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Research Article

Prognostic Value of Multiple Electrocardiographic Abnormalities in Predicting Heart Failure Worsening and In-Hospital Mortality: A Prospective Observational Study

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Abstract:

Background: Abnormalities of the electrocardiogram (ECG), which indicate underlying cardiac dysfunction, are known to be prognostic markers in heart failure (HF). Less is known about how several ECG abnormalities work together to affect HF outcomes. The aim of this study was to explore the relationship between various ECG anomalies and the prediction of in-hospital mortality and worsening of heart failure.

Subjects and Methods: 100 HF patients who were admitted to Rizgary Teaching Hospital participated in our prospective observational study over one year. QRS prolongation, ST-segment deviations, left ventricular hypertrophy (LVH), atrial fibrillation (AF), and QT interval prolongation were all assessed on standard 12-lead ECGs. Patients were divided into three groups according to how many anomalies they had (0–1, 2, ≥3). In-hospital mortality and HF exacerbation were the primary outcomes.

Results: 60% of patients were men, with average age of 65 ± 12 years. The most prevalent anomalies were ST-segment variations (40%), AF (32%), and QRS prolongation (35%). Worsening of HF was experienced in 20% of patients with 0–1 abnormality, 34% with 2 abnormalities, and 63% with ≥3 abnormalities ($p<0.001$). In-hospital death rates were 8%, 14%, and 38%, respectively ($p<0.001$). The most significant predictors of unfavorable outcomes were AF (HR: 1.8, $p=0.002$) and QT interval prolongation (HR: 1.9, $p=0.001$).

Conclusion: Multiple ECG anomalies are a powerful, independent predictor of in-hospital mortality and the progression of heart failure. Risk assessment in HF care can be greatly enhanced by a comprehensive ECG study.

Key words: QT interval; atrial fibrillation; QRS prolongation; heart failure; and aberrant ECG readings

Introduction

Abnormalities in electrocardiograms (ECGs) are vital prognostic indicators for heart failure (HF), offering valuable information about the anatomy and physiology of the heart that aids in predicting unfavorable outcomes. QRS prolongation, ST-segment deviations, left ventricular hypertrophy (LVH), atrial fibrillation (AF), and QT interval prolongation have been independently associated with worsening heart failure, increased hospitalization rates, and increased mortality [1–3]. The following abnormalities such as myocardial fibrosis, electrical dyssynchrony, and neurohormonal activation are indicative of pathophysiological alterations that underlie the evolution of heart failure [4].

Previous researches indicate that ventricular dyssynchrony, which is significantly linked to poor outcomes in HF with reduced ejection fraction (HFrEF), is indicated by QRS complex durations longer than 120 ms. Shenkman et al., for instance, showed that QRS prolongation alone raised the probability of all-cause death in HF patients by 1.8 times [5]. Likewise, increased cardiac troponin levels and worse functional status are associated with anomalies of the ST-T segment, which are frequently suggestive of myocardial strain or ischemia [6]. In patients with hypertension who proceed to heart failure, LVH, a hallmark of chronic pressure overload, is strongly associated with both systolic and diastolic dysfunction and a much-increased risk of hospitalization for heart failure

[7]. Thirty to forty percent of HF patients have atrial fibrillation, which deteriorates hemodynamic stability and raises the risk of death by forty percent [8]. The risk is also increased when there are several ECG abnormalities. For example, Myhre et al.'s cohort analysis revealed that patients with three or more ECG abnormalities were 3.1 times more likely to experience heart failure decompensation than those with fewer abnormalities [9]. The necessity of thorough ECG assessments in risk evaluation is highlighted by this cumulative effect.

Recent research has also highlighted QT interval lengthening as a predictor of ventricular arrhythmias and sudden cardiac death in advanced HF [10]. Prognostic accuracy is improved when these ECG indicators combine with neurohormonal activity, especially increased natriuretic peptides [11]. There are still some debates; for example, LVH may become less accurate in predicting end-stage heart failure when looking at long-term outcomes [12]. The purpose of this study was to examine the predictive power of various ECG anomalies for in-hospital mortality and progression of heart failure.

Subject and Methods:

One hundred patients with HF who were admitted to Rizgary Teaching Hospital during the course of a year (2023–2024) were included in this prospective observational study. We included adults with confirmed HFrEF who were at least 18 years old [13]. Individuals with recent myocardial infarction (within the last three months), congenital cardiac disease, HFpEF, or missing ECG data were not included. All patients gave their informed consent, and the study was approved by the Hawler Medical University College of Medicine's ethical committee. Every patient had a comprehensive clinical evaluation upon admission, which included a physical examination, laboratory testing, and a review of their medical history. Within 24 hours of admission, standard 12-lead ECGs were conducted, and abnormalities were categorized as follows:

1. 1.QRS Prolongation: >120 ms of QRS duration [14].
2. ST-Segment Deviations: two contiguous leads with ST elevation or depression ≥1 mm [15].
3. The Sokolow-Lyon criteria are used to define left ventricular hypertrophy (LVH) [16].
4. Atrial fibrillation (AF) is characterized by uneven RR intervals and the absence of identifiable P waves.
5. Corrected QT interval (QTc) >460 ms in women and >450 ms in males are indicative of QT interval prolongation [17].

The number of ECG abnormalities (0–1, 2, or ≥3) was used to group the patients. In-hospital mortality and HF deterioration, which is characterized by the requirement for mechanical breathing, injectable inotropes, or ICU transfer, were the primary outcomes. Throughout the hospital stay, information was gathered to record death and clinical deterioration.

SPSS version 22 was used for statistical analysis. The chi-square test was used to compare categorical variables, while the student's t-test or ANOVA was used to analyze continuous variables, which were expressed as mean ± standard deviation. The independent prognostic relevance of certain ECG abnormalities was evaluated using multivariate Cox proportional hazards models, which controlled for confounding variables such age, sex, comorbidities, and baseline heart failure severity. Statistical significance was defined as a p-value of ≤0.05.

Results:

Sixty percent of the 100 HF patients in the research were male, and their mean age was 65 ± 12 years. The two most common comorbidities, impacting 70% and 55% of patients, respectively, were hypertension and ischemic heart disease. With an average ejection fraction of 38 ± 10%, 65% of patients had advanced heart failure (NYHA class III–IV). Significant neurohormonal activation was indicated by the mean serum BNP level of 450 ± 120 pg/mL (Table 1).

Characteristic	Total (n=100)
Age (years), mean ± SD	65 ± 12
Male, n (%)	60 (60%)
Hypertension, n (%)	70 (70%)
Diabetes Mellitus, n (%)	40 (40%)
Ischemic Heart Disease, n (%)	55 (55%)
Ejection Fraction (%), mean ± SD	38 ± 10
NYHA Class III-IV, n (%)	65 (65%)
Serum BNP (pg/mL), mean ± SD	450 ± 120

Table 1: Baseline Characteristics of the Study Population

ST-segment deviations accounted for 40% of the ECG abnormalities evaluated, followed by QRS prolongation in 35%, atrial fibrillation in 32%, left ventricular hypertrophy in 30%, and QT interval prolongation in 28% of cases (Table 2).

ECG Abnormality	n (%)
QRS Prolongation (>120 ms)	35 (35%)
ST-Segment Deviations	40 (40%)
Left Ventricular Hypertrophy	30 (30%)
Atrial Fibrillation	32 (32%)
QT Interval Prolongation	28 (28%)

Table 2: Prevalence of ECG Abnormalities

The number of ECG abnormalities was used to stratify the patients. 25% of patients had 0–1 abnormality, 35% had 2 abnormalities, and 40% presented with ≥3 abnormalities (Table 3).

Number of Abnormalities	n (%)
0-1	25 (25%)
2	35 (35%)
≥3	40 (40%)

Table 3: Distribution of Patients by Number of ECG Abnormalities

Poor clinical outcomes were shown to be significantly correlated with the number of ECG abnormalities. Worsening of heart failure was experienced in 20% of patients with 0–1 abnormality, 34% with 2 abnormalities, and 63% with ≥3 abnormalities (p<0.001). Multiple ECG abnormalities have a substantial prognostic value, as evidenced by the in-hospital death rates, which rose with the number of abnormalities: 8% for 0-1, 14% for 2, and 38% for ≥3 abnormalities (p<0.001) (Table 4).

Outcome	0-1 (n=25)	2 (n=35)	≥3 (n=40)
HF Worsening, n (%)	5 (20%)	12 (34%)	25 (63%)
In-Hospital Mortality, n (%)	2 (8%)	5 (14%)	15 (38%)

Table 4: Clinical Outcomes According to Number of ECG Abnormalities

All individual ECG abnormalities were shown to be independent predictors of unfavorable outcomes using multivariate Cox regression analysis. Atrial fibrillation (HR: 1.8, 95% CI: 1.3–2.6, p=0.002), QRS prolongation (HR: 1.7, 95% CI: 1.2–2.4, p=0.003), and QT interval lengthening (HR: 1.9, 95% CI: 1.3–2.7, p=0.001) had the highest hazard ratio. The risk of HF deterioration and death was also markedly elevated by ST-segment abnormalities and left ventricular hypertrophy (Table 5).

Variable	Hazard Ratio (HR)	95% Confidence Interval (CI)	p-value
QRS Prolongation	1.7	1.2–2.4	0.003
ST-Segment Deviations	1.5	1.1–2.1	0.015
Left Ventricular Hypertrophy	1.6	1.1–2.3	0.008
Atrial Fibrillation	1.8	1.3–2.6	0.002
QT Interval Prolongation	1.9	1.3–2.7	0.001

Table 5: Multivariate Analysis of ECG Abnormalities and Outcomes

Discussion:

This study shows that HF progression and in-hospital mortality are significantly predicted by various ECG abnormalities. The cumulative impact of electrical disturbances on the course of heart failure was highlighted by the fact that patients with three or more anomalies were at the highest risk. Our results are in line with previous researches. Our hazard ratio of 1.7 is consistent with Shenkman et al.'s finding that QRS prolongation raised the probability of all-cause mortality [5]. Similar to our findings of 63% HF deterioration and 38% in-hospital death in this group, Myhre et al. discovered that patients with ≥3 ECG abnormalities had a 3.1-fold increased risk of HF decompensation [9].

In our population, QT interval prolongation and AF were two of the strongest predictors. Hemodynamic instability and neurohormonal activation are documented side effects of AF that can lead to worse outcomes [8]. QT prolongation has a great predictive significance since it is a marker for ventricular arrhythmias and sudden cardiac death [10]. Even though LVH was strongly associated with poor outcomes, some research indicates that other competing factors may reduce its predictive ability in end-stage HF [12]. This discrepancy may result from variations in the patient demographics and stages of heart failure.

A thorough ECG study needs to be an essential component of any routine HF evaluation. Valuable information on the pathophysiology of heart failure, including myocardial fibrosis, electrical dyssynchrony, and ischemia burden, can be collected from the accumulated burden of ECG abnormalities. Integrating these findings into clinical practice can enhance risk stratification and guide personalized treatment.

Conclusion

Many ECG abnormalities are strong, independent indicators of both in-hospital mortality and the progression of heart failure. For HF patients, a thorough ECG assessment is essential for enhancing risk assessment and directing therapeutic treatment.

Limitations

This study was conducted at a single center with a relatively small sample size, limiting the generalizability of the findings. Additionally, long-term outcomes beyond hospitalization were not assessed, which could offer further insights into the prognostic significance of ECG abnormalities.

Recommendation

More extensive multicenter trials with extended follow-up are required to confirm these results and investigate their implications for various HF subtypes.

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