Brazilian Journal of Veterinary Research and Animal Science (2003) 40 (supl 2): 90-95
ISSN *printed*: 1413-9596
ISSN *on-line*: 1678-4456

Correlation between tympanic and rectal temperature in marmosets (*Callithrix penicillata*) under acute stress
Correlações entre a temperatura timpânica e temperatura retal em saguis (*Callithrix penicillata*) sob estresse agudo

Vanner BOERE[1],
Ita Oliveira SILVA[1],
Gustavo CANALE[1],
Taíssa PIANTA[1],
Carlos TOMAZ[1]

1- Centro de Primatas do Departamento de Ciências Fisiológicas do Instituto de Biologia da Universidade de Brasília, Brasília - DF

Correspondence to:
VANNER BOERE
Centro de Primatas
Departamento de Ciências Fisiológicas
Instituto de Biologia
Universidade de Brasília
70910-900 - Brasilia - DF
vanner@unb.br

Received: 24/03/2003
Accepted: 19/02/2004

Abstract

In veterinary practice, tympanic temperature (TT) measurement is not very disseminated. It is surprising, because TT could have advantages compared to the rectal temperature (RT). In the present study, we investigate (*Callithrix penicillata*), right TT, left TT and RT. We used an infra-red thermometer to measure the temperature in marmosets of tympanic membrane, and a digital clinical thermometer for the measurement of rectal temperature. Right TT was lower than left TT and RT. There was not statistical difference between left TT and RT. Correlation between left TT and RT was stronger than correlation between right TT and both, left TT and RT. This results suggests of a regional thermal dissociation and an asymmetric cerebral metabolism and body temperature, due to the stress of contention in marmosets.

Key-words:
Marmoset.
Callithrix penicillata.
Tympanic temperature.
Rectal temperature.
Acute stress.

Introduction

Measurement of tympanic membrane temperature through infrared thermometers is a recent procedure in human clinic practice routine and seems to present methodological and economical advantages[1,2], however there is disagreement regarding the reliability of this technique when it is compared to oral temperature measurement.[3] In veterinary clinic practice, tympanic temperature (TT) measurement technique is not very disseminated[4,5], probably perhaps because there is few apparatus with design and adjustment suitable for animal use.

It is surprising, because TT could presents advantages compared to rectal measure temperature (RT), the most used method for thermal clinical checking in animals. RT method can present lower accuracy due to variation on the portion of the rectum measured, variations of local blood flow and the presence of feces.[1] RT is not faster than TT method. Besides, an indocile and agitated patient can precipitate fissures and wounds in the rectum during the procedure.

TT measurement has been used in studies that investigate functional differences among primates' cerebral hemispheres, through record of TT variation between left and right ear.[6,7,8] The tympanum is a membrane with thin vases that is believed suffer influence of the cerebral metabolism, especially of the hypothalamus, through the heating of cerebral tissue and cooling for the same ipsilateral tributaries of interne carotide.[9,10,11] Seemingly, non-human primates exhibit a lateral bias of TT depending on the external stimulus. Exhibition to aggressive visual stimulus seems to activate in a more preponderant way the right side of the brain.[8] Fearful and stressed rhesus monkeys showed lower right TT (RTT) than left TT (LTT).[6] Among humans, evidences suggest that there is a thermal asymmetry of TT in relation to emotional and sociality profile.[6,12]

Generally, corporal temperature measurement of primates requests its manual restraint, which is a strong emotional activator *per se*. In this case, it is possible that there are significant differences between right and left TT. There is also the possibility of significant differences between TT and RT, which could change the clinical interpretation. In fact, some studies indicated that significant differences occur between RT and TT[3,10] and between RT and hypothalamus and hippocampus temperature.[13]

Considering how fast TT is measured[2], the anatomical similarity of the auditory channel among humans and Neotropical primates[14], and the success in the experimental use of this technique, took place a comparative investigation of TT in marmosets raised in captivity, correlating it to RT, to sequence of captures and duration.

Materials and Methods

Tympanic and rectal temperatures of 22 marmosets (*Callithrix penicillata)* were measured, 14 males and 8 females (6 juvenile and 16 adults). The animals were housed in groups of two or three individuals. The subjects did not present clinical signs of pathology. They lived in captivity for at least 12 months at the Primate Center, University of Brasilia (PCUnB). However, marmosets were not tame and each capture elicits a characteristic fligt or aggressive responses.[15] Biology Institute's Ethics Commission from the University of Brasilia approved this research project. A veterinarian (V. B.) supervised the procedure.

The animals weighted between 250g and 450g and were housed in a pavilion with adjacent cages (2m long, 1.3m wide, 2m high). The cages were enriched with branches, platforms, strings and a nest-box. PCUnB is located at the border of a gallery forest, in an area of environmental protection. The creation system is *indoor-outdoor* where animals have free access to the exposed areas. Feeding consisted of a mixture of chopped fruits and puppy dog food, enriched with vitamins and boiled eggs. Food was placed 7:00 a.m. and removed 5:00 p.m., and water was available *ad libitum*.

TT was measured with a self-calibrating thermometer (ThermoScan, Braun, Germany) that measures the infrared heat generated by the eardrum and surrounding tissues. This thermometer takes eight measurements in one second and displays the highest temperature. Data collection was accomplished between 7:00 a.m. and 10:30 a.m., in the subject's own cage.

For temperature measurement the animals were divided randomly in three groups with seven, nine and six individuals respectively. There was an interval of 48 hours among each group measurement. In each group animals were captured one by one successively. For data collection an experienced caretaker familiar to the animals, with his hands protected by leather gloves, got into the cage, captured the subject using a net and placed it in dorsal decubitus for temperature measurement. The time between the entrance of the caretaker in the cage and the first TT measurement of subjects was considered the time of capture. TT was measured twice in each ear, alternately, in each subject. Immediately after TT was measured, RT measure took place. The temperature was measured for two consecutive times introducing a clinical digital thermometer (Normo, Porto Alegre, Brazil) in the rectum. The time elapsed between introducing thermometer and the final point of highest temperature, was 60 to 90 seconds.

The capture order was considered the position of the subject (first, second, etc) in the sequence of animals captured in that day. The whole procedure took place with the minimum of noise, with simple gestures to minimize excitement of the animals.

Means are presented with standard error (± SE) or standard deviation (± SD). Differences among RTT, LTT and RT were analysed by a paired-samples T test (two-tailed). To observe the correlation between RT and TT, Pearson correlation test (two-tailed) was applied. For the analysis of the correlation among the temperatures, the duration and the order of captures, a non-parametric test was performed (Spearman, two-tailed). Significance level in all the tests was considered $P \leq 0.05$.

Results

The comparative analysis (Figure 1) indicated that RTT mean (38.39 ± SE 0.18 ºC) was significantly lower than LTT mean (38.77 ± SE 0.20 ºC) (N=22, T= -2.589, P=0.017). RTT mean was also significantly lower than RT mean (38.84 ± SE 0.22 ºC) (N=22, T= -2.46, P=0.023). There were no significant differences between TTE mean and RT mean, (N=22, T = -0.249, P=0.80). RTT range and variance (R=37.35 ºC to 39.85 ºC, s^2= 0.721) were lower than LTT (R= 37.10 ºC to 40.45 ºC, s^2=0.911) and TR (R= 36.65 ºC to 40.50 ºC, s^2=1.006).

A significant positive correlation was found between the RTT mean and LTT mean (r = 0.71, $P \leq 0.0001$). Between the average of LTT and the average of RT it happened a strong highly significant positive correlation (r = 0.86; $P \leq 0.0001$). The average of RTT was correlated significantly with RT (r = 0.67, $P \leq 0.001$).

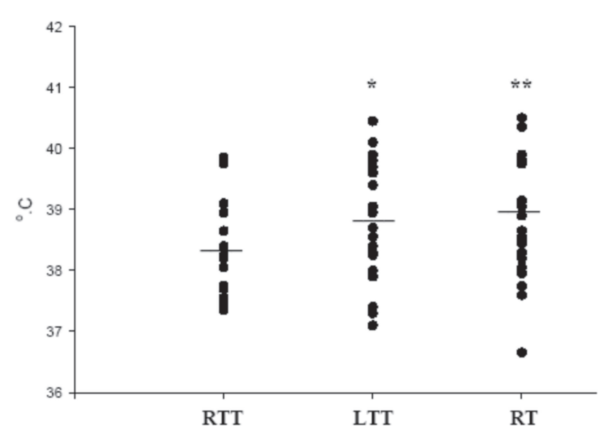
There was no correlation between time of capture (54.9 ± SD 40.6 s) and RTT (r= 0.04, P=0.86), LTT (r= 0.12, P=0.59) or RT (r= 0.45, P= 0.84). In the same way, there was no correlation between capture order and RTT mean (r = 0.18, P= 0.42), LTT mean (r = 0.18, P= 0.42) or RT mean (r = 0.16, P= 0.48).

Discussion and Conclusions

In this study, where tympanic and rectal temperature were measured in captive marmosets under restraint, it was observed that LTT mean and RT mean were strongly correlated. RTT mean was correlated with LTT mean and RT mean and the analyses showed that RTT was significantly lower than both. On the other hand, there were no significant differences between LTT and RT.

The most plausible explanation for the difference between RTT and LTT would be due to cerebral regional metabolism

Figure 1
Means of right tympanic temperature (RTT), left tympanic temperature (LTT) and rectal temperature (RT) of marmosets. * N=22, T= -2.589, P=0.017; ** N=22, T= -2.46, P=0.023



differences. In primates, including humans, the tympanum is a slender membrane with thin vases. It is believed that temperature of tympanic membrane suffers influence from cerebral metabolism, especially from the hypothalamus temperature. Brain temperature can be slightly lower than systemic temperature because constant brain activity produces of CO_2 (carbonic dioxide) and autonomous vascular adrenergic mechanisms release NO (nitric oxide[16]) causing reflex vasodilatation, which increases heat lost. Areas with larger brain metabolic activation demand larger arterial blood flow[17] that is decisive for temperature gradients observed in the tympanic membrane and in the hypothalamus.[9] Therefore, the tympanic membrane is "cooled" by blood from the branches of the carotid artery which irrigated part of brain.[11] The suggestion that brain temperature would depend mostly on regional irrigation[13] does not invalidate the preponderant role of regional metabolic activity in environments with relatively stable temperature, because vasodilators factors (CO_2 and NO) seem to anticipate and in some level, on control blood flow.

Therefore, the difference between RTT and LTT seems to reflect a larger metabolism on the right side of the brain. Due to the emotional activation of the capture and manual contention, it is believed that cerebral areas preferably related to intense stress, as limbic area and with autonomous control (hypothalamus) are strongly stimulated, converging for a substantial increase of the regional brain metabolism. Areas related to fear, to anxiety and autonomous activation, are located predominantly in structures from the right hemisphere of the brain (in humans,[18,19,20,21]; in chimpanzees,[8]; in mice[22]). In fact, Boyce *et al.*[6] observed lower RTT in relation to LTT or to a base line in rhesus macaques and humans with behavioral disturbances. Parr and Hopkins[8] observed that same pattern in chimpanzees submitted to aggressive visual stimulus.

It was considered that the difference between RTT and LTT in human beings and Old World monkeys submitted to emotional activation, is a product of higher metabolism on the right hemisphere of the brain in relation to left side. The hypothalamus is the main limbic cerebral structure, irrigated with tributaries of the same arteries (interne carotide) which bath the tympanic membrane.[9] Cortical activation in affective disorders is preponderant on the right hemisphere in humans.[12] Therefore, the measured temperatures would be a result of the increase in blood flow for metabolic demand in this area.

The differences between RTT and LTT found in this study suggest that in marmosets there is a larger cerebral activation on the right side of the brain under high emotional demands. This discovery can be another evidence of brain functions lateralization in marmosets, a fact that still has to be fully proven.

LTT elevation can be interpreted as a result of the general metabolic activation, as observed by RT increase. Subjects from the several captured groups had auditory, visual and olfactory contact with the other cages. Therefore, the whole procedure of capture and contention attended with strong vocalizations and escape attempts, could be observed by the marmosets from the adjacent cages. The capture of the subjects demands larger physical activity due to the invariable escape attempts of the animals. As observed in mice, an increase of corporal metabolism is predictable.[13] In humans under moderate muscular exercise for example, there is an increase in the brain blood flow cerebral of around 30%.[23] It is suggested that the same happens in marmosets.

As primates in general are very attracted and influenced by nearby events, we believe that a generalized activation could have happened in these animals. Therefore, the blood flow in the left side of brain seems to be under smaller reflex influence of the regional metabolic activity than the right area. The lack of differences between LTT and RT, associated to the highly significant correlation among both suggests a thermal level similar, but slightly dissociated from the right brain metabolism. This dissociation between RT and TT was described in humans, mice and bovine.[1,3,4,10] Besides, our study just indicated larger RT in relation to RTT disagreeing with studies that indicate larger RT in relation to RTT and LTT.[9] Thus, the narrow association between LTT and RT, can reflect the systemic temperature activated by intense muscular activity, and in certain way, for concomitant autonomous reactions that accompany capture stress. Consequently there is a smaller vasodilatation and the brain temperature on the left side is closer to rectal temperature.

The fact that RTT and LTT are not the same, is important to consider clinical decisions in brain injuries. Excessive brain heating can aggravate ischemic lesions while cooling seems to protect cerebral tissue.[10]

A correlation between order of captures and RTT, LTT and RT was not observed. That suggests that there are not a predictability or learning of capture set by marmosets, and the procedures were a typical acute stress. Time of capture seems not to have influenced the gradients of TT and RT, because there was not observed a correlation among them, probably due to the briefness procedures.

These results drive to two important conclusions. The first refers to brain activity asymmetry in marmosets, that is, the right side of the brain would be more activated in a high stressful situation of capture. This state resembles to fear and emotional disturbance, state that activate mainly the right side of the brain in another animal species. The relative cooling of RTT suggests lateralization of brain function in this small New World anthropoid.

The other conclusion is related to the diagnosis approach for the measurement of temperature in marmosets. Central corporal temperature in theory could be better measured at the hypothalamus, where there are thermosensor neurons that act as a thermostat changing metabolism and regulating temperature.[24] In fact, for contiguity, the tympanic membrane has been the best viable anatomical structure for central temperature measurement with much faster answers to blood flow in this area when compared to rectal area.[1,5,10]

In our study TT presented smaller thermal widths than RT and given the proximity with brain areas critical in body temperature control it should be a favorable area for thermal checking. Although small, the difference between RTT and LTT or RT, can modifies the clinical interpretation. In short, tympanic thermometry seems to be a promising diagnosis approach in wild primates and possibly in another taxa. A comparative approach between tympanic and rectal temperatures would be particularly interesting in animals with clinical, otological and neurological disorders.

Resumo

Na prática de clínica veterinária a temperatura timpânica (TT) não é disseminada. Isto é surpreendente porque a TT poderia apresentar vantagens em relação à medida da temperatura retal (RT).Neste estudo, investigou-se a temperatura timpânica direita (RTT), temperatura timpânica esquerda (LTT) e temperatura retal em sagüis do cerrado (*Callithrix penicillata*). Usou-se um termômetro de emissão de raios infra-vermelhos para a mensuração da temperatura da membrana timpânica e um termômetro clínico digital para a medida da temperatura retal. RTT foi menor do que LTT e RT. Não houve diferença estatística entre a LTT e RT. A correlação entre LTT foi mais forte em relação à RT do que à RTT. Estes resultados são sugestivos de uma dissociação e assimetria térmica regional entre o metabolismo cerebral e a temperatura sistêmica, devido ao estresse agudo da contenção.

Palavras-chave:
Sagüi.
Callithrix penicillata.
Temperatura timpânica.
Temperatura retal.
Eestresse agudo.

References

1. ROBINSON, J. et al. Comparison of oesophageal, rectal, axillary, bladder, tympanic and pulmonary artery temperatures in children. **Journal of Pediatrics**, v. 133, p. 553–556, 1998.
2. STAVEM, K.; SAXHOLM, H.; ERIKSSEN, J. Tympanic or rectal temperature measurement? A cost-minimization analysis. **Scandinavian Journal of Infectious Diseases,** v. 32, p. 299-301, 2000.
3. MODELL, J. G. et al. Unreliability of the infrared tympanicthermometer in clinical practice: a comparative study with oral mercury and oral electronic thermometers. **Southern Medicine Journal**, v. 91, p. 649–654, 1998.
4. MYERS, M. J.; HENDERSON, M. Assessment of two devices for measuring tympanic membrane temperatures in swine, dairy cattle and dairy calves. **Journal of American Veterinary Association,** v. 207, p. 1700-1701, 1996.
5. BERGEN, R. D.; KENNEDY, A.D. Relationship between vaginal and tympanic membrane temperature in beef heifers**. Canadian Journal of Animal Science**, v. 80, p. 515–518, 2000.
6. BOYCE, W. T. et al. Tympanic temperature asymmetry and stress behavior in rhesus monkeys and children. **Archives of Pediatric and Adolescent Medicine**, v. 150, p. 518–523, 1996.
7. HOPKINS, W. D.; FOWLER, L. A. Lateralized changes in tympanic membrane temperature in relation to different cognitive tasks in chimpanzees (*Pan troglodytes*). **Behavioural Neuroscience,** v. 112, p. 83–88, 1998.
8. PARR, L. A.; HOPKINS, W. D. Brain temperature asymetries and emotional perception in chimpanzees, *Pan troglodytes*. **Physiology and Behavior**, v. 71, p. 363-371, 2000.
9. BAKER, M. A.; STOCKING, R. A.; MEEHAN, J. P. Thermal relationship between tympanic membrane and hypothalamus in conscious cat and monkey**. Journal of Applied Physiology**, v. 32, p. 739–742, 1972.
10. BRAMBRINK, A. M. et al. Control of brain temperature during experimental global ischemia in rats. **Journal of Neuroscience Methods**, v. 92, p. 111–122, 1999.
11. MEINERS, M. L.; DABBS, J.M. Ear temperature and brain blood flow: Laterality effects. B. **Psychonomic Society**, v. 10, p. 194–196, 1977.
12. BOYCE, W. T. et al. Temperament, tympanum, and temperature: four provisional studies of the biobehavioral correlates of tympanic membrane temperature asymmetries. **Child Development**, v. 73, p. 718-733, 2002.
13. AHLERS, S. T.; THOMAS, J. R.; BERKEY, D. L. Hippocampal and body temperature changes in rats during delayed matching-to-sample performance in a cold environment. **Physiology and Behavior**, v. 50, p. 1013-1018, 1991.
14. HERSHKOVITZ, P. Skull: Middle ear region. In: HERSHKOVITZ, P. (Ed.), **Living new World Monkeys (Platyrrhini)**. Chicago: The University Chicago Press, , 1977. v. 1, p. 172–187.
15. BOERE, V. **Efeitos do estresse psicossocial crônico e do enriquecimento ambiental em sagüis (*Callithrix penicillata*):** um estudo comportamental, fisiológico e farmacológico. 2002. 238 f. Tese (Doutorado – Programa de Pós-graduação em Neurociências e Comportamento), Instituto de Psicologia, Universidade de São Paulo, São Paulo, 2002.
16. DREVETS, W. C.; RAICHLE, M. E. Positron emission tomographic imaging studies of human emotional disorders. In: GAZZANIGA, M. S. (Ed.). **The cognitive neurosciences**. Cambridge: The Mit Press, p. 1153-1164.
17. GUR, R. C. et al. Lateralized increases in cerebral blood flow during performance of verbal and spatial tasks: relationship with performance level. **Brain and Cognition,** v. 24, p. 244–258, 1994a.
18. GUR, R. C. Effects of emotional discrimination tasks on cerebral blood flow: regional activation and its relation to performance. **Brain and Cognition,** v. 25, p. 271–286, 1994b.
19. KAYSER, J. et al. Event-related potentials (ERPs) to hemifield presentations of emotional stimuli: differences between depressed patients and healthy adults in P3 amplitude and asymetry. **International Journal of Psychophysiology**, v. 36, p. 211–236, 2000.
20. OSUCH, E. A. et al. Regional cerebral metabolism associated with anxiety symptoms in affective disorder patients. **Biological Psychiatry**, v. 48, p. 1020–1023, 2000.
21. VAN STRIEN, J. W.; VAN BEEK, S. Rates of emotion in laterally presented faces: Sex and handedness effects. **Brain and Cognition, v.** 44, p. 645–652, 2000.
22. ADAMEC, R., SHALLOW, T. Rodent anxiety and kindling of the central amygdala and nucleus basalis. **Physiology and Behavavior**, v. 70, n. 1-2, p. 177-187, 2000.
23. CABANAC, M. Selective brain cooling in humans: "Fancy or fact?". **FASEB Journal** v. 7, p. 1143–1147, 1993.
24. BENZINGER, T. H. Heat regulation: homeostasis of central temperature in man. **Physiology Reviews**. v. 49, p. 671–759, 1969.