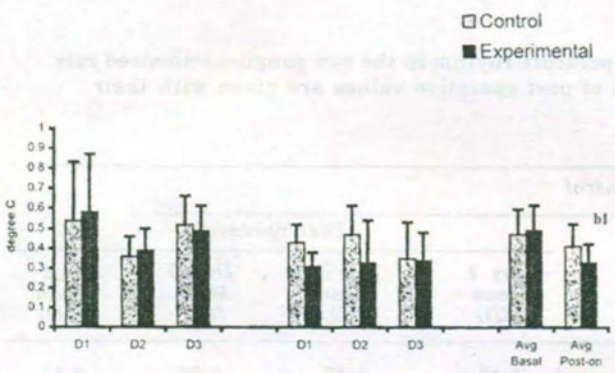

Fig. 1 : Showing the comparison of the basal AMP value with the Post operative AMP. There is significant ($P<0.05$) decrease in the Post operative AMP in the Ganglionectomised group.
b = Basal Vs Post operative SCGx/Sham
1 = $P<0.05$; 2 = $P<0.01$ & 3 = $P<0.001$

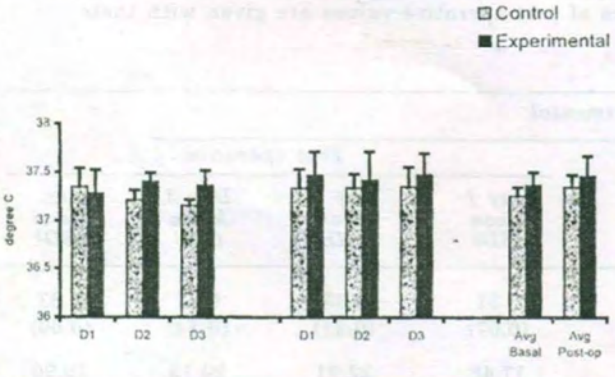

Fig. 2 : Comparison of the basal ME value with the Post operative ME. Mesor or the mean temperature did not change after ganglionectomy in both the groups.

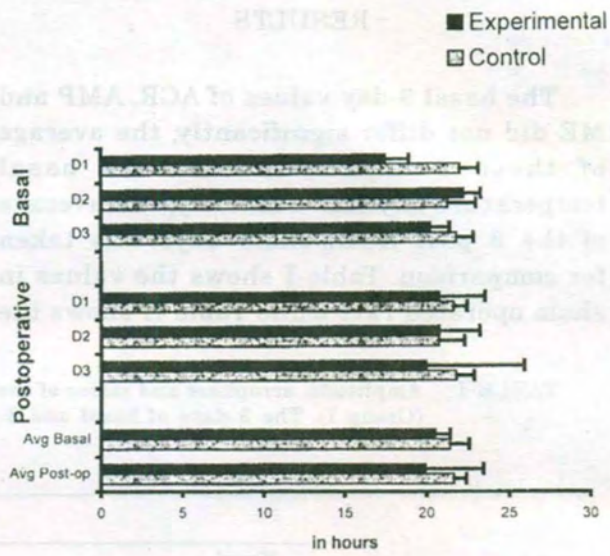

Fig. 3 : Comparison of the basal ACR value with the Post operative ACR. Statistical analysis did not show any significant change in the ACR in both ganglionectomised and non-ganglionectomised groups.

DISCUSSION

The SCGx resulted in the dampening of the amplitude of the temperature rhythm in rats. The amplitude remained same in control rats. This suggests that the observed disrupted temperature rhythm of the ganglionectomised rats caused from the removal of the superior cervical ganglion. However, the mean body temperature was not changed following the removal of superior cervical ganglion, suggesting that melatonin has little role to play on the thermoregulation.

There was a significant decrease in the AMP of the temperature rhythm in the ganglionectomised rats showing oscillatory function of the SCN. The suprachiasmatic nucleus is the primary site for the

generation of the body temperature rhythm in rats (12). After SSGx, the neural pathways mediating the rhythmic pineal melatonin secretion are lost (8), leading to decreased melatonin secretion. Loss of the oscillatory function of the SCN can be attributed to the disturbed pineal function and melatonin secretion. Though the pineal secretion of melatonin is under the influence of the SCN, it is now known that the melatonin has a feedback control over the SCN (13, 14). The role of melatonin in regulating the SCN function is further supported by the fact that receptors for melatonin has been localised in the SCN of rats (15). Moreover melatonin receptors have been localised in many areas of the brain like anterior pituitary gland, area postrema and SCN (16). There is a relationship between the pineal gland and the serotoninergic nerve endings of hypothalamus (17). Melatonin is known to generate 40% of the amplitude of the core body temperature rhythm (14). The dampened amplitude of temperature rhythm in the ganglionectomised rats might be caused from the loss of this above mentioned feedback control. The decrease in the amplitute of the temperature rhythm can be related to the disturbed melatonin rhythm.

Pineal gland has other neural connections apart from the polysynaptic sympathetic connection via the superior cervical ganglion (18, 19, 20). The normal circadian pattern of melatonin secretion is generated by the SCN via the sympathetic postganglionic sympathetic fibers of the superior cervical ganglion (21). The present study shows that the disrupted temperature rhythm following SCGx occurs due to the loss of pineal function and that melatonin plays an important role in the generation of the CRT.

REFERENCES

1. Honma K, Honma S. Internal synchronization among several circadian rhythms in rats under constant light. *Am J Physiol* 1987; 235: R243–R249.
2. Kent S, Satinoff E. Influence of ambient temperature on sleep and body temperature after phentolamine in rats. *Brain Res* 1990; 511: 227–233.
3. Jaim-Etcheverry G, Zieher LM. Localising serotonin in central and peripheral nerves. In: Neurosciences, edited by F.O. Schimdt, MIT Press, Cambridge 1974; 917–923.
4. Jaim-Etcheverry G, Zieher LM. Octopamine probably co exists with noradrenaline and serotonin in vesicles of the pineal adrenergic nerves. *J Neurochem* 1975; 25: 915–918.
5. Saper CB, Loewy AD, Swanson LW, Cowan WM. Direct hypothalamoautonomic connections. *Brain Res* 1976; 117: 305–312.
6. Klein DC, Weller JL. The role of N-acetylserotonin in the regulation of melatonin production. *In: Program 4th Intern Congr Endocrinology* 1971; P 52.
7. Morgan WW, Hansen JT. time course of disappearence of the pineal noradrenaline following superior cervical ganglionectomy. *Exp Brain Res* 1978; 32: 429–434.
8. Siaud P, Mekaouche M, maurel D, Givalois L, Ixart G. superior cervical ganglionectomy supresses circadian corticotrophic rhythms in male rats in the short term (5 days) and long term (10 days). *Brain Res* 1994; 652: 273–278.
9. Sears ML, Barany EH. Out flow resistance and adrenergic mechanism. *Arch Opthal* 1960; 64: 59–68.
10. Barrett RK, Underwood H. The SCG are not required for entrainment or persistence of pineal

melatonin rhythm in Japanese Quail. *Brain Res* 1992; 569: 249–254.

11. Nelson W, Tong YL, Lee JK, Halberg F. Methods for cosinar-rhythmometry. *Chronobiology* 1979; 6: 305–323.
12. Kittrell EMW, Satinoff E. Development of the circadian rhythm of body temperature in rats. *Physiology & Behaviour* 1986; 38: 99–104.
13. Gilette MU, McArthur AJ. Circadian actions of melatonin at the suprachiasmatic nucleus. *Behavioural Brain Research* 1996; 73: 135–139.
14. Cagnacci A. Melatonin in relation to physiology in adult humans. *J Pineal Res* 1996; 21: 200–213.
15. Gauer F, Mason PM, Pevet P. Differential regulation of melatonin receptors by short versus long term pinealectomy in the rat suprachiasmatic nuclei and pars tuberalis. *J Pineal Res* 1994; 16: 73–76.
16. Laitinen JT, Vishwanathan M, Vakkuri O, Saavedra JM. Differential regulation of rat melatonin receptors: selective age associated decline and lack of melatonin induced changes. *Endocrinology* 1992; 130: 2139–2144.
17. Cardinalli DP. Changes in the hypothalamic neurotrnsmitter uptake following pinealectomy, superior cervical ganglionectomy or melatonin administration to the rats. *Neuroendocrinology* 1975; 19: 91–95.
18. Leander P, Vrang N, Moller M. Neuronal projections from the mesencephalic raphe nuclear complex to the suprachiasmatic nucleus and the deep pineal gland of the golden hamster (Mesocricetus auratus). *J Comp Neurol* 1998; 399: 73–93.
19. Moller M, Hay Schmidt A. Direct neuronal projection from the dorsal raphe nucleus to the pineal complex of the rat: a Phaseolus vulgaris leucoagglutinin *in vivo* neuronal tracing study. *J Pineal Res* 1998; 25: 19–23.
20. Sparks DL. Anatomy of a new paired tract of the pineal gland in humans. *Neurosci Lett* 1998; 248: 179–182.
21. Moore RY. Neural control of the pineal gland. *Behav Brain Res* 1996; 73: 125–130.