

Effects of Repeated Atropine Injection on Heart Rate Variability in Thoroughbred Horses

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ABSTRACT. To investigate the effects of repeated atropine injection on heart rate (HR) variability in resting Thoroughbred horses, two $\mu\text{g}/\text{kg}$ of atropine as parasympathetic nervous blockade was injected intravenously every 6 min to a total of $8 \mu\text{g}/\text{kg}$ after intravenous administration of $0.2 \text{ mg}/\text{kg}$ of propranolol as sympathetic nervous blockade. We recorded electrocardiograms and obtained the HR, then evaluated variation in HR from the power spectrum in terms of low frequency (LF, $0.01\text{--}0.07 \text{ Hz}$) power and high frequency (HF, $0.07\text{--}0.6 \text{ Hz}$) power. Administration of atropine decreased parasympathetic nervous activity in a dose-dependent manner, affecting first the LF power, then the HF power and finally HR. These responses may provide valuable information for evaluating autonomic nervous activity in Thoroughbred horses.

KEY WORDS: atropine, heart rate variability, Thoroughbred horse.

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Heart rate (HR) variability has been suggested to be a noninvasive index of autonomic nervous activity [1, 5, 6]. The power spectrum of HR variability in the high-frequency (HF) power is generally thought to reflect primarily parasympathetic nervous function. Both the sympathetic and the parasympathetic nervous systems have been shown to contribute to the low-frequency (LF) power. Therefore, the LF/HF ratio has been considered to be an index of the cardiac sympathovagal balance. Recently we established a power spectral analysis of HR variability to assess autonomic nervous function in Thoroughbred horses [4], and evaluated the influence of training on autonomic function in young Thoroughbreds [3]. We have suggested that it is necessary to evaluate the balance of autonomic function carefully by using the LF/HF ratio because parasympathetic nervous activity strongly mediates HR variability not only in the HF power but also in the LF power.

The purpose of this study was to investigate the influence of changes in parasympathetic nervous activity on the HF power, the LF power and the LF/HF ratio in the HR variability power spectrum in Thoroughbred horses. We induced changes in parasympathetic tone with repeated injections of atropine as a parasympathetic antagonist. It has been reported that the response to the sympathetic beta-adrenergic blocker propranolol on HR variability in Thoroughbreds is different from that in other mammals, i.e., propranolol increases both the HF and the LF power without affecting HR [4]. Therefore, in order to exclude potentially confounding effects of sympathetic activity and to clarify the role of changes in parasympathetic activity alone on the HF power, the LF power and the LF/HF ratio, we repeatedly injected atropine after blocking sympathetic nervous activity with propranolol.

Experiments were performed on seven healthy Thoroughbreds (five males and two females, average age $5.0 \pm$

3.5 (SD) years, average weight $490 \pm 24 \text{ kg}$). The horses were standing in stock in a quiet and lighted room. A 14-gauge Teflon catheter was inserted into the left jugular vein after local anesthesia was administered. Propranolol hydrochloride ($0.2 \text{ mg}/\text{kg}$) was administered intravenously to block cardiac beta-adrenergic receptors. Thereafter, $2 \mu\text{g}/\text{kg}$ of atropine sulfate was injected intravenously every 6 min to a total dose of $8 \mu\text{g}/\text{kg}$. Electrocardiograms (ECGs) were recorded by base-apex lead using a Holter-type electrocardiograph (SM-60; Fukuda Denshi Co. Ltd., Tokyo). The recorded ECGs were analyzed with an ECG processor analyzing system (Softron Co. Ltd., Tokyo) that we have previously described [4]. The program first detected R waves and calculated the R-R interval tachogram as the raw HR variability in sequence order. From this tachogram, data sets of 512 points were resampled at 200 msec. We applied each set of data to the Hamming window and a fast Fourier transform to obtain the power spectrum of the fluctuation. We set the LF power at $0.01\text{--}0.07 \text{ Hz}$ and the HF power at $0.07\text{--}0.6 \text{ Hz}$. Heart rate, the LF power, the HF power, and the LF/HF ratio were obtained from each recording. We used these values as indices of autonomic nervous function.

Figure 1 shows changes in HR and HR variability after repeated injections of atropine. Heart rate did not change until $4 \mu\text{g}/\text{kg}$ of atropine was administered, but it increased after the total dosage of $6 \mu\text{g}/\text{kg}$. The LF power decreased in a dose-dependent manner with administration of atropine. The HF power started to decrease in a dose-dependent manner after administration of the $4 \mu\text{g}/\text{kg}$ dose of atropine, although it did not change at $2 \mu\text{g}/\text{kg}$. The LF/HF ratio stayed almost constant throughout the experiment as both the LF power and the HF power decreased dose-dependently and by similar magnitude with administration of atropine.

Heart rate, the LF power and the HF power were changed

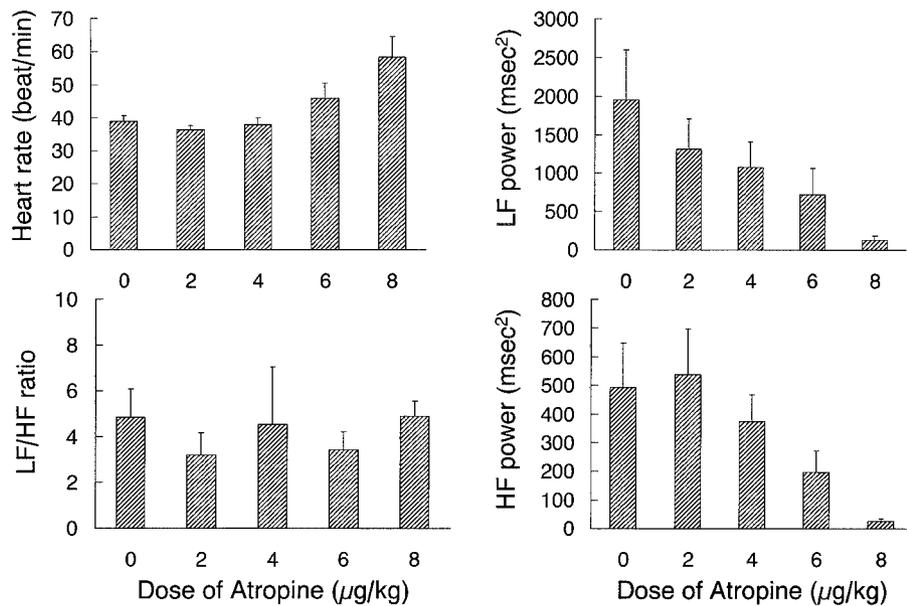


Fig. 1. Effects of repeated atropine injection on heart rate variability in Thoroughbred horses. Values are mean \pm S.E.

in a dose-dependent manner by atropine in this study, but the dosages required to cause changes in those variables were different. The HF power decreased by 4 $\mu\text{g}/\text{kg}$ of atropine, but that dose did not change HR. This observation suggests that a slight change in parasympathetic nervous activity influenced beat-by-beat fluctuations in HR as reflected in the HF power.

We have also shown that the LF power reflects parasympathetic nervous activity in Thoroughbred racehorses [4]. In the present study, the least dose of atropine administration changed the LF power. This finding is consistent with our previous observations and strongly supports our conclusions. Our results also indicate that changes in parasympathetic activity are not reflected in the LF/HF ratio, because parasympathetic nervous activity might play a role in mediating both HF power and LF power, and similar changes in both may result in the LF/HF ratio maintaining a relatively constant value.

It was thought that the decrease in parasympathetic nervous activity might cause gastrointestinal disorders such as colic in the horse [2]. It is important to understand the influence of a change in the environment or administration of various medicines on parasympathetic nervous activity in horses. We have shown the changes in parasympathetic activity alone on HR and HR variability after repeated injections of atropine. We believe that power spectral analysis of HR variability provides a powerful tool for investigating the cause of disease, which autonomic nervous activity concern, in Thoroughbred horses.

In conclusion, this study has shown that in a beta-blocked horse increasing amounts of parasympathetic blockade by injection of atropine results in changes in indices of HR

variability. Administration of atropine decreased parasympathetic nervous activity in a dose-dependent manner, affecting first the LF power, then the HF power and finally HR. These responses may provide valuable information for evaluating autonomic nervous activity in Thoroughbred horses. Furthermore, it is necessary to evaluate the balance of autonomic function carefully by using the LF/HF ratio because parasympathetic nervous activity strongly mediates HR variability not only in the HF power but also in the LF power.

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