Analysis of Mice Heart Rate Variability Obtained through Plethysmograph Power Spectrum

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Abstract

In this work we focus on the measurement of heart rate variability (HRV) from the murine plethysmograph. We check whether the recently proposed heart instantaneous frequency (HIF) idea is a viable tool to assess HRV under normal and the adverse conditions of signal saturation. We also characterize the heart rate variability of unanesthetized and anesthetized mice.

1. Introduction

Mice have been widely used because they are economical, easy to breed and easy to handle. Heart rate has proved to be a useful tool for understanding the status of the autonomic nervous system (ANS). However, no equivalent study has been conducted in mice. While extracting the HRV from the conscious mouse poses problems, some researchers are trying to extract the HRV from the pulse wave [1]. We propose to use the heart instantaneous frequency (HIF) [2] of the plethysmograph measured from the tail of the mouse.

2. Methods

Ten wild-type mice, weighing 24 to 38g, were studied. Each mouse was weighed, placed in a mouse restrainer, and positioned over a heating pad. An occlusion cuff and mechanical plethysmograph sensor (Kent Scientific, Litchfield, CT) were placed around the tail of the mouse. The tail was taped down to minimize movement. The plethysmograph was then measured continuously for ten minutes with a Yokogawa DL708E Digital Scope at 1000 samples/sec.

The mouse was then removed from the restrainer and anesthetized. The mouse was secured to an operating table. A heating element was positioned directly under the mouse. The occlusion cuff and plethysmograph sensor were repositioned on the tail and systemic pressure was measured three times. Upon conclusion of data collection, the mouse was euthanized with 35 ml of propofol.

The concept of instantaneous frequency has been previously described. Given that a signal is repeating itself in time, one may question how often it is being repeated, and how this changes occur along time. This can be extended to cardiac signals. In fact, the well known that heart rate variability, which is extracted from the R-waves of the ECG, may be thought as the instantaneous frequency itself. Barros and Ohnishi [2] have previously described the calculation of the HIF applied to the ECG in detail.

ID	Pre-anesthesia	Post-anesthesia
1.	0.0194	1.1118
2.	0.0525	0.4853
3.	0.0197	1.0146
4.	0.1005	1.4375
5.	0.0051	2.1795
6.	0.1172	0.0383
7.	0.4260	1.5375
8.	0.0981	0.1041
9.	0.1694	1.6827
10.	0.5284	1.6827
11.	0.4068	0.1395

Table 1. The ratio of the high to low frequencies in the HIF before and after anesthesia administration.

3. Results

We found the HIF for all animals. We measured the ratio between the lower and higher frequencies energy (HF/LF) before and after anaesthesia, whereas the result are shown in Table 1.

4. Discussion

The conscious murine plethysmograph is easy to measure. Furthermore, the HIV can appears to accurately measure the affect of anesthesia on the HRV. Another conclusion is that there was a drop of energy at higher frequencies after anesthesia. This is consistent with what occurs in other animals, because anesthesia limits the action of the sympathetic nervous system.

References

[1] J. V. M. Karrakchou, S. Laberer and E. Pruvot, Analysis of heart rate variability: comparison between spectra obtained from ECG and finger blood pressure, 1993, Proc the IEEE Eng. in Med. and Biol. Soc.

[2] A. K. B. a. N. Ohnishi, Heart Instantaneous Frequency (HIF): An Alternative Approach to Extract Heart Rate Variability, 2001, IEEE Trans. on Biomedical Engineering.

[3] L. Fei, Affects of pharmacological interventions on heart rate variability: animal experiments and clinical observations, in *Heart rate variability*, M. M. a. A. Camm, Ed.: Futura Publishing Company, 1995, pp. 275-291. 220-222.

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