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Original Research Article

Association of Serum Catecholamine Concentrations with Heart Rate Variability in Patients with Chronic Heart Failure

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Abstract:

Background: In order to identify higher-risk patients who might be the focus of additional treatment measures, a wide range of factors related to CHF can be assessed. By doing a bedside examination, it is quite simple to identify patients who exhibit symptoms and signs while at rest. Even with the best medical care, these patients still have an annual mortality rate of more than 40%, but their share of the overall heart failure population is quite modest.

Objectives: In patients with chronic heart failure, the study sought to determine the association between HRV parameters and blood catecholamine levels as well as the usefulness of these measurements in indicating autonomic dysfunction and the severity of the condition.

Materials and Methods: It was a retrospective, observational study. The study was carried out at a tertiary care centre. The study data that was retrieved was for one year. Data from 184 participants were retrieved for the study. Patients 18 years of age and older who had a diagnosis of chronic heart failure verified by clinical assessment and echocardiography and whose medical records had information on heart rate variability, blood catecholamine levels, and NYHA functional class were included in the study.

Results: A significant proportion of patients (64.1%) demonstrated reduced left ventricular ejection fraction (<40%). Common associated conditions included hypertension in 55.4%, diabetes mellitus in 41.3%, and ischemic heart disease in 48.4% of patients. Heart rate variability analysis showed reduced autonomic control of the heart. The mean SDNN was 92.6 ms, and RMSSD was 21.4 ms.

Conclusion: Reduced time-domain and frequency-domain HRV characteristics show that patients with chronic heart failure have severe autonomic dysfunction, according to this study. Increased sympathetic activation is linked to compromised autonomic regulation, as seen by elevated serum catecholamine levels and a moderately negative connection with HRV indices.

Recommendations: Larger studies are required to validate the predictive utility of HRV and catecholamine monitoring, which can help evaluate autonomic dysfunction in CHF and direct tailored therapy.

Keywords: Chronic Heart Failure, HRV, Catecholamines, CHF, Heart Rate Variability.

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Introduction

Chronic heart failure (CHF) is a challenging condition to treat in clinical practice, and mortality is still high despite recent advancements. Although the discovery of new therapy modalities has the potential to lower mortality, issues with toxicity or cost may restrict their general use [1, 2].

In order to identify higher-risk patients who might be the focus of additional treatment measures, a wide range of factors related to CHF can be assessed. By doing a bedside examination, it is quite simple to identify patients who exhibit symptoms and signs while at rest. Even with the best medical care, these patients still have an annual mortality rate of more than 40%, but their share of the overall heart failure population is quite modest [3, 4].

The phenomenon known as heart rate variability (HRV) is defined by fluctuations in both the instantaneous heart rate and the intervals between successive heartbeats. A popular technique for measuring sympathetic and parasympathetic activity is HRV in the frequency domain [5]. However, there hasn't been much research done on how serum cytokine levels affect HRV in CCHD patients [6].

It has been acknowledged that measuring HRV is a practical and non-invasive method for determining

autonomic function [7]. Analyses of HRV, which represents the cardiac sympathovagal balance, can be used to investigate autonomic impacts on the sinus node. While low frequency (LF) fluctuation includes elements produced by both sympathetic and vagal nerve activity, high frequency (HF) variability is associated with vagal nerve activity [8].

Since plasma noradrenaline levels have been discovered to predict a poor prognosis in heart failure patients, neurohormonal activation in chronic heart failure has been thoroughly researched. This includes elements like anomalies of plasma catecholamines. While hypoglycemia primarily activates the adrenomedullary hormonal system, which secretes epinephrine (EPI) into the peripheral circulation from the adrenal medulla, orthostatic challenge primarily activates the sympathetic noradrenergic system innervating the heart and peripheral blood vessels, a process primarily mediated by norepinephrine (NE) [9, 10].

In patients with chronic heart failure, the study sought to determine the association between HRV parameters and blood catecholamine levels as well as the usefulness of these measurements in indicating autonomic dysfunction and the severity of the condition.

Methodology

Study Design: The study was a retrospective, observational.

Study Settings: It was carried out at a tertiary care centre. The study data that was retrieved was for one year.

Study Population: Data of 184 participants were retrieved for the study. Patients 18 years of age and older who had a diagnosis of chronic heart failure verified by clinical assessment and echocardiography and whose medical records had information on heart rate variability, blood catecholamine levels, and NYHA functional class were included in the study. Individuals with pacemakers or implanted cardioverter-defibrillators, acute cardiac failure, acute coronary syndromes, or serious arrhythmias such atrial fibrillation were not included. Furthermore, the study excluded patients with insufficient medical records, systemic inflammatory or viral disorders, heart surgery, or a recent myocardial infarction.

Data Collection: Over the course of a year, information was gathered retrospectively from hospital records of patients who had been diagnosed with chronic heart failure. Age, sex, left ventricular ejection fraction, NYHA functional class, and comorbidities were obtained. Serum catecholamine levels recorded in lab records and heart rate variability characteristics from resting ECG recordings were included. Patient confidentiality was upheld, and only complete records were examined.

Study Procedure: For every subject, the process was as follows. Prior to the trial, patients had fasted and abstained from smoking for eight hours. Each individual was placed supine in their hospital bed with the head of the bed at 30° angle two hours after a thermodilution pulmonary artery catheter was inserted for hemodynamic assessment (typically in the late afternoon). For thirty minutes, the patient d, -n was not bothered by medical personnel, relatives, friends, or television. After 30 minutes, 7 milliliters of blood were gently extracted via the pulmonary artery catheter's proximal port and promptly placed in a vial containing ethylenediaminetetraacetic acid.

Statistical Analysis: The statistical analysis was conducted using SPSS version 26.0. Microsoft Excel was used to originally enter the data. The information has been displayed as mean±SD or as the number of participants (n) with percentages (%).

For statistical analysis, the independent t-test was employed. A p-value of less than 0.05 was considered to be statistically significant.

Results

Figure 1 shows the age group distribution among study participants. The study included 184 participants distributed across different age groups. 36 participants (19.6%) were in the 41–50 years age group. The largest group was 51–60 years, with 54 participants (29.3%). 28 participants (15.2%) were older than 70 years.

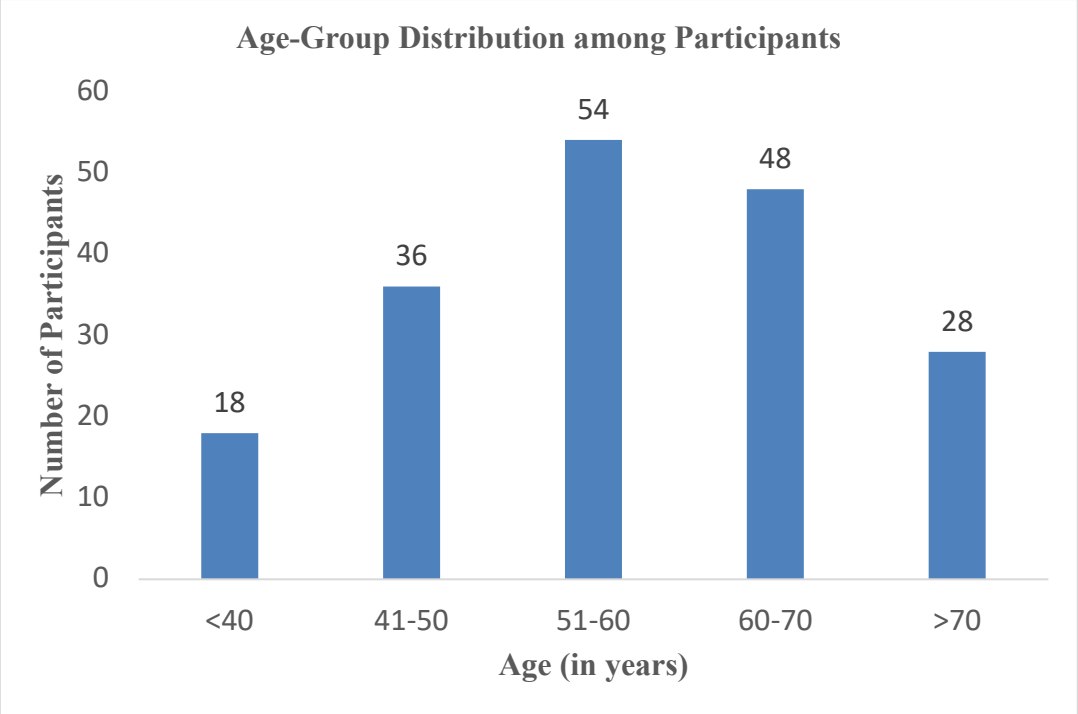

Figure 1: Distribution of Age-Group among Study Participants

A significant proportion of patients (64.1%) demonstrated reduced left ventricular ejection fraction (<40%). Common associated conditions included hypertension in 55.4%, diabetes mellitus in 41.3%, and ischemic heart disease in 48.4% of patients. Heart rate variability analysis showed reduced autonomic control of the heart. The mean SDNN was 92.6 ms, and RMSSD was 21.4 ms. Table 1 elaborates demographics of study participants.

Table 1: Demographics of Study Participants

Variable	**Value**
Mean age (in years)	58.6 ± 11.2
NYHA Class I	32 (17.4%)
NYHA Class II	78 (42.4%)
NYHA Class III	60 (32.6%)
NYHA Class IV	14 (7.6%)
Mean LVEF (in %)	38.4 ± 8.7
LVEF < 40%	118 (64.1%)
Hypertension	102 (55.4%)
Diabetes Mellitus	76 (41.3%)
Ischemic Heart Disease	89 (48.4%)
HRV Parameter	
SDNN (ms)	92.6 ± 24.8
RMSSD (ms)	21.4 ± 8.9
pNN50 (%)	7.8 ± 4.3
LF power (ms^2)	412.5 ± 186.7
HF power (ms^2)	186.3 ± 92.4
LF/HF ratio	2.48 ± 0.91
Catecholamine (pg/mL)	612.7 ± 158.4

The study includes 69 (37.5%) of females and 115 (62.5%) of males. Figure 2 shows gender of study participants.

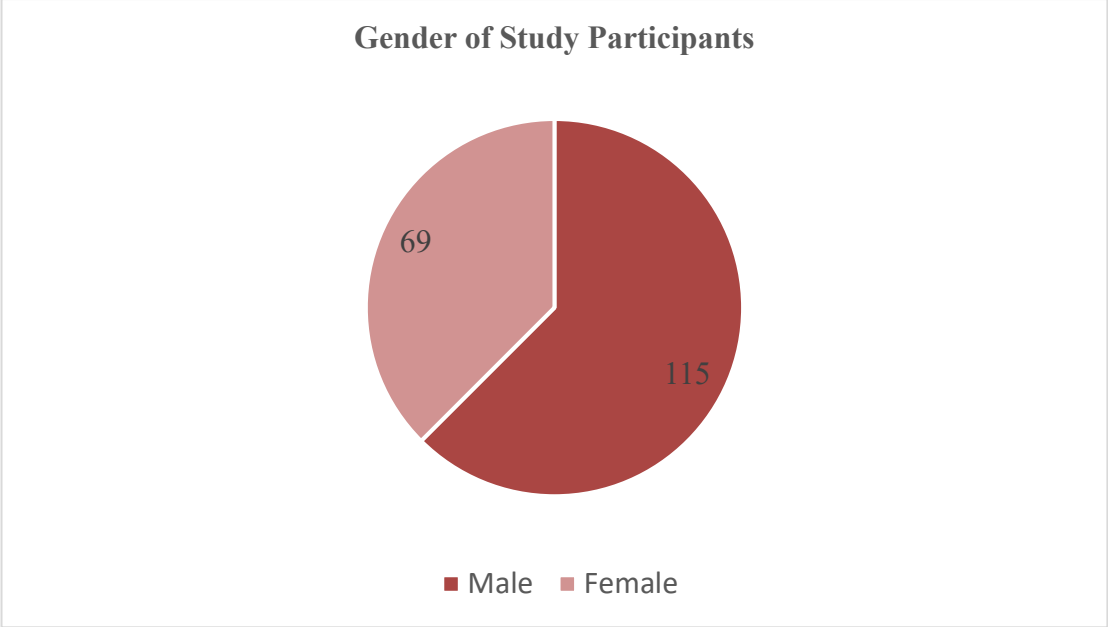

Figure 2: Distribution of Gender of Study Participants

Time-domain HRV indices showed a moderate negative correlation with catecholamine levels, with SDNN ($r = -0.52$, $p < 0.001$) and RMSSD ($r = -0.48$, $p < 0.001$). Similarly, the frequency-domain parameter HF power was negatively correlated with catecholamine levels ($r = -0.46$, $p < 0.001$). Table 2 depicts correlation between HRV parameters and serum catecholamine levels.

Table 2: Correlation Between HRV Parameters and Serum Catecholamine Levels

HRV Parameter	Correlation Coefficient (r)	p-value
SDNN	−0.52	<0.001
RMSSD	−0.48	<0.001
HF power	−0.46	<0.001
LF/HF ratio	+0.43	<0.001

Discussion

Neurohormonal activation and autonomic instability are characteristics of CHF that contribute to the disease's progression and unfavorable prognosis. In this study, we found that individuals with CHF exhibited lower HRV, as shown by lower SDNN, RMSSD, and HF power, indicating diminished parasympathetic activity and relative sympathetic dominance. The evidence of sympathovagal imbalance was further supported by the higher mean LF/HF ratio.

The group had considerably higher serum catecholamine levels, and there was a moderately negative connection between HRV parameters and catecholamines (SDNN: $r = -0.52$; RMSSD: $r = -0.48$; HF power: $r = -0.46$; all $p < 0.001$). This result is consistent with other research demonstrating that reduced autonomic regulation of the heart in CHF is linked to increased sympathetic activity [5,7,9,10]. In patients with heart failure, elevated norepinephrine levels have been found to be a reliable indicator of a poor prognosis [3,4].

Overall and parasympathetic-specific cardiac autonomic tone are reflected by time-domain HRV indices such SDNN and RMSSD, respectively. The observed decrease in these indices indicates that vagal regulation of the sinus node is suppressed by chronic sympathetic overactivity, as seen by higher catecholamines, which contributes to decreased autonomic control [5,8]. Similar patterns were seen in frequency-domain analysis, where a relative rise in the LF/HF ratio indicated sympathetic predominance and decreased HF power indicated decreased vagal activity. These findings are in line with earlier findings that sympathetic and parasympathetic activity in CHF is correlated with HRV parameters [7,8].

These discoveries have important clinical ramifications. Autonomic dysfunction is indicated by lower HRV and higher catecholamines, which are linked to a poorer prognosis in CHF. Catecholamine measurement can supplement HRV testing by directly measuring sympathetic activation, whereas HRV assessment offers a non-invasive, economical method of assessing autonomic imbalance [9,10]. By combining these signs, risk classification may be enhanced and specific treatment measures, like beta-blocker therapy or device-based autonomic modulation, may be guided.

Conclusion

Reduced time-domain and frequency-domain HRV characteristics show that patients with chronic heart failure have severe autonomic dysfunction, according to this study. Increased sympathetic activation is linked to compromised autonomic regulation, as seen by elevated serum catecholamine levels and a moderately negative connection with HRV indices. These results support the usefulness of HRV analysis as a non-invasive method for evaluating autonomic imbalance and the influence of neurohormonal activity on prognosis in chronic heart failure.

Limitations: It might not be possible to generalize the results of this study to a larger population because it was carried out in a single urban tertiary care facility. Furthermore, the study's sample size was insufficient for extrapolating results and drawing inferences.

Recommendations: Larger studies are required to validate the predictive utility of HRV and catecholamine monitoring, which can help evaluate autonomic dysfunction in CHF and direct tailored therapy.

List of Abbreviations:

CHF- Chronic heart failure.

HRV- Heart Rate Variability.

NHYA- New York Heart Association Functional Classification.

SD- Standard Deviation.

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