

Analysis of Heart Rate Variability Among Patients in Functional Examination Department of a Hospital in Shanghai from 2023 to 2024

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Abstract: Objective The characteristics of heart rate variability (HRV) in patients in the functional examination department of a Shanghai hospital from 2023 to 2024 were analyzed. Methods Ninety-five patients who received functional examination in our hospital from 2023 to 2024 were selected as the study objects, including 33 patients with depression, 32 patients with anxiety, and 30 patients with insomnia. Hrv-related indicators of patients with depression, anxiety and insomnia were compared respectively: The standard deviation (SDNN) of the difference of heartbeat cycles, the whole process is divided into consecutive periods by 5 minutes, the mean value of N-N interval every 5 minutes is calculated, then the standard deviation (SDNN5) of all the mean values are calculated, and the number of beats in all N-N interval periods where the difference between adjacent N-N interval periods is greater than 50ms is divided by the total number of NN interval periods. Finally, multiply by 100 (pNN50), the root-mean-square value (RMSSD) of the difference between all adjacent N-N intervals, extremely low frequency power (VLF), low frequency power (LF), high frequency power (HF), total power (TP), LF/HF. The HRV-related indexes of patients of different genders and ages were compared respectively: SDNN, SDNN5, pNN50, RMSSD, VLF, LF, HF, TP, LF/HF. Results There was no significant difference in the levels of SDNN, SDNN5, pNN50, RMSSD, VLF, LF, HF, TP and LF/HF in patients with depression, anxiety and insomnia ($P > 0.05$). There was no significant difference in SDNN, SDNN5, pNN50, RMSSD, VLF, LF and TP between male and female patients ($P > 0.05$). There were significant differences in HF and LF/HF levels between male and female patients ($P < 0.05$). There were significant differences in the levels of SDNN, SDNN5, VLF, LF, TP and LF/HF among different age groups ($P < 0.05$). There was no significant difference in pNN50, RMSSD and HF levels among different age groups ($P > 0.05$). Conclusion HRV has a certain predictive power for patients with depression, anxiety and insomnia in the functional examination department of a Shanghai hospital from 2023 to 2024. In addition, the HF and LF/HF levels of HRV related indicators may be correlated with gender. At the same time, with the increase of age, the levels of SDNN, SDNN5, VLF, LF, TP, LF/HF showed a decreasing trend, and the autonomic nervous system function of the body was also declining.

Keywords: Heart rate variability, Depression, Anxiety; High frequency power,

Low-frequency power

Heart rate variability (HRV) refers to the fluctuation level of the heartbeat interval. It is also an important indicator for evaluating the function of the body's autonomic nervous system. It can also quantitatively evaluate the tension and balance of the cardiac sympathetic and vagal nerves. It has the characteristics of non-invasive, quantitative and highly repeatable ^[1-2]. When HRV decreases, it indicates that the body's sympathetic nerve tension increases, the ventricular fibrillation threshold decreases, and the autonomic nervous system function is abnormal. When HRV increases, it indicates that the body's parasympathetic nerve tension increases, the ventricular fibrillation threshold increases, and the balance of the sympathetic-parasympathetic nervous system can be effectively maintained ^[3]. Some studies have pointed out that because psychological state can affect the regulation of the autonomic nervous system, patients with depression and anxiety are often accompanied by autonomic dysfunction, which may affect HRV ^[4]. Insomnia is the most common sleep disorder, and patients are often accompanied by psychological conditions such as depression and anxiety. Insomnia can even aggravate negative psychology. This study selected 95 patients who underwent electrocardiogram examinations in the functional examination department of our hospital from 2023 to 2024 as the research subjects, to analyze the HRV characteristics of patients with depression, anxiety, and insomnia.

1 Subjects and Methods

1.1 General Data

A total of 95 patients who underwent functional examination in the hospital of research team from 2023 to 2024 were selected as research subjects, including 46 males and 49 females. The age ranged from 16 to 66 years old, with an average age of (35.11 ± 11.06) years old. The body mass index (BMI) ranged from 15.4 to 31.2 kg/m², with an average of (22.76 ± 4.00) kg/m². This study has been approved by the hospital ethics committee.

1.2 Inclusion and Exclusion Criteria

Inclusion criteria: (1) Patients with normal cognitive function and ability to cooperate in completing ECG testing. (2) Patients without major changes or diseases in the past six months. (3) Patients with complete medical records. (4) Patients who have not used drugs that affect the function of the autonomic nervous system in the past two weeks.

Exclusion criteria: (1) Patients with factors that affect HRV, such as non-sinus rhythm, pacemaker implantation, and third-degree atrioventricular block. (2) Patients with valvular disease and congenital heart disease. (3) Patients whose R wave ECG signals cannot be extracted. (4) Patients with combined organic brain lesions. (5) Patients with severe liver and kidney dysfunction. (6) Patients with

combined infectious and blood system diseases. (7) Patients with autoimmune system diseases. (8) Patients with low compliance. (9) Patients with serious self-harm or suicidal tendencies.

1.3 Methods

12-lead synchronous dynamic electrocardiogram examination: Shenzhen Boying 12-lead synchronous dynamic electrocardiogram recorder was used for 24h monitoring. HRV related indicators were recorded, including: standard deviation of heart cycle difference (SDNN), the whole process was divided into continuous time periods of 5 minutes, first calculating the average value of N-N interval every 5 minutes, then calculating the standard deviation of all average values (SDNN5), the number of heart beats with a difference of more than 50ms between adjacent N-N intervals in all N-N intervals, then divided by the total number of NN intervals, and finally multiplied by 100 (pNN50), the root mean square value of the difference between adjacent N-N intervals in the whole process (RMSSD), very low frequency power (VLF), low frequency power (LF), high frequency power (HF), total power (TP), and calculating LF/HF.

1.4 Observation Indication

1.4.1 Compare the HRV-related indicators of patients with depression, anxiety, and insomnia: SDNN, SDNN5, pNN50, RMSSD, VLF, LF, HF, TP, LF/HF.

1.4.2 Compare the HRV-related indicators of patients of different genders and age groups: SDNN, SDNN5, pNN50, RMSSD, VLF, LF, HF, TP, LF/HF.

1.5 Statistic Analysis

SPSS 26.0 software was used for statistical analysis. HRV-related indicators and other quantitative data that met non-normal distribution were expressed as medians (interquartile ranges) and Wilcoxon nonparametric tests were used. Count data such as gender were expressed as (n, %) and the χ^2 test was used. When $P < 0.05$, it indicated that the difference in the research data was statistically significant.

2 Results

2.1 Comparison of HRV -related indicators in patients with depression, anxiety, and insomnia

There was no significant difference in the levels of SDNN, SDNN 5, pNN50, RMSSD, VLF, LF, HF, TP, and LF/HF between patients with depression, anxiety, and insomnia ($P > 0.05$). See **Table 1**.

Table 1. Comparison of HRV -related indicators in patients with depression, anxiety, and insomnia [M (P 25 ~ P 75)]

index	Depression (n=33)	Anxiety (n=32)	Insomnia (n=30)	H	P
SDNN (ms)	36.99 (26.34~48.37)	39.13 (30.99~60.76)	36.06 (22.50~52.29)	1.667	0.434
SDNN5 (ms)	28.62 (22.73~37.88)	31.82 (25.33~49.07)	28.64 (19.53~43.53)	1.541	0.463
pNN50 (%)	2.35 (0.81~7.23)	3.23 (1.24~8.55)	5.20(0.92~11.33)	1.120	0.571
RMSSD (ms)	26.89(16.91~34.45)	25.32(18.44~34.68)	27.64(18.05~36.38)	0.098	0.952
VLF(ms2)	361.82(217.66~786.39)	377.49(196.51~876.52)	340.49(128.02~1135.60)	0.517	0.772
LF(ms2)	241.74(174.39~498.32)	401.60(174.46~622.42)	175.37(85.34~437.92)	4.632	0.099
HF (ms 2)	147.54(79.03~272.84)	147.04(76.11~259.40)	124.49(54.64~319.12)	0.455	0.796
TP (ms 2)	1017.95(676.21~1974.14)	1221.91(722.28~2582.48)	890.99(395.51~2486.65)	1.383	0.501
LF/HF	2.25(1.26~2.69)	2.24(1.28~5.76)	1.47(0.95~2.95)	3.954	0.139

2.2 Comparison of HRV -related indicators in patients of different genders

There was no significant difference in SDNN, SDNN 5, pNN50, RMSSD, VLF, LF, and TP levels between male and female patients ($P > 0.05$). However, there was a significant difference in HF and LF/HF levels between male and female patients ($P < 0.05$). See **Table 2**.

Table 2. Comparison of HRV -related indicators in patients of different genders [M (P 25 ~ P 75)]

index	Male (n=46)	Female (n=49)	Z	P
SDNN (ms)	38.97 (25.06~58.41)	37.23 (28.72~46.71)	-0.577	0.564
SDNN5 (ms)	31.82 (20.80~46.74)	30.25 (24.52~36.79)	-0.186	0.852
pNN50(%)	2.83 (1.07~11.33)	3.26 (0.81~8.69)	-0.354	0.723
RMSSD(ms)	26.56(17.21~34.52)	26.03(18.11~35.22)	-0.216	0.829
VLF(ms2)	358.21(135.43~1327.61)	356.96(221.09~669.88)	-0.067	0.947
LF(ms2)	284.05(113.60~853.55)	278.77(153.27~449.49)	-0.402	0.688
HF(ms2)	100.64(51.52~230.83)	172.88(86.79~311.39)	-1.973	0.048
TP (ms 2)	953.91 (439.88~2570.04)	1115.79 (716.52~1735.32)	-0.647	0.518
LF/HF	2.59 (1.23~5.28)	1.66 (0.99~2.43)	-2.852	0.004

2.3 Comparison of HRV -related indicators in patients of different age groups

There were significant differences in SDNN, SDNN 5, VLF, LF, TP, and LF/HF levels among patients of different age groups ($P < 0.05$). However, there were no significant differences in pNN50, RMSSD, and HF levels among patients of different age groups ($P > 0.05$). See **Table 3**.

Table 3. Comparison of HRV- related indicators in patients of different age groups [M (P 25 ~ P 75)]

index	≦ 20 years old (n=13)	21-40 years old (n=55)	41-59 years old (n=23)	≧ 60 years old (n=4)	H	P
SDNN (ms)	46.92 (36.22~53.19)	39.93 (27.82~58.08)	31.44 (19.10~44.08)	26.02 (20.99~35.26)	10.025	0.018
SDNN5 (ms)	37.24 (28.44~42.85)	32.84 (23.77~45.81)	28.34 (15.24~33.57)	20.56(14.70~28.49)	10.443	0.015
pNN50(%)	5.18(2.15~10.33)	2.65(1.08~11.28)	2.77(0.39~6.61)	3.08(0.72~6.73)	1.784	0.618
RMSSD(ms)	29.58(23.63~34.45)	28.13(17.41~35.13)	21.20(15.81~34.72)	25.03(15.27~30.45)	2.595	0.458
VLF(ms2)	603.56(290.30~971.24)	465.24(241.23~1049.31)	189.42(98.92~443.70)	308.30(165.84~579.91)	13.140	0.004
LF(ms2)	532.16(290.04~604.22)	307.19(188.17~777.21)	131.61(85.64~307.00)	64.94(39.60~283.91)	18.734	< 0.001
HF(ms2)	223.36(88.21~286.98)	148.65(70.38~319.50)	110.32(50.54~245.38)	88.01(47.37~176.28)	3.454	0.327
TP(ms2)	1505.96 (1023.85~2376.05)	1197.92 (688.09~2699.97)	461.21 (344.67~1192.72)	584.80 (442.13~1179.78)	14.893	0.002
LF/HF	2.21(1.01~3.39)	2.34(1.32~3.80)	1.55(0.58~2.65)	0.97(0.59~1.64)	9.035	0.029

3 Discussion

HRV is the periodic change of sinus rhythm within a certain period. It can reflect the specificity of the autonomic nervous system in regulating the heart, and can directly reflect the changes in heart rhythm. It also contains information about the regulation of the cardiovascular system by neurohumoral factors, and shows the impact of the autonomic nervous system on the cardiovascular system [5-7]. Studies have pointed out that the autonomic nervous system includes sympathetic and parasympathetic nerves, which are controlled and regulated by the cerebral cortex and hypothalamus. They mainly control the digestive tract, cardiovascular and other internal organs, and are also involved in the regulation of body temperature, sleep, emotions and blood pressure, and are not controlled by consciousness [8]. The sympathetic nervous system can excite the cardiovascular, respiratory and other systems, and it mainly maintains the physiological needs of the body when it is tense. The parasympathetic nervous system can maintain the physiological balance of the body when it is calm. The two restrict and antagonize each other, and together maintain the homeostasis and balance of the body's physiological activities [9-10].

Time domain and frequency domain are the main methods for analyzing dynamic electrocardiogram HRV. The combined application of the two can complement each other, and the calculation method is relatively simple. It can effectively distinguish the body's cardiac vagus nerve and sympathetic nervous system, and is easily accepted by clinicians [11-12]. SDNN, SDNN5, pNN50, and RMSSD are commonly used time domain measurement parameters of HRV. Among them, SDNN mainly evaluates the degree of autonomic nerve damage and measures the overall changes in cardiac sympathetic and parasympathetic nerve functions. When its level is greater than 100ms, it indicates that the body's cardiac vagus

nerve regulation is dominant, and the smaller the level, the more dominant the sympathetic nerve regulation, and the poorer the patient's prognosis. SDNN5 can reflect the slow changes in heart rate and evaluate the tension of the sympathetic nerves. Its level is negatively correlated with the activity of the sympathetic nerves. pNN50 and RMSSD reflect the rapid changes in heart rate, can effectively evaluate the vagus nerve function, and have high sensitivity. The smaller its level, the lower the vagus nerve activity^[13-14]. Most scholars believe that when the time domain indicators of HRV, such as SDNN and SDNN5, are less than 50ms, it indicates that the function of the body's autonomic nervous system is significantly reduced and the prognosis is poor^[15]. VLF, LF, HF, TP, and LF/HF are commonly used frequency domain measurement parameters of HRV, among which VLF is related to peripheral vasomotion and the renin-angiotensin system. LF is related to the activity of the sympathetic and parasympathetic nerves, among which the sympathetic nerves are dominant. HF can reflect the vagal tone and can quantitatively evaluate the level of cardiac vagal regulation activity, but it is affected by respiratory activity. TP can evaluate the overall functional state of the autonomic nervous system. LF/HF reflects the trend of changes in the balance between the sympathetic and parasympathetic nervous systems^[16-17]. In the study by Ozden HC et al.^[18], 30 patients with severe depression and 30 healthy controls were asked to watch videos that stimulated anger, fear, and sadness. At the same time, dynamic electrocardiograms were obtained during the viewing process, and HRV parameters were calculated in the resting state. The results showed that the LF and LF/HF levels of the depressed group were significantly lower than those of the control group, but this effect was not related to the severity of depression. This may be because depressed patients cannot inhibit sympathetic nerve activity when stimulated in a sad state. .

Related studies have also shown that patients with schizophrenia, anxiety, and depression have lower HRV, which indicates that individuals with psychological problems may be dominated by the sympathetic nervous system for a long time, their vagus nerve is inhibited, and the balance of the autonomic nervous system is disturbed, resulting in excessive stress response and reduced emotional regulation ability^[19]. In this study, there was no statistically significant difference in the levels of SDNN, SDNN5, pNN50, RMSSD, VLF, LF, HF, TP, and LF/HF in patients with depression, anxiety, and insomnia ($P>0.05$), which indicates that HRV has a certain predictive power for patients with depression, anxiety, and insomnia. However, some studies have pointed out that when patients present with different physical symptoms, their HRV indicators are different and the correlation is also different^[20]. In addition, there is a statistically significant difference in the levels of HF and LF/HF between male and female patients ($P<0.05$), indicating that the levels of HF and LF/HF in HRV-related indicators may be related to gender. The analysis is that compared with men, women's autonomic nervous system regulation ability is weaker, coupled with the influence of estrogen, they are more prone to depression, anxiety, insomnia, etc., and men's sympathetic

nervous system regulation is stronger than women, which is reflected in HRV related indicators. In addition, there were significant differences in the levels of SDNN, SDNN5, VLF, LF, TP, and LF/HF among patients of different age groups ($P < 0.05$), indicating that with the increase of age, the levels of SDNN, SDNN5, VLF, LF, TP, and LF/HF of patients showed a downward trend, indicating that the function of the body's autonomic nervous system is also declining. However, this study has certain limitations. In addition, HRV is affected by many factors, and the psychological conditions of different regions and different populations may be different. Therefore, it should be improved in subsequent studies to enrich the research results.

In summary, HRV has a certain predictive power for patients with depression, anxiety, and insomnia in the functional examination department of a hospital in Shanghai from 2023 to 2024. In addition, the levels of HF and LF/HF in HRV-related indicators may be correlated with gender. At the same time, with the increase of age, the levels of SDNN, SDNN5, VLF, LF, TP, and LF/HF of patients showed a downward trend, indicating that the function of the body's autonomic nervous system is also declining.

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