



A Study on Holter Electrocardiogram Characteristics in Patients with Hypertension and Paroxysmal Atrial Fibrillation and Their Relationship with Postoperative Recurrence

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Abstract: Objective: This study aimed to investigate the Holter ECG characteristics of patients with hypertension complicated by paroxysmal atrial fibrillation and to analyse their association with postoperative arrhythmia recurrence. Methods: A retrospective cohort study was conducted on 230 patients with hypertension complicated by paroxysmal atrial fibrillation (PAF) treated at the Electrocardiography Department of Yichang Central People's Hospital between July 2023 and December 2024. Patients were categorised into a recurrence group (n=48) and a non-recurrence group (n=182) based on postoperative recurrence status. Preoperative 24-hour Holter monitoring data were collected for all patients. Univariate analysis compared clinical characteristics between groups, whilst multivariate logistic regression identified risk factors for postoperative recurrence. Results: Univariate analysis revealed that patients in the recurrence group exhibited significantly higher values for BMI, LAD, ultra-low frequency power, low-frequency power, and heart rate deceleration capacity compared to the non-recurrence group, while high-frequency power, rMSSD, pNN50, and SDNN were significantly lower ($P < 0.05$). Multivariate logistic regression analysis identified heart rate deceleration capacity, SDNN, and LAD as independent risk factors for postoperative recurrence in hypertensive patients with PAF ($P < 0.05$). Conclusion: Quantitative parameters of Holter monitoring in patients with hypertension complicated by PAF exhibit characteristic alterations, with reductions observed in high-frequency power, rMSSD, pNN50, and SDNN. Heart rate deceleration capacity, SDNN, and LAD constitute independent risk factors for recurrence following radiofrequency ablation.

Keywords: hypertension; paroxysmal atrial fibrillation; Holter monitoring; postoperative recurrence

1. Introduction

Paroxysmal atrial fibrillation (PAF) represents a clinically prevalent type of rapid arrhythmia, closely associated with cardiac electrophysiological and structural remodelling. Hypertension constitutes a key risk factor in the progression of PAF [1]. The coexistence of hypertension and PAF increases the risk of adverse cardiovascular events such as thromboembolism and heart failure. Radiofrequency ablation currently represents the preferred minimally invasive approach for treating PAF. However, postoperative recurrence rates remain high at 20-30%, significantly impacting treatment efficacy and patient prognosis. Consequently, this study analyses the Holter ECG characteristics of hypertensive patients with PAF and their correlation with postoperative recurrence, aiming to provide reference for optimising clinical treatment strategies and improving prognosis.

2. Materials and Methods

2.1 General Data

A retrospective study was conducted on 230 patients with hypertension complicated by paroxysmal atrial fibrillation (PAF) who were diagnosed and treated at the Electrocardiography Department of Yichang Central People's Hospital between July 2023 and December 2024. Inclusion criteria: ① Diagnosis of moderate-to-severe hypertension according to the Chinese Hypertension Prevention and Treatment Guidelines (2023 Edition) [2]; ② Diagnosis of PAF meeting criteria in the Chinese Guidelines for Diagnosis and Treatment of Atrial Fibrillation [3], confirmed by electrocardiography or Holter monitoring; ③ First-time radiofrequency ablation treatment; ④ Complete clinical records. Exclusion criteria: ① Patients with persistent or permanent atrial fibrillation; ② Concurrent severe heart failure, acute myocardial infarction, cardiomyopathy, or other organic heart disease; ③ Concurrent severe hepatic or renal insufficiency, malignancy, or coagulation disorders. This study was approved by the Ethics Committee of Yichang Central People's Hospital, and all patients provided written informed consent.

2.2 Methods

2.2.1 Holter Monitoring

All patients underwent 24-hour continuous monitoring using a Mortara H12+ Holter monitor within one week prior to surgery, recording dual leads CM1 and CM5. During monitoring, patients were instructed to maintain normal daily activities while avoiding strenuous exercise and stimulants such as strong tea or coffee. Detailed activity logs were maintained. Two experienced electrocardiogram diagnosticians analysed the Holter data according to standardised criteria; any discrepancies were resolved through discussion.

2.2.2 Data Collection

Clinical data collected included patient gender, age, BMI, duration of hypertension, duration of atrial fibrillation, smoking history, alcohol consumption history, comorbidities, cardiac ultrasound parameters, and Holter ECG parameters.

2.2.3 Treatment and Follow-up

All patients in the intervention group underwent radiofrequency ablation performed by the same cardiology team. Postoperatively, routine antiplatelet, antihypertensive, and antiarrhythmic medication was administered. Outpatient follow-up was conducted at 1, 3, 6, and 12 months post-procedure, with an electrocardiogram performed at each visit. If patients reported symptoms such as palpitations or chest tightness, a Holter monitor was promptly arranged to determine whether atrial fibrillation had recurred. Based on atrial fibrillation recurrence within 12 months post-procedure, the 230 study subjects were categorised into a recurrence group (n=48) and a non-recurrence group (n=182). Recurrence was defined as the detection of an atrial fibrillation episode lasting over 30 seconds via routine ECG or 24-hour Holter monitoring at least 3 months post-procedure.

2.3 Statistical Methods

Data analysis was conducted using SPSS 26.0 software. For quantitative data, this study presented results in the form of ($\bar{x} \pm s$), employing t-tests to assess significant differences. Data are expressed as percentages, with comparisons conducted using chi-square tests. Multivariate logistic regression analysis was utilised to identify independent risk factors for postoperative recurrence. A p-value < 0.05 was considered statistically significant.

3. Results

3.1 Holter ECG Characteristics in Patients with Hypertension and Paroxysmal Atrial Fibrillation

Analysis of Holter ECG characteristics reveals that atrial fibrillation episodes in hypertensive patients with paroxysmal atrial fibrillation exhibit typical ECG features: sinus P wave is completely absent, while the f waves exhibit irregular morphology, amplitude, and spacing. They are clearly visible in leads CM1 and CM5, with a frequency of approximately 350 to 600 beats per minute. The ventricular rate exhibits marked variability, generally tachycardic and arrhythmic, with mean rates reaching 120–160 beats per minute. During episodes of rapid ventricular rate, transient RR interval shortening may occur. The morphology of QRS complexes largely remains consistent with sinus rhythm, predominantly supraventricular in nature with durations < 0.12 seconds. However, due to the influence of f-wave conduction, marked inter-QRS interval variability is observed. Some rapidly conducted impulses may exhibit mild QRS complex widening or deformation owing to intraventricular conduction heterogeneity.

3.2 Univariate analysis of recurrence versus non-recurrence groups

Univariate analysis revealed that patients in the recurrence group exhibited significantly higher BMI, LAD, ultra-low frequency power, low-frequency power, and heart rate deceleration capacity compared to the non-recurrence group, while high-frequency power, rMSSD, pNN50, and SDNN were significantly lower ($P < 0.05$) (Table 1).

Table 1. Univariate analysis comparing recurrence and non-recurrence subgroups in the combined cohort

Item	Recurrence group (n=48)	Non-recurrence group (n=182)	χ^2/ t	P
Gender [n(%)]			0.006	0.936
Male	28 (58.33)	105 (57.69)		
Female	20 (41.67)	67 (42.31)		
Age (years, $\bar{x} \pm s$)	65.32±7.45	64.15±6.89	1.029	0.305
BMI (kg/m ² , $\bar{x} \pm s$)	26.15±2.34	23.82 ± 2.21	6.418	<0.001
Smoking history [n(%)]	15 (31.25)	52 (28.57)	0.132	0.716

Item	Recurrence group (n=48)	Non-recurrence group (n=182)	χ^2/ t	P
History of alcohol consumption [n(%)]	13 (27.08)	46 (25.27)	0.065	0.799
Diabetes [n(%)]	11 (22.92)	38 (20.88)	0.094	0.759
Hyperlipidaemia [n(%)]	14 (29.17)	50 (27.47)	0.054	0.816
LAD (mm, $\bar{x} \pm s$)	43.75±4.42	39.32±4.15	6.490	<0.001
Left ventricular ejection fraction (% , $\bar{x} \pm s$)	61.25 ± 5.34	62.15 ± 4.89	1.112	0.267
Very low frequency power (ms ² , $\bar{x} \pm s$)	987.65±132.45	834.56±118.76	7.751	<0.001
Low-frequency power (ms ² , $\bar{x} \pm s$)	1423.56±198.67	1198.76±176.54	7.641	<0.001
High-frequency power (ms ² , $\bar{x} \pm s$)	389.45±87.65	487.65±102.34	6.083	<0.001
rMSSD (ms, $\bar{x} \pm s$)	20.34±4.56	27.89±5.67	8.523	<0.001
pNN50 (% , $\bar{x} \pm s$)	2.15±0.87	3.68±1.05	9.285	<0.001
Heart rate deceleration force (ms, $\bar{x} \pm s$)	5.68±0.84	4.56±0.72	9.249	<0.001
SDNN (milliseconds, $\bar{x} \pm s$)	66.35±11.28	77.42±12.35	5.621	<0.001

3.3 Multivariate logistic regression analysis of postoperative recurrence

Results indicated that heart rate deceleration capacity, SDNN, and LAD were independent risk factors for postoperative recurrence in hypertensive patients with PAF ($P < 0.05$). See Table 2.

Table 2. Multivariate logistic regression analysis of postoperative recurrence in the combined group

Factor	β	SE	Wald χ^2	OR	95% CI	P
Heart rate deceleration force	-1.370	0.466	9.000	0.253	0.103–0.620	0.001
SDNN	-1.632	0.643	6.421	0.195	0.054–0.690	0.002
LAD	0.195	0.086	5.023	2.563	1.245–5.278	0.011

4. Discussion

Univariate analysis revealed that the recurrence group exhibited higher BMI, LAD, ultra-low-frequency power, low-frequency power, and heart rate deceleration capacity compared to the non-recurrence group. Conversely, high-frequency power, rMSSD, pNN50, and SDNN were lower in the recurrence group. Statistical analysis using a multivariate logistic regression model confirmed that heart rate deceleration capacity, SDNN parameters, and left atrial diameter were independent risk factors for postoperative recurrence ($P < 0.05$). Heart rate deceleration and SDNN, as core quantitative parameters in Holter monitoring, demonstrate significant predictive value. Elevated heart rate deceleration indicates profound autonomic cardiac dysfunction, suggesting impaired autonomic regulation persists even after radiofrequency ablation, predisposing to atrial electrical abnormalities and AF recurrence. Conversely, reduced SDNN indicates poor heart rate variability and severe atrial electrical remodelling, thereby increasing the risk of postoperative recurrence. Enlarged left atrial dimensions constitute a key indicator of atrial structural remodelling. An enlarged atrium complicates ablation procedures, and remodelled myocardium struggles to fully regain normal electrophysiological function, representing another critical risk factor for postoperative recurrence [4].

In summary, quantitative Holter ECG parameters in hypertensive patients with PAF exhibit characteristic alterations. Deceleration power, SDNN, and LAD constitute independent risk factors for recurrence following radiofrequency ablation.

References

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