TIME AND FREQUENCY DOMAIN AND WAVELET ANALYSIS OF CARDIAC INTERBEAT INTERVALS IN THE LABORATORY RAT

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Abstract: The effects of the parasympathetic antagonist atropine and the beta-adrenergic receptor antagonist propranolol on the cardiac inter-beat-interval were investigated in conscious rats. Transmitters were implanted into rats and lead II electrocardiogram (ECG) signals were transmitted and recorded. Rats were injected with atropine (1 mg/kg i.m.), propranolol (1 mg/kg i.m.), or combination of atropine (1 mg/kg i.m.) and propranolol (1 mg/kg i.m.). Both pre-injection and post-injection ECG recordings (5000 Hz) were made. Sixty-second inter-beat interval (IBI) records were generated and then re-sampled using a cubic spline interpolation function. The IBI data were analyzed in the time and frequency domains using both Fourier and wavelet techniques to determine the effects of the antagonists on autonomic function. Validation of the Fourier and wavelet algorithms was done by using mathematically generated multi-frequency data files and rediscovering the frequency components and the ratios of energies between the various frequency components. The results of the present study demonstrate that the wavelet transform appears to be superior to the standard Fourier transform in that it may be able to differentiate between the various treatments. However, additional data from additional animals are necessary to confirm these findings.

Introduction

This paper presents preliminary results of an analysis of the cardiac inter-beat interval (IBI) of conscious rats. The study was conducted to determine the effects of parasympathetic antagonist atropine and the beta-adrenergic receptor antagonist propranolol on in heart beat variability in concious rats. Time domain, frequency domain, and wavelet analysis techniques were employed to facilitate multi-perspective observations of the IBI information.

Materials and Methods

Lead II electrocardiogram (ECG) telemetric transmitters were surgically implanted into rats and recordings of the ECG data were made for a duration of up to three hours per session. The recordings were done before and after administration of the various antagonists. The recordings were done digitally with a sampling rate of 5000 samples per second at a 16- bit resolution. The treatments were as follows: after the recording of baseline data (no treatment) the rats were injected with atropine (1 mg/kg i.m.) Propranolol (1 mg/kg i.m) was administered 24 to 48 hours later. A combination of atropine (1 mg/kg i.m.) and propranolol (1 mg/kg i.m.) was administered 72 to 96 hours later. The pre-injection and post-injection recordings were made with exactly the same instrument settings and under laboratory conditions. Post-injection recordings were done within one hour after the injection. Hereafter the atropine treatment will be referred to as ATR, the propranolol treatment will be referred to as PRO, and the combination treatment of atropine and propranolol will be referred to as ATR+PRO. One-minute segments of IBI data were extracted from the ECG recordings using software provided by the equipment manufacturer (Data Science International, St. Paul, MN, USA). A total of thirty six segments of data from two rats (eighteen segments each) were selected for analysis using the methodology described in this paper.

The IBI data were analyzed in the time domain and in the frequency domain using Fourier and wavelet transform techniques. The results from each of the analyses were then statistically analyzed to determine the degree of correlation between rats and between treatments. The influences of outliers and common mode (DC component) data were also examined statistically.

The IBI data were analyzed in the time domain by examining the mean and standard deviation values pre and post-treatment for each rat (baseline, ATR, PRO, aTR+PRO). The changes in mean and standard deviation values were then tabulated and discussed.

Cubic Spline was used to reconstruct and resample the IBI data at a sampling rate of 20 Hz before Fourier and wavelet analyses were performed. The Fourier frequency domain analyses were done by performing