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Original Article

Body-temperature circadian rhythm in 67 patients after heart valve replacement surgery secondary to valvular heart disease

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ABSTRACT

Purpose: Patient body temperature was monitored after cardiac valve replacement, in order to explore the characteristics of body-temperature circadian rhythm and the factors influencing that rhythm.

Methods: A cohort of 67 patients who received cardiac valve replacement in a Fuzhou, Fujian province, China, general hospital underwent temperature measurements and analysis (by cosine curve) of their body-temperature circadian rhythm. A biological rhythm model was established through principal component analysis and evaluation of biological rhythm features. Multiple circadian parameters were included through linear regression analysis.

Results: Patients' temperature after cardiac valve replacement exhibited circadian characteristics ($p < 0.05$), among which the scores of temperature mesor, amplitude, and acrophase were respectively (37.61 ± 0.08), (0.10 ± 0.09), and -33 (-355, -119). Body-temperature rhythms were influenced by both gender and cardiopulmonary bypass time ($p < 0.05$).

Conclusion: Although some patients' circadian characteristics disappeared after cardiac valve replacement, circadian rhythms remained intact for most patients. Measures that were found to mitigate body-temperature circadian rhythm disruption included building a natural rhythm of light/darkness and decreasing cardiopulmonary bypass time.

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1. Introduction

In recent years, cardiovascular diseases have been the leading causes of death in China, with valvular heart diseases accounting for the largest proportion of these [1]. The present study was undertaken to investigate the circadian rhythm of body temperature and its determinants in patients undergoing heart valve replacement surgery as a consequence of rheumatic heart disease.

In nature, numerous physiological parameters in both single-celled organisms and higher plants and animals clearly exhibit diurnal fluctuation, commonly known as circadian rhythm [2]. Some physiological phenomena related to cardiovascular diseases, including valvular heart diseases, also show circadian rhythm. Valvular heart diseases caused by rheumatic fever have high morbidity and mortality [1], and changes in body temperature usually predict disease progression subsequent to valve replacement surgery. In clinical practice, understanding body-temperature circadian rhythm and its determinants and employing interventions to reduce postoperative impacts on this circadian rhythm can be beneficial for patient recovery. Our findings may provide evidence for the value of certain such interventions in the clinical care of patients after valve replacement surgery.

2. Methods

2.1. Patients

A cohort of 67 patients (19 males and 48 females) who received elective valve replacement surgery from April 2012 to June 2012 was recruited from a tertiary hospital in Fuzhou, Fujian province, China. Inclusion criteria were as follows: (1) Study participants had rheumatic heart disease and subsequently received elective surgery; (2) such valve replacement was only the first instance of this surgery subsequent to rheumatic heart disease; (3) participants had no history of severe cerebrovascular diseases; (4) participants had normal liver, kidney, and lung function; (5) participants were free of hepatitis, syphilis, or other infectious diseases; (6) participants' cardiac function was grade II or higher (New York Heart Association classification).

Exclusion criteria were as follows: (1) Patients who were treated in the intensive care unit for less than 24 h; (2) patients who received surgical intervention for an additional cardiac condition (such as coronary artery bypass grafting) simultaneously with valve replacement; (3) patients who exhibited malignant arrhythmias prior to admission; (4) patients who had been diagnosed with a nervous system disease or psychological disorder.

This study was approved by the Fuzhou, Fujian province hospital Ethics Committee and informed consent was obtained from all 67 participants, prior to the initiation of the study.

2.2. Methods

2.2.1. Monitoring body temperature

After surgery, each patient's body temperature was monitored with an electrocardiogram monitor (BENE View, Mindray, Inc., Shenzhen, P.R. China). A probe was inserted into the rectum 6 cm from the anus, and body temperature was recorded hourly over a consecutive 24-h period.

2.2.2. Cosine curve fitting

Using a Halberg single cosine curve, each patient's consecutively recorded body-temperature data was entered into a mathematical model for fitting and analysis of circadian rhythm, with the 24-h data serving as a cycle. In the mathematical model,

$$Y = M + A\cos(\omega t + \phi),$$

Y refers to biological variables, t is the time of observation, and M, A and ϕ represent the characteristics of the biological rhythm (M, adjusted mean, reflecting the estimated mean within 24 h; A, amplitude, reflecting the maximum deviation from the estimated mean; ϕ, peak phase reflecting the time of peak occurrence). The least squares method was used to calculate M, A, and ϕ, as well as p values. The meaning of the p value is defined as follows: $p < 0.05$ suggests the presence of circadian rhythm and $p > 0.05$ indicates the absence of circadian rhythm. The average cosine method was employed to analyze each patient's daily temperature and fit an optimal cosine function.

2.3. Statistical analysis

Statistical analysis was performed with SPSS version 11.5 for Windows (SPSS Inc., Chicago, IL, USA). Principal component analysis was used to establish a biorhythm model in order to evaluate biorhythm characteristics, and multiple linear regression was employed to analyze the determinants of circadian rhythm.

3. Results

The patient cohort consisted of 19 males and 48 females with a mean age of 51.31 ± 9.89 years (range: 23–82 years). The mean body weight was 56.60 ± 10.64 kg (range: 37–93 kg). There were no marked differences in age and body weight between males and females. Sixty-two (92.5%) patients were NYHA grade III, and five patients (7.5%) were grade IV. The mean cardiothoracic ratio was 0.62 ± 0.74 (range: 0.41–0.87). Concomitant coronary heart disease, hypertension, and diabetes were found in three, three, and four patients, respectively. Of the 67 patients, 51 received single-valve replacement surgery and 16 underwent two-valve replacement surgery. Simultaneously with valve replacement, tricuspid valvuloplasty was also performed in 38 patients.

3.1. Characteristics of body-temperature circadian rhythm after surgery

Body-temperature circadian rhythm was found in these patients after valve replacement surgery ($p < 0.05$). The M, A, and ϕ were 37.61 ± 0.08, 0.10 ± 0.09, and −33 (−355, −119), respectively. The cosine curve of body temperature is shown in Fig. 1. The results showed that body temperature began to increase at 3 h after surgery, peaked at 10 h, and decreased