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Study on the Correlation Between Night ECG Parameters and Sleep Quality in Elderly Patients with Atrial Premature Beat

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Abstract: *Objective:* To explore the correlation between night ECG parameters and sleep quality in elderly patients with atrial premature beat (PAC). *Methods:* A total of 307 elderly patients with PAC were selected from March 2022 to March 2024. The parameters of room morning load and heart rate variability (HRV) at night (22:00–6:00) were collected by 24h holter electrocardiogram, and the sleep quality of PAC patients was evaluated by Pittsburgh Sleep Quality Index (PSQI). Multiple regression analysis was used to explore the correlation between night ECG parameters and sleep quality. *Results:* The incidence of sleep disorder in 307 elderly PAC patients was 62.54%. Univariate analysis showed that there were no statistically significant differences in gender, BMI and education level ($P > 0.05$), but there were statistically significant differences in age, disease course, underlying diseases, atrial morning load, SDNN, RMSSD, LF, HF, LF/HF and TP ($P < 0.05$). Multivariate Logistic regression analysis showed that atrial morning load, SDNN, RMSSD, LF and LF/HF were independent influencing factors of sleep disorder in elderly PAC patients ($P < 0.05$). Patients with sleep disorders were divided into mild group, moderate group and severe group according to PSQI score, and there were statistically significant differences in the indexes of atrial morning load, SDNN, LF, LF/HF and TP among the three groups (all $P < 0.05$). Spearman correlation analysis showed that room morning load, LF, LF/HF and TP were positively correlated with the degree of sleep disorder, while SDNN parameters were negatively correlated with the degree of sleep disorder (all $P < 0.05$). *Conclusion:* There is a significant correlation between night ECG parameters and sleep disorders in elderly patients with PAC. It is possible to prevent and treat sleep disorders by monitoring ECG abnormalities and improve the reliability of treatment.

Keywords: Atrial premature beat; Elderly patients; Nocturnal electrocardiogram; Sleep quality

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1. Introduction

Premature atrial contraction (PAC) is one of the most common types of clinical arrhythmia, which is not only an important sign of cardiac structural abnormalities but also increases the risk of sudden cardiac death. With the acceleration of the aging process of our population, cardiovascular health of the elderly has gradually become a hot topic of social concern, and PAC has become a new health killer with an incidence rate of more than 25% among the elderly (≥ 65 years old) [1]. Previous clinical studies have mostly focused on the pathophysiological mechanisms of PAC on left atrial enlargement, decreased cardiac output and atrial fibrillation conversion risk in patients, ignoring the two-way interaction of sleep disorders in elderly PAC patients. Epidemiological data show that the incidence of sleep disorders in elderly PAC patients is about 68%, which is significantly higher than 45% in normal elderly population [2, 3]. It has been reported that sleep disorders in elderly PAC patients have obvious circadian rhythm characteristics, and hologram monitoring has found that there is a positive correlation between premature beats at night and the number of awakenings [4], suggesting that sleep quality may become a new target for alleviating arrhythmia. This study investigated the correlation between night ECG parameters and sleep quality in elderly patients with PAC, aiming to provide theoretical basis for individualized treatment of PAC patients based on sleep regulation.

2. Data and methods

2.1. Research object

A total of 307 elderly patients with PAC were selected from March 2022 to March 2024 for clinical trial, including 175 males and 132 females. The patients ranged from 65 to 78 years old, with an average age of (70.4 ± 4.2) years. BMI ranged from 18.9 to 25.3kg/m2, with an average of (21.34 ± 1.45) kg/m2; The course of disease ranged from 6 months to 4 years, with an average of (2.03 ± 0.78) years; Basic diseases: 194 cases of hypertension, 78 cases of coronary heart disease, 24 cases of chronic heart failure, 11 cases of heart valve disease; Education level: junior high school and below 157 cases, senior high school/technical secondary school 86 cases, junior college and above 64 cases.

2.2. Nanorow standard

Inclusion criteria: (1) age ≥ 65 years; (2) Those who meet the diagnostic criteria for PAC established by the European Society of Cardiology (ESC) [5]; (3) 24h holter ECG confirmed atrial premature beat (≥ 30 times /h), and night ECG monitoring can identify atrial premature beat events; (4) Clear consciousness can cooperate with medical staff to complete sleep assessment; (5) Knowledge of this clinical trial and signed the authorization letter; (6) Approved by the hospital Ethics Committee, approval number [KY2022-015].

Exclusion criteria: (1) Patients with acute coronary syndrome and severe heart failure (NYHA grade III–IV); (2) Patients who have received heart surgery or interventional surgery in the past 3 months; (3) Those who have used antiarrhythmic and antipsychotic drugs within the past month; (4) Patients with basic diseases such as hyperthyroidism, hypothyroidism and COPD induced sleep disorders; (5) There are cognitive dysfunction, mental illness.

2.3. Observing indicators

(1) ECG parameter detection: All patients were treated with Philips Holter system (PHILIPS DigiTrak 24h ECG monitoring (operating frequency 1000Hz) was performed for XT type, and the time domain parameters of atrial morning load (number of premature beats/total number of beats ×100%), heart rate variability

(HRV) [standard deviation of R-R interval (SDNN)] and the square sum of the difference between adjacent R-R intervals were collected from 22:00 to 6:00 the next day (RM) SSD)] and HRV frequency domain parameters [LF power (LF), HF power (HF), LF/HF power ratio (LF/HF), total power (TP)].

(2) Sleep quality assessment: The Chinese version of the Pittsburgh Sleep Quality Index (PSQI) scale was used to evaluate the sleep quality of patients with early room hours [6]. The scale was scored from seven dimensions, including subjective sleep quality, time to fall asleep, sleep efficiency, sleep disorders, hypnotic drugs, and daytime dysfunction, with the score ranging from 0 to 21 points, and the total score ≥ 7 points was diagnosed as sleep disorder.

2.4. Statistical treatment

SPSS28.0 statistical software was used to process the test data. Continuous variables were represented by (±s), and an independent sample t-test was used for comparison between groups. $\chi 2$ test was used to describe categorical variables by frequency (%). Stepwise regression method was used to analyze the correlation between night ECG parameters and sleep quality in multivariate analysis. $P < 0.05$ was used to indicate the difference and statistical significance.

3. Result

3.1. Sleep status of elderly patients with PAC

A total of 307 patients were divided into two groups according to the basis of PSQI scale score 7:192 (62.54%) with 7 points and 115 (37.46%) with < 7 points.

3.2. Univariate affecting sleep quality in elderly PAC patients

Univariate analysis was conducted on whether they were elderly PAC patients with sleep disorders (sleep disorder group =1, non-sleep disorder group = 0) as dependent variable and basic data, atrial early load indicators, HRV time domain parameters and frequency domain parameters as independent variables. The results showed no significant differences in gender, BMI and education level ($P > 0.05$), and age, disease course, underlying disease, atrial premature load, SDNN, RMSSD, LF and LF / HF ($P < 0.05$), as shown in **Table 1**.

Table 1. Univarifactors affecting sleep quality in elderly PAC patients

Item		Sleep disorder group(192)	Non-sleep disorder group(115)	t/x^2	P
	Gender (Male)	104(54.17)	71(61.74)	1.848	> 0.05
	Age (years)	72.06 ± 5.28	68.53 ± 4.70	6.082	< 0.05
	BMI(kg/m$^{2)}$	20.80 ± 1.43	21.07 ± 1.67	1.450	> 0.05
	Disease course (year)	2.62 ± 0.78	1.89 ± 0.64	8.904	< 0.05
Underlying disease	hypertension	128	64	2.086	> 0.05
	Coronary heart disease	52	26		
	Chronic heart failure	16	8		
	Valvular heart disease	6	5		

Table 1 (Continued)

Item		Sleep disorder group(192)	Non-sleep disorder group(115)	t/x^2	*P*
Educational level	Junior high school and below	108	49	1.857	> 0.05
	High school/technical secondary school	63	23		
	College or above	51	13		
	APC burden(%)	5.63 ± 1.28	2.14 ± 0.64	31.730	< 0.001
	SDNN(ms)	86.23 ± 17.24	101.03 ± 13.67	8.313	< 0.001
	RMSSD(ms)	34.36 ± 7.25	53.28 ± 6.47	23.680	< 0.001
	LF(ms^2)	1072.50 ± 89.20	834.45 ± 36.23	32.744	< 0.001
	HF(ms^2)	496.79 ± 56.23	546.59 ± 49.62	49.802	< 0.001
	LF/HF	2.16 ± 0.34	1.53 ± 0.28	17.506	< 0.001
	TP	1569.29 ± 187.35	1381.04 ± 103.23	207.390	< 0.001

3.3. Logistic regression analysis of HRV parameters and the occurrence of sleep disorders in elderly PAC patients

With sleep disorder as the dependent variable, binary Logistic regression analysis was performed after adjusting for independent variables such as age, course of disease, underlying disease, atrial morning load, SDNN, RMSSD, LF, and LF/HF. The results showed that early room load, SDNN, LF, LF/HF, and TP were independent influencing factors of sleep disorder in elderly PAC patients ($P < 0.05$). See **Table 2** and **Figure 1**.

Table 2. Logistic regression analysis of HRV parameters and the occurrence of sleep disorders in elderly PAC patients

Item	*β*	*SE*	Wald	*P*	*OR*	95% *CI*	
						Lower limit	Upper limit
APC burden	-0.049	0.014	13.126	0.000	0.952	0.927	0.978
SDNN	-0.036	0.013	7.688	0.007	0.965	0.942	0.990
RMSSD	-0.061	0.032	3.639	0.055	0.941	0.884	0.937
LF	-0.182	0.049	13.865	0.000	0.834	0.758	0.918
HF	-0.008	0.032	0.062	0.808	0.992	0.931	1.057
LF/HF	-0.082	0.039	4.561	0.031	0.921	0.854	0.993
TP	-0.050	0.014	13.664	0.000	0.951	0.926	0.977
constant	1.402	1.204	23.033	0.004	-	-	-

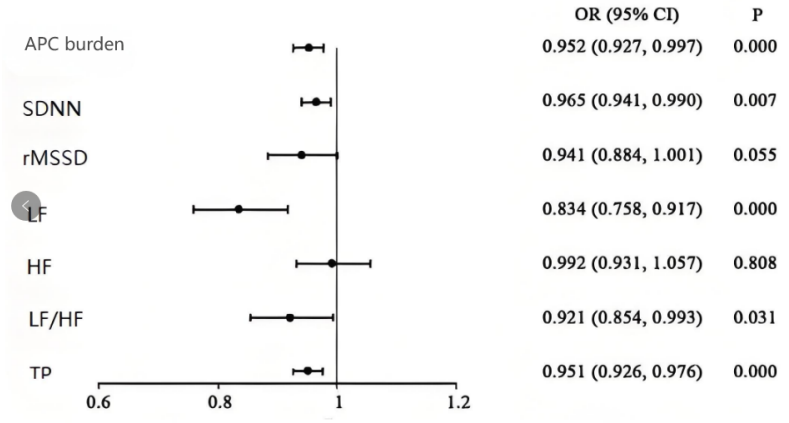

Figure 1. Forest plot of the correlation between nocturnal ECG parameters and sleep disturbance in elderly PAC patients

3.4. Correlation between nocturnal ECG parameters and the degree of sleep disturbance in elderly PAC patients

3.4.1. Comparison of nighttime ECG parameters in different elderly patients with PAC with sleep disorders

According to the score of PSQI scale, the elderly patients with PAC with sleep disorder were divided into 3 subgroups: mild sleep disorder group (PSQI score 7–10 points), moderate sleep disorder group (PSQI score 11–15 points) and severe sleep disorder group (PSQI score > 15 points). The indexes of chamber early load, LF, LF/HF and TP in severe sleep disorder group were significantly higher than those in moderate and mild groups ($P < 0.05$), and the indexes of chamber early load, LF, LF/HF and TP in moderate sleep disorder group were higher than those in control group ($P < 0.05$), while the indexes of SDNN in severe sleep disorder group were significantly lower than those in mild and moderate group. Variance test showed that the difference among the three groups was statistically significant ($P < 0.05$). See **Table 3**.

Table 3. Night ECG parameters of elderly PAC patients with different degrees of sleep disorders in the 3 groups

Index	Mild group (56)	Moderate group (96)	Severe group(40)	*F*	*P*
APC burden(%)	3.64 ± 1.04	5.63 ± 1.28	7.34 ± 1.54	101.699	< 0.001
SDNN(ms)	90.36 ± 20.13	85.73 ± 18.04	78.90 ± 17.47	4.449	0.013
LF(ms^2)	944.71 ± 56.49	1072.50 ± 89.20	1203.46 ± 76.43	128.914	< 0.001
LF/HF	1.85 ± 0.44	2.10 ± 0.52	2.56 ± 0.75	19.238	< 0.001
TP	1472.34 ± 193.45	1569.29 ± 187.39	1684.53 ± 231.42	13.312	< 0.001

3.4.2. Correlation between night ECG parameters and the degree of sleep disorder in elderly PAC patients

Spearman correlation analysis was used to analyze the correlation between atrial morning load, SDNN, LF, LF/HF, TP, and the degree of sleep disorder in elderly PAC patients. The results showed that the indexes of atrial morning load, LF, LF/HF, and TP were positively correlated with the degree of sleep disorder ($P < 0.05$). SDNN parameters were negatively correlated with the degree of sleep disorder ($P < 0.05$), as shown in **Table 4** and **Figure 2**.

Table 4. Correlation between night ECG parameters and the degree of sleep disorder in elderly PAC patients

Parameter	Degree of sleep disturbance		
	r	***P***	***OR*(95%*CI*)**
APC burden	0.744	< 0.001	0.671–0.803
SDNN	-0.346	< 0.001	-0.379– -0.104
LF	0.735	< 0.001	0.659–0.795
LF/HF	0.497	< 0.001	0.379–0.599
TP	0.363	< 0.001	0.122–0.394

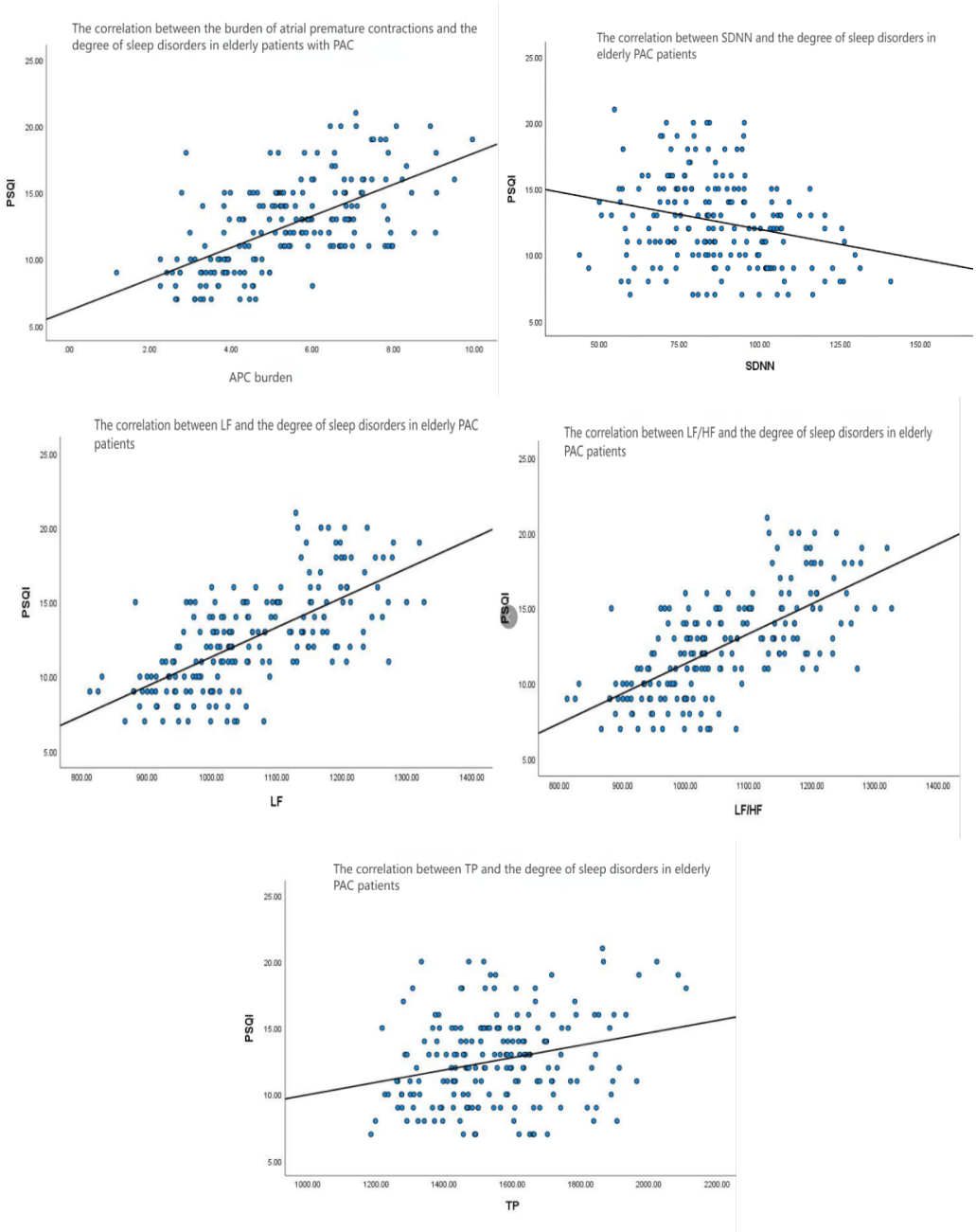

Figure 2. Correlation between night ECG parameters and the degree of sleep disorder in elderly PAC patients

4. Discussion

PAC is one of the most common types of clinical arrhythmia, and its pathological characteristics are characterized by the interaction between abnormal atrial myoelectric activity and autonomic nervous dysfunction [7]. Data have shown that frequent PAC triggers the imbalance of atrial and cellular calcium homeostasis by activating the intracardial electrical feedback mechanism, resulting in atrial structural remodeling [8]. It is worth noting that this pathological process is more pronounced at night when vagal tone is elevated, thus increasing the risk of paroxysmal atrial fibrillation. Sleep disorders are common comorbidities in elderly patients with PAC. Traditional theories generally believe that autonomic nervous dysfunction is the main reason for the destruction of patients' sleep system, but some patients with normal autonomic nervous function still have sleep disorders. Based on this, this study explored the correlation between nocturnal ECG parameters and sleep disorders in elderly patients with PAC, providing a new target for precision treatment strategies for such patients.

The results of this study showed that the incidence of sleep disorders in 307 elderly PAC patients was 62.54%, which was basically consistent with the results of Zhang *et al.*, indicating that elderly PAC patients had more prominent sleep disorders [9]. Univariate and multivariate Logistic analysis showed that atrial morning load, SDNN, RMSSD, LF, and LF/HF were independent influencing factors of sleep disorder in elderly PAC patients.

Atrial premature load is an index reflecting the overall cardiac load of patients with atrial premature beat. Frequent atrial premature beat at night may cause heart discomfort such as palpitations and palpitation, and pathological discomfort will destroy the continuity of sleep and affect the quality of sleep. The HRV parameter reflects the regulatory function of the cardiac autonomic nervous system, and the decrease of SDNN indicates the impaired regulatory function of the cardiac autonomic nervous system and the imbalance of sympathetic and parasympathetic nerves [10]. The abnormal excitation of sympathetic nerve will cause the patient's body to be in a state of stress and increase the heart rate, which will affect the normal rhythm of the heart during sleep and lead to the decrease of sleep efficiency.

RMSSD mainly reflects the functional activity of vagus nerve, and the decrease of RMSSD means that vagus nerve has a weakened regulatory effect on the heart, which further affects the stability of heart rhythm and sleep quality [11]. LF and LF/HF are also important factors affecting sleep quality. LF represents the result of the joint action of sympathetic and parasympathetic nerves.If the low-frequency (LF) component increases, both the LF/HF ratio and total power (TP) will also rise, indicating heightened sympathetic nerve activity while parasympathetic nerve activity remains relatively suppressed. This disruption leads to an imbalance in the autonomic nervous system, interfering with normal electrophysiological functions and the neuroregulatory mechanisms of sleep [12]. Prolonged excitation of the patient's system can significantly impair sleep quality..

In this study, a total of 192 elderly patients with PAC were divided into 3 subgroups according to the degree of sleep disorder. The comparison showed that the atrial morning load, LF, LF/HF, and TP of patients with severe sleep disorder were significantly higher than those of the other two groups, while the SDNN parameters were significantly lower than those of the other two groups. Spearman correlation analysis showed that room morning load, LF, LF/HF, and TP parameters were positively correlated with PSQI, while SDNN was negatively correlated with PSQI. It suggests that severe sleep disorders may negatively affect the heart health of older patients with PAC, leading to increased atrial load and an imbalance in autonomic nervous function, potentially increasing the risk of heart attack or other heart problems.

5. Conclusion

To sum up, there is a significant correlation between abnormal cardiac activity at night and decreased sleep quality in elderly patients with PAC. Clinicians should pay attention to sleep problems in elderly patients with PAC, comprehensively evaluate ECG parameters and sleep quality, and take targeted treatment measures to improve patient prognosis.

Disclosure statement

The author declares no conflict of interest.

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