Prevalence of Prolonged QRS Duration and Associated Factors among Heart Failure Patients in a Tertiary Healthcare Facility in Bayelsa State

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Abstract

Background: *Prolonged QRS duration, low ejection fraction and low NYHA class are all independent poor prognostic indices in patients with heart failure. We assessed the prevalence of prolonged QRS duration and it's relationship with ejection fraction and NYHA class, among patients with heart failure at Niger Delta University Teaching Hospital, Okolobiri, Nigeria.*

Methods: *Eighty three patients diagnosed with heart failure were recruited consecutively. NYHA class was determined at presentation. Electrocardiography and echocardiography were done to determine the QRS duration and ejection fraction respectively.*

Results: *The prevalence of prolonged QRS was 33.7%. Most of the participants had QRS duration less than 120ms (66.3%), were classified as NYHA class 4 (48.2%) and had a diagnosis of hypertensive heart disease (57.8%). Sixty two patients (74.7%) had ejection fraction <45%. Ejection fraction showed a statistically significant relationship with prolonged QRS duration (X^2 = 10.55; p – 0.001). Other factors such as age, sex, NYHA classification, BMI and blood pressure were not significantly related to prolonged QRS duration in this population.*

Conclusion: *Over a third of patients in heart failure had QRS prolongation and there was a significant relationship between prolonged QRS duration and systolic dysfunction. Given these findings, appropriate screening of patients with heart failure is suggested to detect QRS prolongation and other ECG abnormalities, in order to adequately intervene and reduce risks of cardiovascular mortality.*

KEYWORDS: Heart failure, QRS duration, Ejection fraction, NYHA class, Relationship

Introduction

Heart failure (HF) is a final common pathway for diseases of diverse aetiologies.[1] HF is a global pandemic and affects about 26 million people worldwide with reported increasing prevalence.[2] In the developing world, there is a dearth of information on the overall prevalence, or risk of developing HF because of lack of population–based studies.[3] At least 9.4–42.5% of all medical admissions in Africa are attributable to heart failure.[4]A routine 12-lead ECG is recommended in HF patients to assess cardiac rhythm, determine the presence of a previous myocardial infarct (i.e. presence or absence of Q waves), left ventricular hypertrophy and also to determine the QRS duration so as to ascertain if the patient would benefit from resynchronization therapy.[5] A QRS complex on an ECG strip represents ventricular depolarization. Several studies looking at the QRS duration inpatients with HF have found that a widened QRSindicates a worse prognosis.[6-9]Approximately 20% of the general heart failure population may have a prolonged QRS duration within the first year of diagnosis. This suggests that up to one-fifth of patients with heart failure may be candidates for biventricular pacing.[10] Low ejection fraction and worse NYHA class are poor prognostic indices in patients with heart failure. A previous study had shown that a linear relationship between increased QRS duration and decreased ejection fraction ($p < 0.01$) and systolic dysfunction was associated with graded increases in mortality across ascending levels of QRS prolongation.[10]

QRS prolongation is an important marker for prognosticating patients in heart failure.[11,12] Intervention with cardiac resynchronization therapy (CRT) could reduce risk of cardiac deaths in patients in chronic systolic heart failure with a wide QRS complex.[13] Studies on QRS duration in heart failure patients are scarce in our environment and cardiac resynchronization therapy is hardly recommended or instituted in treatment of heart failure. This study, therefore, sought to determine the prevalence of prolonged QRS duration and its associated factors among patients with heart failure attending medical outpatient clinic/emergency roomof the Niger Delta University Teaching Hospital, Okolobiri, Bayelsa state.

Materials and Methods

The study was conducted in the medical outpatient clinic/emergency roomof the Niger Delta University Teaching Hospital, Okolobiri in Bayelsa State, a tertiary center located in the south-south geopolitical zone of Nigeria.

Eighty three adult Nigerians, above 18years of age, presenting to the medical outpatient clinic /emergency roomwith HF were recruited consecutively. The inclusion criteria included adult Nigerians aged 18years and above with symptomatic heart failure, who gave informed consent to participate in the study. The exclusion criteria included those who refused to participate in the study. This was a cross-sectional descriptive study.

A questionnaire developed by the authors was used for data collection from each study participant. Section 1 of the study questionnaire explored sociodemographic data which included age, marital status, educational level, religion, occupation and ethnicity of the study participants. Section 2 investigated symptoms of congestive heart failure, precipitating factors, underlying causes such as being a known hypertensive and/or diabetic, previous diagnosis of valvular heart disease, congenital heart disease, coronary artery disease, renal

disease or any other chronic medical conditions such as chronic liver or respiratory disease. Physical examination, clinical findings and investigation results were recorded in Section 3 of the study instrument (see study procedure).

The minimum sample size of patients required for the study was calculated from the method of Kish[14]

Sample size for studying proportions with population <10, 000[14]

$$nf = \frac{n}{1 + \frac{n}{N}}$$

nf= the desired sample size when population is less than 10,000

N = the estimate of the population size (this is estimated to be 200 heart failure patients which is the average population seen annually in the medical outpatient/emergency room)

$$n = \frac{z^2pq}{d^2}$$

Where z = the standard normal deviate (using 95% confidence level = 1.96)

p = the proportion in the target population estimated to have a particular characteristic (20% of the generalized general heart failure population may have a prolonged QRS duration, therefore, midpoint = 10%)

q = 1.0 – p

d = degree of accuracy desired, set at 0.05

therefore,

$$n = \frac{(1.96)^2 \text{ X } 0.26 \text{ X } 0.74}{(0.05)^2} = 138.3$$

$$\text{Hence, nf} = \frac{138.3}{1+138.3/200} = 81$$

Eighty nine patients with symptomatic heart failure (NYHA II to IV) with ages ≥18years were recruited consecutively based on clinical and echo diagnosis.

The questionnaire was interviewer administered after each participant gave an informed consent to participate in the study. Sociodemographic data and history of heart failure was explored by trained Research Assistants. Physical measurement and laboratory investigations were conducted using standard protocols. Height was measured in metres (m) using a height–o–meter with the subject standing feet together, without shoes, back and heel against a vertical ruled bar to which a movable horizontal bar was attached. During measurement, the horizontal bar was brought to the vertex of the participants head and the reading at this level was taken to the nearest millimeter. Weight was measured in kilograms (kg) using a bathroom scale with the participant wearing only light clothing. It was standardized against a fixed weight at every ten readings. Body mass index (BMI) was calculated as weight in kg divided by the square of the height in metres (kg/m^2). Obesity was defined as a BMI of ≥30 kg/m^2 using the WHO categorization [15] while BMI of <18.5, 18.5–24.9, and 25–29.9 kg/m2 were characterized as underweight, normal, and overweight, respectively. [15]

Blood pressure was measured on admission using Accoson mercury sphygmomanometer to determine the brachial artery systolic and diastolic blood pressures at Korotkoff 1 and 5 respectively in sitting position after 30 minutes rest, with the arm at heart level and readings taken ~~at~~ to the nearest 2mmHg.[16]

Chest radiograph (postero-anterior view) was done to assess the cardiac silhouettes, aorta and the lung fields. A conventional resting 12–lead electrocardiography was performed with Cardiofax ECG – 9620

model machines. Lead II was recorded for a long rhythm strip. The recommendation of the American Heart Association (AHA)[17] concerning standardization of leads and specification for instrument was followed. The QRS duration was noted and a prolonged duration was identified as ≥120ms because has been defined as a critical cut-off value by previous studies.[6,18]

Two-dimensional (2–D), motion mode (M–mode) and Doppler study were performed with transthoracic echocardiography using Siemens Sonoline G60S Ultrasound Imaging System with P4–2 transducer. Measurements were in accordance with the recommendations of the American Society of Echocardiography[19] with leading edge to leading edge recordings taken. Calculations were made using the internal analysis software of the echocardiographic device. The 2–D views were used for real time morphological characteristics and also as a reference for the selection of the M–mode beam. The echo views utilized for the study included: parasternal long axis view and apical 4-chamber view. These views and measurements were used to examine pericardial morphology, pericardial cavity, wall dimensions, aortic dimensions, wall motion abnormalities, valve morphology and dimensions, chamber dimensions and appearance as well as systolic function. Left ventricular ejection fraction was calculated from LV dimensions measured with M-mode as follows: $(LVEDD^2–LVESD^2)/LVEDD^2$.
Diagnosis of HF was made using the Framingham citeria.[20] The New York Heart Association (NYHA) class was also determined on admission.[21]

Data generated from data collection was directly entered into IBM SPSS 22.0 version which was also used for the analysis. Demographic characteristics and anthropometric measures were identified and presented as frequencies and percentages. Ejection fraction < 45% was categorized as systolic dysfunction. QRS > 120ms was classified as prolonged QRS. Prevalence of prolonged QRS was determined among participants in relation to gender, age, left ventricular ejection fraction. With a Chi-square test, relationship between QRS duration and gender, age, BMI, hypertension ejection fraction and NYHA classification was also determined. Multivariate logistic regression analysis was carried out to identify predictor variables of prolonged QRS duration in the study population. Level of significance was set at p value <0.05.

All participants provided written informed consent and the study was approved by the Ethics and Research Committee of the Niger Delta University Teaching Hospital (NDUTH), Okolobiri, Bayelsa State in line with the Helsinki Declaration of 1975 that was revised in 2000.

Results

Table 1 showed that out of the 83 participants in the study, about half were men (56.6%),65 years and older 49.4%) and had normal body mass index (50.6%). The mean age ± standard deviation of participants was 61.33 ± 12.60.

Table 1: Age, Body Mass Index and Sex distribution among Study Population

Characteristics	Frequency (N = 83)	Percent (%)
Age group		
< 45 years	9	10.8
45 – 64 years	33	39.8
≥ 65 years	41	49.4
Body Mass Index		
Underweight	6	7.2
Normal weight	42	50.6
Overweight	22	26.5
Obesity	13	15.7
Sex		
Female	36	43.4
Male	47	56.6

The prevalence of prolonged QRS among the study participants was 33.7% (Table 2). Table 2 also showed that most of the participants had QRS duration less than 120ms (66.3%), were classified as NYHA Class 4 (48.2%) and had a diagnosis of hypertensive heart disease (57.8%).

Table 2: Prevalence of Aetiology of Heart Failure, NYHA Classification, Prolonged QRS duration and QRS Duration Categories among Study Population

Characteristics	Frequency (N = 83)	Percent (%)
Aetiology		
Systemic hypertension	48	57.8
Dilated Cardiomyopathy	26	31.3
Ischaemic heart disease	5	6.0
Rheumatic heart disease	4	4.8
NYHA Classification		
2	15	18.1
3	28	33.7
4	40	48.2
Prevalence of Prolonged QRS duration		
Normal QRS duration	55	66.3
Prolonged QRS duration	28	33.7
QRS Duration (ms)		
< 120	55	66.3
120 – 129	3	3.6
130 – 139	13	15.7
140 – 149	4	4.8
150 – 159	2	2.4
> 160	6	7.2

ms – Milliseconds, NYHA – New York Heart Association

As presented in Table 3, the Chi-square test of proportion showed that sex, age and NYHA classification of participants did not show significant association with prolonged QRS duration ($p > 0.05$), only ejection fraction showed a statistically significant relationship with prolonged QRS duration ($X^2 = 10.43$; p – 0.001).

Table 3: Association between QRS prolongation and demographics, clinical characteristics and heart failure –related indices

Characteristics	QRS Duration		
	Total N = 83 (%)	< 120 N = 55 (%)	Prolonged QRS N = 28 (%)
Sex			
Female	36 (43.4)	24 (43.6)	12 (42.9)
Male	47 (56.6)	31 (56.4)	16 (57.1)
		$X^2 = 0.005$;	p – 0.946
Age group			
< 45 years	9 (10.8)	8 (14.5)	1 (3.6)
45 – 64 years	33 (39.8)	21 (38.2)	12 (42.9)
≥ 65 years	41 (49.4)	26 (47.3)	15 (53.5)
		Fisher's= 2.31	p – 0.362
Ejection fraction			
Systolic Dysfunction	62 (74.7)	35 (63.6)	27 (96.4)
Diastolic dysfunction	21 (25.3)	20 (36.4)	1 (3.6)
		Fisher's = 10.43;p – 0.001	
NYHA			
2	15 (18.1)	11 (20.0)	4 (14.3)
3	28 (33.7)	19 (34.5)	9 (32.1)
4	40 (48.2)	25 (45.5)	15 (53.6)
		Fisher's = 0.62; p – 0.825	
Body mass index			
Underweight	6 (7.2)	4 (7.3)	2 (7.1)
Normal weight	42 (50.6)	29 (52.7)	13 (46.4)
Overweight	22 (26.5)	13 (23.6)	9 (32.1)
Obesity	13 (15.7)	9 (16.4)	4 (14.3)
		Fisher's = 0.70;	p – 0.918
Systolic Blood Pressure			
Normal Systolic BP	43 (51.8)	27 (49.1)	16 (57.1)
Systolic Hypertension	40 (48.2))	28 (50.9)	12 (42.9)
		$X^2 = 0.48$;	p – 0.488
Diastolic Blood Pressure			
Normal Diastolic BP	36 (43.4)	22 (40.0)	14 (50.0)
Diastolic Hypertension	47 (56.6)	33 (60.0)	14 (50.0)
		$X^2 = 0.76$;	p – 0.385
Hypertension			
Absent	32 (38.6)	19 (34.5)	13 (46.4)
Present	51 (61.4)	36 (65.5)	15 (53.6)
		$X^2 = 1.11$;	p– 0.293

BP – Blood pressure, NYHA – New York Heart Association

However, in the multivariate regression analysis (table 4), participants aged 65 years and above showed an increased likelihood of developing prolonged QRS duration (OR – 11.08; p – 0.040) compared with younger ages.

Table 4: Predictors of prolonged QRS duration among the participants'

Characteristics (Reference group)	B Coefficient	OR	95%CI		p-Value
			Min	Max	
Age group (< 45 years)					
45 – 64 years	1.97	7.15	0.74	69.25	0.090
≥ 65 years	2.41	11.08	1.12	109.45	0.040*
Systolic	3.19	24.21	2.76	212.62	0.004*
Hypertension (Hypertensive Patient)					
No hypertension	0.87	2.38	0.79	7.16	0.122
NYHA Class (Class 4)					
Class 2	-0.14	0.87	0.17	4.34	0.861
Class 3	0.01	1.01	0.29	3.53	0.987
Pulse rate	-0.03	0.99	0.97	1.03	0.829
Sex (Male)					
Female	0.02	1.02	0.33	3.11	0.975
Constant	-5.41	0.04			0.004

NYHA – New York Heart Association
*Significant statistically
Also, participants with systolic dysfunction demonstrated an increased odd of prolonged QRS duration compared with those with diastolic dysfunction.

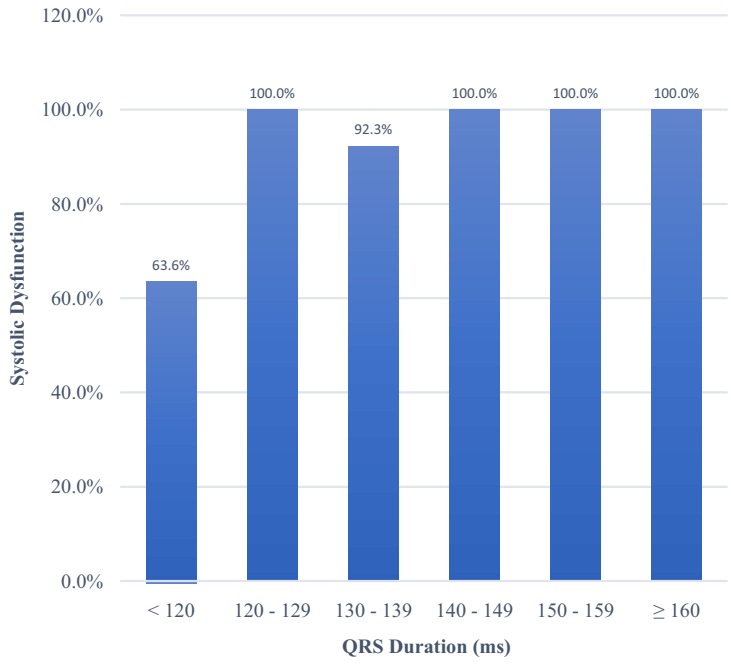

Figure 1: ~~Prevalence~~ Frequency of Systolic dysfunction in relation to the QRS duration of participants.

All participants who had QRS duration from 120 to 129ms; 140 to 149ms and greater than 150ms had systolic dysfunction (Figure 1).

Discussion

The prevalence of prolonged QRS in heart failure patients in this study was 33.7%. Prevalence rates of 14 to 47% have been previously reported in heart failure patients.[22,23] Heart failure patients with QRS prolongation have higher all-cause mortality and a higher incidence of sudden death, with increasing risk as the QRS duration increases.[24]

All participants in the study who had QRS duration from 120 to 129ms; 140 to 149ms and greater than 150ms had systolic dysfunction. QRS prolongation has been shown to be a significant predictor of left ventricular systolic dysfunction in patients with heart failure [25]and is a risk factor for death in both heart failure with reduced ejection fraction and preserved ejection fraction.[26] A QRS duration of > 90msec has been shown to be predictive of significant underlying CAD and a lower LVEF in patients with NSTEMI.[27] NYHA class in th~~is~~ study did not show significant association with QRS duration, similar findings have previously been demonstrated and showed QRS as an independent risk factor contributing to the adverse prognosis in HF presumably through the induction of ventricular dyssynchrony. [22] However, in a longitudinal study on the clinical characteristics and survival of patients with chronic heart failure and prolonged QRS duration, a moderate prolongation of QRS duration (120–149 ms) was associated with worse NYHA class [24] and in another study involving patients in heart failure, patients in NYHA 3 with an increased QRS duration had a greater occurrence of cardiac mortality.[28]

The most common cause of heart failure in our study was hypertension (57.8%). Hypertension is a leading cause of heart failure[29] and accounts for over 50% of cases in Nigeria,[29] similar to other sub-Saharan African countries.[30] Hypertension tends to be more prevalent, has an earlier onset in life, and runs a more severe course, with a greater degree of target-organ damage in blacks compared to Caucasians.[31] Blacks also have a greater burden of hypertension-related diseases— heart failure, stroke, coronary heart disease and renal dysfunction than whites. [31] Majority of patients presented with severe symptoms (NYHA class 4). Unfortunately, most patients in heart failure tend to present to the hospital for treatment when moderately or severely symptomatic according to several local studies.[29]

The sample size for this study was small and this may have impacted on some of the findings in this study. It is therefore recommended that further studies on a larger population in our locality be done in order to be able to draw more precise conclusions. Nevertheless, this study serves as a reference for this local population and provides a guide for future studies.

Conclusion

Over a third of patients in heart failure had QRS prolongation and there was a significant relationship between prolonged QRS duration and systolic dysfunction. Given these findings, appropriate screening of patients with heart failure is suggested to detect QRS and other ECG abnormalities, in order to adequately intervene and reduce risks of cardiovascular mortality.

Data sharing statement

The datasets analyzed during the current

study are available from the corresponding author on reasonable request.

Authors' contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

Figure Legend

Figure 1: Prevalence of Systolic dysfunction in relation to the QRS duration of participants

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