Slovak J. Anim. Sci., 42, 2009, SUPPLEMENT 1: 63-66
ISSN 1337-9984

Scientific paper formerly presented

RADIOTELEMETRY MEASUREMENT OF HEART RATE, BLOOD PRESSURE AND LOCOMOTORY ACTIVITY OF RATS IN PHYSIOLOGICAL EXPERIMENT

Ľ. MOLČAN[1*], A. VESELÁ[1], M. ZEMAN[1,2]

[1]Department of Animal Physiology and Ethology, Faculty of Sciences, Comenius University, Bratislava;
[2]Institute of Animal Biochemistry and Genetics, Slovak Academy od Sciences, Ivanka pri Dunaji, Slovak Republic

ABSTRACT

Evaluation of physiological traits in freely moving animals represents an innovative approach allowing physiological studies in undisturbed animals without interference with handling and stress. This approach is important in behavioural sciences and research on physiological basis of cardiovascular diseases. Recently, there is only one such system in the world that enables simultaneous measurement of blood pressure, heart rate, body temperature and electroencephalography together with the locomotory activity which was developed by the Data Sciences International (St. Paul, Minessota, USA). In our laboratory we have introduced and validated this system in laboratory rats and hereby present results on blood pressure, heart rate and locomotory activity in rats exposed to stabile light – dark cycles.

Key words: telemetry; freely moving rats; cardiovascular; behaviour

INTRODUCTION

Measurements of physiological variables in experiments are frequently affected by irregularities resulting from handling of animals and subsequent stress. These limitations can be overcome by telemetric techniques which enable obtaining data without handling of experimental animals before and during measurements.

Determination of blood pressure (BP) and heart rate (HR) is very useful in many types of experiments. Usually BP is measured by tail-cuff plethysmography on the tail of laboratory rodents, mainly rats and mice. This "noninvasive" approach requires handling of animals and an increase of ambient temperature that result in the stress induced increase in BP and HR values (Chiueh et al., 1978; Irvine et al., 1997). Another, more sophisticated approach for measuring BP and HR is a radiotelemetric method. The direct comparison of both methods revealed that the radiotelemetry provided results about 16 ± 2 mmHg lower than the tail plethysmography (Ferrari et al., 1990).

In our experiment we aimed at validation of the radiotelemetry method for measurement of BP, HR and locomotory activity. This type of measurement may provide valuable data especially in continuous long-term experiments. Therefore, we evaluated especially long term changes of these physiological variables during circadian rhythms which cannot be assessed by the noninvasive tail-cuff plethysmography.

***Correspondence:** E-mail: lubos.molcan@centrum.sk
Bc. Ľuboš Molčan, Department of Animal Physiology and Ethology, Faculty of Sciences,
Comenius University Bratislava, Mlynská dolina B2, 842 15 Bratislava, Slovak Replublic
Tel. fax +421 2 60296 576

MATERIAL AND METHODS

In our experiment we used four mature female rats (age 12 months, body weight 284 ± 11g) from the Institute of Experimental Pharmacology, Breeding facility Dobra Voda, Slovak Republic. After two weeks of adaptation, animals were anesthetized with Narketan (Ketamine 10%; CHASSOT AG, Switzerland) : Rometar (Xylazine 2 %; SPOFA, Praha) in ratio 3:2. We administered intramuscularly 600 µl of mixture to 300g of body weight. Animals were kept in the air conditioned facility at temperature 22 ± 1 °C and light (L) : dark (D) cycle 12:12 during the entire experiment. Animals were allowed to recover for 2 weeks after surgery and afterwards radiotelemetry measurements were initiated.

For the measurement of BP, HR and locomotory activity on freely moving animals we used the radiotelemetry system from the Data Sciences International (St. Paul, Minnesota, USA), which is the only one available for this type of measurement. The system consists from telemetric implants which send signals to receivers located under the cages in which animals were individually housed. The receiver converts measured data and sends them to the matrix connected with a computer equipped with Dataquest A.R.T. system that enables recording and storage of results. In our experiment we used the implantable sensor TA11PA-C40 (DSI, St. Paul, Minnesota, USA) which was implanted into the abdominal aorta closely to the point of its bifurcation. We adapted the procedure recommended by the supplier and animals recovered were moving 24 h after the surgery. Data for analysis of circadian rhythms were obtained only 2 weeks after the surgery when all experimental animals exhibited normal behaviour and no consequences of surgery.

Data were analyzed by the software Dataquest A.R.T. 4.1 (St. Paul, Minnesota, USA) and Chronos-Fit 1.05 (Heidelberg University, Mannheim, Germany) (Zuther and Lemmer, 2004).

RESULTS AND DISCUSSION

Implanted animals were kept at a stabile light: dark (LD) 12:12 regimen. Measurements of BP, HR and locomotory activity were taken in 10 second intervals. This mode of measurement provided us with approximately 60,000 records from each animal per parameter and one day. Representative records of daily profiles in BP, HR and locomotory activity are illustrated in the Figure 1. As expected, higher values of all parameters were recorded during the dark-time then the light-time reflecting nocturnality of rats. Blood pressure values during the light-time were found in a range 60 – 90 mmHg for diastolic BP, with the mean 71.7 ± 0.1 mmHg and 110 – 150 mmHg with the mean 118.2 ± 0.1 mmHg for systolic BP (Fig.2). Values measured during the dark-time were higher than during the day-time and represented 76.4 ± 0.1 and 125.1 ± 0.1 mmHg for diastolic and systolic BP, respectively. HR values during the ligh-time were found in a range 240 – 480 beats per minute, with the mean 285.7 ± 0.5 beats per minute. Values measured during the dark-time were substantially higher than during the day with average 341 ± 0.7 beats per minute. We recorded an increase in locomotory activity at the beginning and at the end of the dark period which was accompanied by an increase in BP and HR. Mean locomotory activity during the light-time was 0.8 ± 0.1 counts per minute while during the dark-time it increased up to 3.2 ± 0.1 counts per minute. Measured values of BP and HR are in ranges reported with telemetric measurements and are lower as found by noninvasive tail-cuff plethysmography (Guiol et al., 1992). Recently, it has become possible to use the telemetric system in different species of mammals (Schnell et al., 1996; Kramer, 2000), birds (Savory and Kostal, 2006) and more recently even in fish (Snelderwaard et al., 2006).

In all variables we found an increase of values before lights were put off. This finding demonstrates the circadian control of all studied parameters including the anticipatory increase before the change in the photoperiod. In addition to the significant circadian rhythms in BP, HR and locomotory activity we observed rhythmic changes with shorter periods than 24 h (Fig. 1). These ultradian rhythms with period 2-3 hours were much more variable than the circadian rhythms and their characteristics, which have not been described well yet.

For clearer demonstration of circadian changes in all studied parameters we expressed their daily profile on the basis of hourly means (Fig. 2). These plots emphasized rhythmic changes with longer periods and demonstrated significant correlations among all studied parameters on the basis of circadian rhythms. Short term changes correlated closely between diastolic and systolic BP as well as between heart rate and locomotory activity (Fig. 2). Multiple correlations among all studied parameters monitored during several days and weeks require a bioinformatics approach owing to the huge number of obtained data.

CONCLUSION

We successfully introduced and validated the radiotelemetry techniques for continuous and long term monitoring of BP, HR and locomotory activity in freely moving rats. The ranges of obtained values of systolic and diastolic BP were in the range given in literature. We proved that this approach enables measurement of physiological variables without an interference with handling and subsequent stress stimuli of studied animals. A disadvantage is a high cost of the equipment and exchange of batteries in sensors by the manufacturer. Therefore the use of the system must be carefully considered.

ACKNOWLEDGEMENTS

The work was financially supported by following grants: APVV 20-022704 and APVV-0214-07

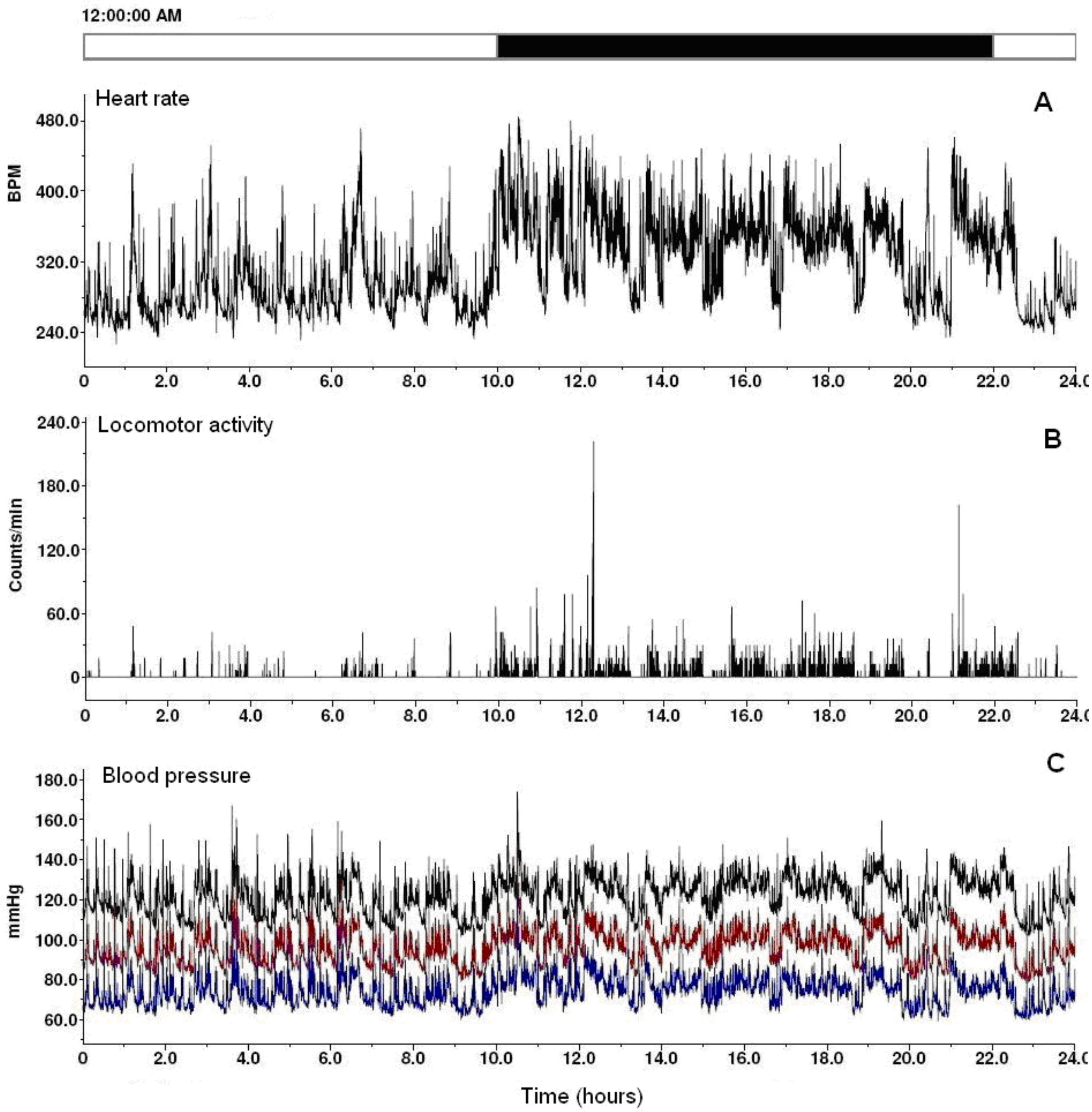

Fig.1: Daily profiles of heart rate (A), locomotor activity (B) and blood pressure (C) in a laboratory rat implanted with the sensor TA11PA-C40 (DSI St. Paul, Minnesota, USA). Plots represent outputs from the program Dataquest A.R.T. 4.1 with 8.640 values per 24 h reflecting 1 min averages of measured parameters. Animals were kept at LD 12:12, with lights on from 22:00 till 10:00. The dark bar above graphs represents the dark time period

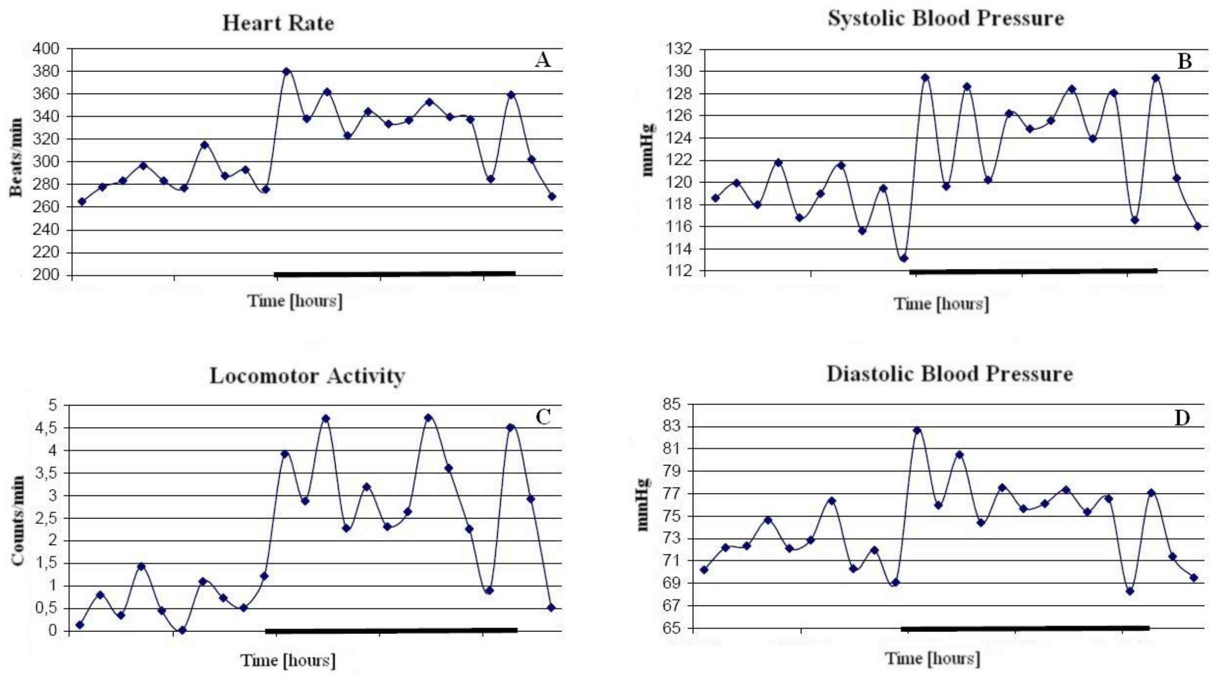

Fig.2: Daily profiles of heart rate (A), locomotor activity (C) and blood pressure (systolic (B) and diastolic (D)) in the laboratory rat kept in LD 12:12 and monitored by the radiotelemetry system (DSI St. Paul, Minnesota, USA). Each point at the graph represents a 1-hour mean. Results illustrate a high correlation between systolic and diastolic BP values and between heart rate and locomotor activity. The dark bar on the abscissa represents the dark period of the 24 h cycle

REFERENCES

FERRARI, A. U. – DAFFONCHIO, A. – ALBERGATI, F. – BERTOLI, P. – MANCIA, G. 1990. Intra-arterial pressure alterations during tail-cuff blood pressure measurements in normotensive and hypertensive rats. *Journal of Hypertension*, vol. 8, 1990, p. 909-911.

CHIUEH, C. C. - KOPIN, I. J. 1978. Hyperresponsivity of spontaneously hypertensive rat to indirect measurement of blood pressure. *American Journal of Physiology*, vol. 234, 1978, p. 690-695.

GUIOL, C. – LEDOUSSAL, C. – SURGE, J.M. 1992. A radiotelemetry system for chronic measurement of blood pressure and heart rate in the unrestrained rat validation of the method. *Journal of Pharmacological Toxicological Methods*, vol. 28, 1992, p. 99-105.

IRVINE, R. J. - WHITE, J. - CHAN, R. 1997. The influence of restraint on blood pressure in the rat. *Journal of Pharmacological Toxicological Methods*, vol. 38, 1997, p. 157-162.

KRAMER, K. 2000. Applications and Evaluation of Radio-telemetry in Small Laboratory Animals. Doctoral thesis, Utrecht University. 2000. ISBN 90-393-2313-5.

SAVORY, C. J. – KOSTAL, L. 2006. Is expression of some behaviours associated with de-arousal in restricted-fed chickens?. *Physiology and Behavior*, vol. 88, 2006, p. 473-478.

SCHNELL, C. R. – DEBON, C. – PERCICOT, C. L. 1996. Measurement of intraocular pressure by telemetry in conscious, unrestrained rabbits. *Investive Ophthalmology and Visual Science*, vol. 37, 1996, p. 958-965.

SNELDERWAARD, P. CH. - VAN GINNEKEN, V. – WITTE, F. – VOSS, H. P. – KRAMER, K. 2006. Surgical procedure for implanting a radiotelemetry transmitter to monitor ECG, heart rate and body temperature in small Carassius auratus and Carassius auratus gibelio under laboratory conditions. *Laboratory Animals*, vol. 40, 2006, p. 465-468.

ZUTHER, P. – LEMMER B. 2004. Chronos-Fit, http://www.ma.uni-heidelberg.de/inst/phar/forschungLemmer.html, 2004.