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Sex Differences in the Electrocardiographic and Echocardiographic Profiles of Hospitalized Heart Failure Patients in Cameroon

Valérie Ndobo[1,2*], Siddikatou Djibrilla[3,4], Christian Ngongang Ouankou[5,6], Guillaume Ebene Manon[1,2], Hermann Tsague[1,7], Grace Belobo[4,8,9], Sylvestre Efonle[2], Marie Ntep[2], Pierre Mintom[1,8,9], Sylvie Ndongo[1,5], Liliane Mfeukeu-Kuate[1,2], Chris Nadège Nganou-Gnindjio[1,6]

[1]Faculty of Medicine and Biomedical Sciences, University of Yaoundé 1, Yaoundé, Cameroon
[2]Cardiology Unit, Central Hospital of Yaoundé, Yaoundé, Cameroon
[3]Cardiology Unit, Laquintinie Hospital, Douala, Cameroon
[4]Faculty of Medicine and Pharmaceutical Sciences, University of Douala, Douala, Cameroon
[5]Internal Medicine Unit, University Teaching Hospital of Yaoundé, Yaoundé, Cameroon
[6]Faculty of Medicine, University of Dschang, Dschang, Cameroon
[7]Cardiology Unit, Yaoundé General Hospital, Yaoundé, Cameroon
[8]Cité Verte District Hospital, Yaoundé, Cameroon
[9]Regional Hospital Annex of Ayos, Ayos, Cameroon
Email: *ndobo86@gmail.com

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Abstract

Background: The electrocardiogram (ECG) and Doppler transthoracic echocardiography (TTE) remain key diagnostic tools that also help identify the etiology, assess severity and guide the therapeutic strategy for heart failure. This study aimed to characterize sex-specific electrocardiographic and echocardiographic profiles among patients admitted for heart failure. **Methods:** We conducted a retrospective descriptive study at Central Hospital of Yaoundé, including all adults aged ≥18 years hospitalized for heart failure between September 2022 and April 2024. Data from resting surface ECGs and Doppler TTEs performed during hospitalization were extracted from medical records. **Results:** We included 397 patients: 230 women [F] vs 167 men [M] with heart failure. Smoking was more frequent in men (19.8%) than in women (6.09%) ($p < 0.001$), as well as alcohol use (3.2% vs 0.5%, $p < 0.001$). On ECG, sinus rhythm predominated without a significant sex difference (73.8% in men vs 66.8% in women; $p = 0.10$), with a similar median heart rate (87 vs 87.5 bpm; $p = 0.50$). The most frequent arrhythmia was atrial fibrillation (8.2% in women vs 7.7% in men; $p = 0.06$), followed by left bundle branch block (2.6% vs 4.1%; $p = 0.20$), with no significant differences. On TTE, only right atrial dilatation differed significantly (23.4% in women vs 11.3% in men; $p = 0.03$). We ob-

served left ventricular remodeling (16.5% vs 16.7%; p = 0.60), left ventricular hypertrophy (12.6% vs 11.9%; p = 0.90), right ventricular hypertrophy (1.3% vs 2.9%; p = 0.40), left ventricular dilation (8.6% vs 8.9%; p = 0.80), and right ventricular dilation (36.6% vs 51.9%; p = 0.20) without significant sex differences. Left ventricular ejection fraction (LVEF) was mostly reduced (20.5%), with a comparable distribution between sexes (p = 0.70), and right ventricular systolic dysfunction was rare (2%) with no significant difference (p = 0.20). **Conclusion:** Among hospitalized patients with heart failure, electrocardiographic and echocardiographic profiles were broadly similar between sexes, except for Doppler echocardiography evidence of right atrial dilation, which was more frequent in women. On ECG, sinus rhythm predominated; on TTE, LVEF was mostly reduced.

Keywords

Electrocardiographic Profile, Echocardiographic Profile, Heart Failure

1. Introduction

Heart failure remains a major global public health problem, with rising prevalence and costs, and a particularly heavy burden of morbidity and mortality in low- and middle-income countries (LMICs) [1]. In Sub-Saharan Africa, etiologic profiles and age at onset differ from Western settings, with hypertensive heart disease, dilated cardiomyopathies, and acute rheumatic fever continuing to be the leading causes of hospitalization [2]. In Cameroon, several hospital-based studies have highlighted the burden of heart failure and documented local particularities in presentation and management [3]-[5].

In this context, the electrocardiogram (ECG) and Doppler transthoracic echocardiography (TTE) are central and accessible tools to support diagnosis, refine severity, explore etiology, and guide therapeutic strategy [6] [7]. Beyond diagnosis, electrocardiographic parameters (e.g., atrial fibrillation, QRS widening, left bundle branch block, left ventricular hypertrophy) and echocardiographic parameters (left ventricular ejection fraction, chamber remodeling and dilation, diastolic function and right ventricular function, pulmonary pressures) are associated with prognosis [8]-[11]. International guidelines detail measurement methods, thresholds, and phenotypic categories, notably for chamber quantification and for measuring ejection fraction using Simpson's method [6] [12].

Sex-related differences have also been described in heart failure—ranging from risk factors and phenotypes (including the higher frequency of heart failure with preserved ejection fraction in women) to therapeutic response and certain clinical outcomes [12]-[14]. Yet these differences remain under-documented in LMICs and particularly in Central African hospital settings, where limited access to advanced imaging and cardiac resynchronization devices further elevates the role of ECG and echocardiography [2] [6] [7]. In Cameroon, some hospital-based studies exist

but are often dated, focused on specific populations, or do not systematically describe electrocardiographic and echocardiographic profiles by sex [3]-[5]. Describing, in a referral hospital in Yaoundé, the sex-specific electrocardiographic and echocardiographic characteristics among patients hospitalized for heart failure helps fill this local knowledge gap, contextualize international data, and identify potential disparities useful for risk stratification and care-pathway optimization. Accordingly, the objective of our study was to characterize electrocardiographic and echocardiographic profiles by sex among adult patients hospitalized for heart failure in Yaoundé, and to situate these profiles relative to regional data and international standards for measurement and interpretation.

2. Methods

2.1. Study Design and Setting

This was a retrospective, descriptive study conducted at one referral hospitals in Yaoundé, Cameroon, Central Hospital of Yaoundé. Medical records, electrocardiograms (ECGs) and transthoracic Doppler echocardiograms of consecutive adult patients admitted with a primary diagnosis of heart failure were reviewed.

2.2. Study Period and Population

We included all patients aged ≥18 years admitted for heart failure between 1 September 2022 and 30 April 2024. Heart failure was defined according to the European Society of Cardiology/American College of Cardiology criteria used in the hospitals (clinical signs and symptoms of HF supported by imaging when available). Patients were included if at least one standard 12-lead ECG recorded during hospitalization was available. When transthoracic Doppler echocardiography was performed during hospitalization, those data were extracted and analyzed. We excluded all participants without a diagnosis of heart failure, those younger than 18 years, and those with incomplete medical records.

2.3. Data Sources and Collection

Demographic, clinical, ECG and echocardiographic data were extracted from inpatient charts and electronic medical records using a standardized data extraction form. Data collected included age, sex, key comorbidities (hypertension, diabetes, ischemic heart disease), HF etiology (as recorded in the chart), New York Heart Association (NYHA) class on admission, vital signs, basic laboratory results, echocardiographic parameters (LVEF, chamber dimensions, valvular lesions, diastolic function parameters) and in-hospital outcomes (length of stay, in-hospital mortality).

2.4. ECG Acquisition and Interpretation

All resting 12-lead ECGs performed during hospitalization (ideally at admission) were retrieved in original digital or paper form. ECGs were analyzed by two independent cardiologists/experienced readers blinded to patient outcomes. Discrep-

ancies were resolved by consensus or by a third adjudicator. The following ECG parameters were systematically recorded: heart rate (bpm), cardiac rhythm (sinus rhythm, atrial fibrillation, flutter, other supraventricular rhythms), regularity, P morphology and duration (ms) (left and right atrial enlargement criteria), PR interval (ms), QRS duration (ms), QRS morphology (left bundle branch block [LBBB], right bundle branch block [RBBB], nonspecific intraventricular conduction delay), QRS axis, presence of pathologic Q waves, ST-T changes (ischemic pattern), presence of left ventricular hypertrophy (LVH) by Sokolow-Lyon and Cornell criteria, presence and frequency of premature ventricular complexes (PVCs) or supraventricular extrasystoles, and corrected QT interval (QTc) calculated using Bazett's formula (ms). Definitions used: complete prolonged QRS defined as ≥120 ms; LBBB and RBBB defined according to standard ECG criteria; LVH defined by Sokolow-Lyon index (S in V1 + R in V5/V6 ≥ 35 mm) and/or Cornell voltage criteria; pathologic Q waves per standard definitions [15] [16].

2.5. Echocardiography Acquisition and Interpretation

Transthoracic Doppler echocardiograms performed during hospitalization were retrieved and analyzed. When multiple studies were available, the echocardiogram closest to admission was used for primary analyses. Left ventricular ejection fraction (LVEF) was measured using the Simpson biplane method when feasible; if Simpson measurement was not possible, a visual estimate or other validated method recorded in the report was used. Recorded echocardiographic variables included: LVEF (%), left ventricular end-diastolic and end-systolic diameters/volumes, left and right atrial sizes, diastolic function parameters (E, A, E/A ratio, deceleration time, tissue Doppler e' velocities and E/E' when available), presence and severity of valvular lesions, right ventricular function (TAPSE or qualitative assessment), estimated pulmonary artery systolic pressure, and presence of pericardial effusion. Echocardiograms were interpreted by experienced cardiologists/echocardiographers blinded to ECG findings. Standard departmental protocols and measurements were followed to ensure consistency [12] [17].

2.6. Key Variables and Outcomes

Primary objective: describe the prevalence and patterns of ECG and echocardiographic abnormalities among hospitalized heart failure patients. Secondary objectives: explore associations between ECG/echocardiographic findings and clinical variables (etiology of HF, LVEF category, in-hospital mortality). Outcomes of interest included prevalence of atrial fibrillation/flutter, conduction blocks (LBBB/RBBB), prolonged QRS, LVH, pathological Q waves, reduced LVEF, significant valvular disease, and major arrhythmias.

2.7. Statistical Analysis

The data extracted from these files were recorded in a digital database and then analyzed. R software version 4.2.3 and RStudio version 2023.6.1.524 (Integrated

Development Environment for R. Posit software, PBC, Boston, MA) were used to analyze the data. Qualitative variables were described by numbers and percentages. Quantitative variables were described as median [Q1 - Q3]. Pearson's chi-square test and Fisher's exact test were performed to compare risk factors, electrocardiographic and echocardiographic characteristics between sexes; statistical significance was set at $p < 0.05$.

2.8. Ethical Considerations

The study protocol was approved by the institutional ethics committees of the participating hospitals. Given the retrospective design, a waiver of individual informed consent was requested and obtained where local regulations allowed. Patient confidentiality was ensured: all data were anonymized and stored on encrypted drives accessible only to the study team.

3. Results

3.1. Distribution of Risk Factors by Sex among Patients Hospitalized for Heart Failure

In our retrospective series of 397 patients hospitalized for heart failure, 230 were women (58%) and 167 were men (42%), with a median age of 63 years [50 - 74] in women and 60 years [50 - 69] in men. Men smoked (19.8% vs 6.09%; $p < 0.001$) and consumed alcohol significantly more often (3.2% vs 0.5%; $p < 0.001$) than women. Other risk factors did not differ significantly by sex ($p > 0.05$) (Table 1).

Table 1. Gender-based distribution of risk factors among patients hospitalized with heart failure.

Variables	Gender			
	Total (N = 397)	Women (n = 230)	Men (n = 167)	p-value
Median age [minimum - maximum]	62.5 years [50 - 74]	63 years [50 - 74]	60 years [50 - 69]	0.1
Risk factors				
High blood pressure	239 (60.2%)	145 (63.0%)	94 (56.3%)	0.1
Dyslipidemia	19 (28.4%)	13 (30.2%)	6 (25%)	0.6
Obesity	90 (22.6%)	58 (25.2%)	32 (19.2%)	0.1
Diabete	65 (16.4%)	36 (15.7%)	29 (17.4%)	0.6
Smoking	47 (11.8%)	14 (6.09%)	33 (19.8%)	<0.001
Alcoholism	17 (4.2%)	3 (0.5%)	14 (3.2%)	<0.001
Chronic kidney disease	5 (1.2%)	3 (1.3%)	2 (1.1%)	>0.9

Data are presented as counts (N, n) and percentages (%). p-values: Pearson's chi-square test and Fisher's exact test were performed to compare risk factors between sexes; statistical significance was set at $p < 0.05$.

3.2. Distribution of Electrocardiographic Characteristics by Sex among Patients Hospitalized for Heart Failure

Sinus rhythm was the most frequent pattern (69.6%), slightly more common in men (73.8%) than in women (66.8%), with no significant difference ($p = 0.10$). The

median heart rate was similar between sexes (87 vs 87.5 bpm; p = 0.50). Atrial fibrillation affected 8.0% of patients (8.2% in women vs 7.7% in men; p = 0.06), and left bundle branch block 3.2% (2.6% vs 4.1%; p = 0.20) (Table 2).

Table 2. Distribution of electrocardiographic characteristics by sex in patients hospitalized for heart failure.

Electrocardiographic Characteristics	Gender			
	Total (N = 397)	Women (n = 230)	Men (n = 167)	p-value
Sinusal rhythm	220 (69.6%)	127 (66.8%)	93 (73.8%)	0.1
Heart rate median [Q1 - Q3]	87.0 [76.0 - 103.0]	87.0 [75.0 - 106.0]	87.5 [76.0 -102.0]	0.5
Atrial fibrillation	32 (8%)	19 (8.2%)	13 (7.7%)	0.06
Left bundle branch block	13 (3.2%)	6 (2.6%)	7 (4.1%)	0.2

Data are presented as counts (N, n) and percentages (%). p-values: Pearson's chi-square test and Fisher's exact test were performed to compare electrocardiographic characteristics between sexes; statistical significance was set at $p < 0.05$.

3.3. Distribution of Echocardiographic Characteristics by Sex among Patients Hospitalized for Heart Failure

Right atrial dilation was more frequent in women (23.4%) than in men (11.3%; p = 0.03). Other features did not differ significantly: left ventricular remodeling (16.5% vs 16.7%; p = 0.60), left ventricular hypertrophy (12.6% vs 11.9%; p = 0.90), right ventricular hypertrophy (1.3% vs 2.9%; p = 0.40), left ventricular dilation (8.6% vs 8.9%; p = 0.80), and right ventricular dilation (36.6% vs 51.9%; p = 0.20). The distribution of left ventricular ejection fraction categories was comparable between sexes (p = 0.70). Right ventricular systolic dysfunction was rare (≈2%) with no sex difference (p = 0.20) (Table 3).

Table 3. Distribution of echocardiographic characteristics by sex among patients hospitalized for heart failure.

Echocardiographic Characteristics	Gender			
	Total (N = 397)	Women (n = 230)	Men (n = 167)	p value
Right atrial dilation	73 (18.3%)	54 (23.4%)	19 (11.3%)	**0.03**
Left ventricular remodeling	66 (16.6%)	38 (16.5%)	28 (16.7%)	0.6
Left ventricular hypertrophy	49 (12.3%)	29 (12.6%)	20 (11.9%)	0.9
Right ventricular hypertrophy	8 (2%)	3 (1.3%)	5 (2.9%)	0.4
Left ventricular dilation	35 (8.8%)	20 (8.6%)	15 (8.9%)	0.8
Right ventricular dilation	29 (42.6%)	15 (36.6%)	14 (51.9%)	0.2
LVEF				0.7
Preserved (≥50%)	62 (15.6%)	41 (17.8%)	21 (12.5%)	
Impaired 35% - 49%	36 (9%)	21 (9.1%)	15 (8.9%)	
Severely impaired (<35%)	46 (11.5%)	29 (12.6%)	17 (10%)	
Right ventricular systolic dysfunction	8 (2%)	3 (1.3%)	5 (2.9%)	0.2

LVEF: Left ventricular ejection fraction. Data are presented as counts (N, n) and percentages (%). p-values: Pearson's chi-square test and Fisher's exact test were performed to compare echocardiographic characteristics between sexes; statistical significance was set at $p < 0.05$.

4. Discussion

The main findings of our study showed that sex differences were primarily behavioral: smoking and alcohol consumption were higher in men, whereas classical metabolic risk factors (hypertension, diabetes, dyslipidemia, obesity) and median age did not differ significantly. On electrocardiography, no parameter differed by sex (predominant sinus rhythm, atrial fibrillation ~8%, left bundle branch block ~3%). On echocardiography, only right atrial dilation was more frequent in women; the distribution of left ventricular ejection fraction categories was comparable. Our observations fit within an African landscape in which heart failure remains strongly linked to hypertension and non-ischemic cardiomyopathies, with hospitalizations at relatively young ages—findings demonstrated in the systematic review and Meta-analysis by Agbor *et al.* (2018), as well as the works of Bloomfield *et al.* (2013) and Ntusi *et al.* (2009) [2] [15] [18].

Numerous studies in Sub-Saharan Africa describe an epidemiology of heart failure dominated by hypertensive heart disease and dilated cardiomyopathy, with a high burden of hospitalizations and constrained care pathways; our results align with this trend [4] [19] [20]. Overall, heart failure in women more often presents with preserved ejection fraction but distinctive alterations in internal cardiac structure [12] [21] [22]. The literature provides standardized thresholds and measurement methods for reliably interpreting these parameters. In this context, the observation of more frequent right atrial dilation among women in our sample deserves confirmation and interpretation in light of the recommendations for echocardiographic assessment of the right heart in adults issued by the American Society of Echocardiography, with endorsement from the European Association of Echocardiography (a branch of the European Society of Cardiology) and the Canadian Society of Echocardiography, to distinguish what is attributable to biology, clinical phenotype, or measurement effects [23] [24].

From a pathophysiological standpoint, our results are first interpreted through risk behaviors: smoking increases the risk of heart failure and worsens prognosis, which is consistent with the male overrepresentation observed [25] [26]. Likewise, alcohol can induce dilated cardiomyopathy and destabilize heart failure; even at low doses, its cardiovascular effects are complex, supporting abstinence in cases of myocardial disease [27] [28]. Regarding the atria and sex, atrial dilation—especially left atrial dilation—is a robust marker of diastolic load and events, modulated by body size and hemodynamic profiles that often differ in women [29] [30]. Our signal of more frequent right atrial dilation in women could reflect higher right-sided pressures in phenotypes with preserved ejection fraction and exercise-induced pulmonary hypertension, which are reported more often in women [12] [21]. Finally, from the electrocardiographic perspective, the absence of sex differences in atrial fibrillation or left bundle branch block does not diminish their prognostic significance: a widened QRS and bundle branch blocks are associated with a higher risk of adverse events, while cardiac resynchronization therapy improves morbidity and mortality in eligible patients [8] [10] [31] [32].

Echocardiographic acquisition and interpretation should follow international recommendations (dimensions, biplane Simpson ejection fraction, indexation); our results are aligned with these methodological frameworks and facilitate external comparisons [33]. Similarly, the ECG remains a key tool; for left ventricular hypertrophy, the Sokolow-Lyon and Cornell criteria perform differently according to sex and body habitus, underscoring the value of analyses that integrate multiple indices [16] [34]-[36].

5. Clinical and Public Health Implications

From a clinical and public health perspective, our findings first call for targeted prevention: the marked sex disparity in smoking and alcohol use justifies differentiated, culturally tailored interventions, given the well-documented benefits of smoking cessation and alcohol reduction or abstinence in people with heart failure [25] [27]. For risk stratification, patients with a widened QRS complex and an appropriate phenotype should be considered for cardiac resynchronization therapy in line with international guidelines and pivotal trials [6] [17] [31] [32]. In addition, right-heart phenotyping should be strengthened—particularly in view of the female overrepresentation of right atrial dilation—through rigorous measurement of right-sided dimensions, tricuspid annular plane systolic excursion (TAPSE), and estimated pulmonary artery pressure, aligned with society recommendations [24].

6. Study Limitations

The main limitations of our study lie in its retrospective, single-center design, which introduces selection bias toward hospitalized patients and limits the generalizability of the findings. Medical records contained missing data, weakening some estimates. The lack of detailed exposure measurements (quantity and duration of smoking and alcohol use) reduced the precision of risk-behavior analyses. Finally, the low frequency of certain events (e.g., left bundle branch block) decreased statistical power to detect differences. These limitations underscore the need for prospective, multicenter studies with standardized data collection and granular documentation of exposures.

7. Conclusion

Among the 397 patients hospitalized for heart failure at Central Hospital of Yaoundé, sex differences chiefly involved risk behaviors (higher smoking and alcohol use in men) and a higher frequency of right atrial dilation on Doppler transthoracic echocardiography in women; aside from these elements, electrocardiographic and echocardiographic profiles—including left ventricular ejection fraction—were broadly similar between sexes. These findings support strategies prioritizing prevention of modifiable behaviors, careful right-heart assessment, and the implementation of prospective multicenter studies to confirm and deepen these observations.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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