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Original Article

Effect of position on the residual heart rate variability in patients after orthotopic heart transplantation

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Abstract

Background: This study investigated the effects of position on heart rate variability (HRV) in patients some years after orthotopic heart transplantation (OHT) surgery.
Methods: Spectral HRV analysis was performed on 15 patients after OHT and 16 patients with coronary artery disease (CAD). HRV measures were compared between OHT and CAD patients in four randomly ordered positions [supine, right lateral decubitus (RLD), left lateral decubitus (LLD), and upright]. Multivariable linear regression analysis was used to identify the factors associated with cardiac function and HRV of OHT patients in supine position, and the factors associated with the outcome (OHT or CAD) of the patients.
Results: The powers in all frequency ranges were significantly decreased in all four positions in OHT patients about 9 years after OHT surgery, as compared with those of CAD patients. Both RLD and LLD positions can lead to a significantly higher normalized high-frequency power in OHT patients than the supine position, as compared with the CAD patients. The LLD position seemed to be better than the other recumbent positions in terms of vagal enhancement in the OHT patients. Multivariable linear regression analysis showed that the left ventricular ejection fraction of OHT patients can be predicted from a linear combination of the OHT to HRV interval, and normalized very low-frequency power in the supine position. Furthermore, better cardiac function and the presence of cardiomyopathy would increase the necessity of OHT surgery, while the use of nitrates would decrease the necessity of OHT surgery.
Conclusion: Both the RLD and LLD positions, especially the LLD position, can lead to a higher vagal modulation in OHT patients about 9 years after OHT surgery, provided that the HRV measures can still be regarded as indicators of autonomic nervous modulation in such patients. Moreover, left ventricular ejection fraction, cardiomyopathy, and the use of nitrates were all associated with the necessity of OHT surgery.

Keywords: autonomic nervous modulation; heart rate variability; heart transplantation; left lateral decubitus; left ventricular ejection fraction; position

Conflicts of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

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1. Introduction

Power spectral analysis of interbeat intervals of heart beating has shown that sympathetic and vagal nervous activities make frequency-specific contributions to the heart rate (HR) power spectrum.[1] The method used for short-term HR variability (HRV) analysis has been standardized where the areas under the spectral peaks within specific frequency ranges are the indicators of cardiac autonomic nervous modulations.[2]

Many studies have demonstrated the significant relationship between autonomic nervous modulation and cardiovascular diseases. For instance, patients with coronary artery disease (CAD) and acute myocardial infarction have depressed cardiac vagal modulation,[3–5] and low vagal modulation is associated with elevated morbidity and mortality.[6,7] Both exercise and drugs have been proven to be effective in improving the cardiac autonomic regulation and cardiac outcome of the patients.[8,9] In addition to exercise and drugs, right lateral decubitus (RLD) position can also lead to the highest vagal modulation and the lowest sympathetic modulation among three recumbent positions in normal individuals and in patients with severe CAD and acute myocardial infarction.[10–12] The mechanism underlying this effect of position on autonomic nervous modulation is speculated to be related to the anatomical position of the heart relative to the superior and inferior vena cava, and the aorta.[13–17]

Since the rate and strength of the beating heart are controlled by the vagal and sympathetic nerves, the innervation of the heart should play an important role in the effects of positions on the autonomic nervous modulation of the heart. Although there are many studies investigating HRV and cardiac reinnervation in patients after orthotopic heart transplantation (OHT) surgery, no studies reported the effect of position on the HRV in this population. Therefore, this study intended to investigate whether the effects of position on the HRV measures are still present in patients some years after OHT surgery.

2. Methods

2.1. Patients

This prospective case-control study enrolled 15 patients into the study group who had undergone OHT surgery for at least 3 years. Because the underlying diseases of the OHT patients were dilated or ischemic cardiomyopathy, or previous myocardial infarction, and because position has been shown to have an effect on the HRV measures in patients with CAD and acute myocardial infarction,[10,11] we chose patients with CAD as the control group for comparison in this study. The control group consisted of 16 age- and gender-matched CAD patients. Patients who had a pacemaker or arrhythmia, or were taking hypnotics or tranquilizers, were not included.

This study has been approved by the Institutional Review Board of Taipei Veterans General Hospital, and all patients signed informed consents before the study.

2.2. Electrocardiographic recording

All participants were instructed to refrain from any caffeinated or alcoholic intakes within 24 hours prior to ECG recording. Three electrodes were placed on each patient, with the first one at the right clavicle, the second one at the left lower chest, and the third one at the right lower chest. The ECG signals of the patient in four positions [supine (S), RLD, left lateral decubitus (LLD), and upright] were obtained by an ECG monitor (MP36, Biopac multichannel recorder, Goleta, CA, USA) and transmitted to and stored in a notebook computer for 12 minutes so that at least 512 interbeat intervals can be used for later spectral HRV analysis. The sampling frequency for ECG recording was 500 Hz. The order of the four positions assumed by the patient was randomized, and a 5 minute rest was taken by the patient between positions. During the ECG recording period, the patient was asked to relax with eyes closed to avoid visual interference from the environment. If there was any discomfort such as chest pain or shortness of breath, the ECG recording was discontinued. A patient who had unsuitable ECG data due to atrial or ventricular arrhythmia for more than 5%, was excluded from the study.

2.3. Time and frequency domain HRV

At least 512 heart periods were obtained for spectral HRV analysis. Both time and frequency domain indices of HRV were calculated. The time domain indices used in this study included HR, and the mean (mRRI), standard deviation (SD_{RR}), coefficient of variation (CV_{RR}), and root mean squared successive differences (rMSSD) of the RR intervals. The frequency domain indices of HRV were obtained by means of fast Fourier transformation (Mathcad Software, Mathsoft Inc., Cambridge, MA, USA). The area of the spectral peaks within the ranges of 0.01–0.4 Hz, 0.01–0.04 Hz, 0.04–0.15 Hz, and 0.15–0.4 Hz were defined as the total power (TP), very low-frequency power (VLFP), low-frequency power (LFP), and high-frequency power (HFP).[2] The normalized HFP (nHFP = HFP/TP) was used as the index of vagal modulation, the normalized low-frequency power (nLFP = LFP/TP) as the index of sympathetic and vagal modulations, the normalized very low-frequency power (nVLFP = VLFP/TP) as the index of rennin-angiotensin-aldosterone system and vagal withdrawal, and the low-frequency/high-frequency power ratio (LHR = LFP/HFP) as the index of sympathovagal balance.

The percentage changes in HRV measure X when the position was changed from supine to the RLD position ($X_{S\text{-}RLD}$) or LLD position ($X_{S\text{-}LLD}$) were calculated using the following formulae:

$$X_{S\text{-}RLD}\ (\%) = 100\% \cdot (X_{RLD} - X_S)/X_S$$

$$X_{S\text{-}LLD}\ (\%) = 100\% \cdot (X_{LLD} - X_S)/X_{S,}$$