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ORIGINAL RESEARCH

Determinants of Spatial Dispersion of P-Wave, QRS Complex, and QT-Interval on 12-Lead Electrocardiogram in Apparently Healthy Adults

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Abstract

Background: The spatial dispersion of P-wave, QRS complex, and QT interval on 12-lead electrocardiogram are related to the electrical instability in cardiac conducting tissues and elevated parameters are associated with increased risk of cardiovascular morbidity and mortality.

Objectives: We sought to evaluate the dispersion of P-wave, QRS complex, and QT interval in healthy adult Nigerians and assess their relationship to age, gender, anthropometric and some physiologic parameters.

Methods: A total of 128 subjects were recruited for the study. The participants consist of two groups; a young age group of 62 apparently healthy individuals (aged 18-35 years) and an elderly age group of 66 participants (aged 60-89 years) drawn from attendees to the quarterly medical lectures of the Ebreime Foundation for the Elderly, a non-Governmental organization. The exclusion criteria for the study were presence of acute or chronic illnesses and medications capable of affecting electrocardiogram. All subjects had background medical history assessment, clinical examination and resting 12-lead electrocardiography. The dispersion of P-wave, QRS and QT intervals were measured manually under magnifying glass by one observer and were taken as the difference between the maximum and minimum values of each parameter on standard 12-lead electrocardiogram.

Results: The elderly subjects had significantly higher body mass index compared to the young subjects. Blood pressure indices were comparable in the two groups. The dispersions of P-wave, QRS and QT on 12-lead electrocardiography were all significantly increased in the elderly. Significant gender variations were noted in QRS dispersion, QTc interval and QT dispersion which were all significantly increased in women. A significant correlation was noted between QT dispersion and body mass index ($r = 0.280$; $p = 0.023$).

Conclusion: Age, gender and body mass index are significant determinants of P-wave, QRS, and QT dispersion in the adult population. Identification of high risk individuals for cardiovascular disease for prompt preventive intervention is of prime importance.

Keywords

Determinants, Spatial, Dispersions, Electrocardiogram, Healthy, Adults

Introduction

Heterogeneity in cardiac depolarization and repolarization on 12-lead electrocardiogram (ECG) has been identified as an important risk factor for lethal cardiac arrhythmias [1,2]. The spatial dispersion of P-wave, QRS complex, and QTc interval on 12-lead electrocardiogram are related to the electrical instability in cardiac conducting tissues and elevated parameters are associated with increased risk of cardiovascular morbidity and mortality [1-5]. Elucidation of impacts of various

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clinical variables on ECG dispersions has been subject of research interest largely because of their non-invasive and potentially useful clinical applications.

Objective

We sought to evaluate the dispersions of P-wave, QRS complex, and QTc interval in healthy adult Nigerian subjects and assess their relationship to age, gender, anthropometric and some physiologic parameters.

Methods

A total of 128 subjects were recruited for the study. The participants consist of two groups; a young age group of 62 persons (aged 18-35) and an elderly group (66 in number aged 60-89). The young volunteers were made of students, hospital workers as well as members of the local community. The elderly participants were drawn from attendees to the quarterly medical lectures of the Ebreime Foundation for the Elderly, a non-Governmental Organization. The exclusion criteria for the study were presence of acute illness or history/documentation of chronic illnesses and medications capable of affecting electrocardiogram such as hypertension, diabetes, significant alcohol intake, use of tobacco, drug abuse. Individuals who were on treatment with drugs capable of affecting ventricular depolarization and repolarization were excluded. The study was conducted in the medical outpatient clinics of Federal Medical Center, Asaba, Delta State, Nigeria. The study was approved by the ethical committees of Federal Medical Center, Asaba, Nigeria Informed consent was obtained from all the participants. All subjects had background medical history assessment with the aid of a questionnaire and then clinically examined to evaluate their cardiovascular status at rest. Resting 12-lead electrocardiography were performed on all subjects using Schiller electrocardiography machine at a paper speed of 25 mm/s and standardized at 0.1 mv/mm. A single observer analyzed the electrocardiogram. Measurements of the heart rate, cardiac axis, PR- interval, QRS duration and QTc interval were done in the standard fashion [6]. Heart rate correction of the QT-interval was performed using Bazett's formula (QTc = QT/√RR) [7]. The dispersion of p-wave, QRS and QTc intervals were measured manually under magnifying glass by one observer and were taken as the difference between the maximum and minimum values of each parameter on standard 12-lead electrocardiogram [1,2,5]. Randomly selected electrocardiograms were cross checked for accuracy and quality control independently by two cardiologists.

Data Analysis

Descriptive statistics for baseline data were presented as both means and standard deviations for continuous variables or percentages for discrete variables. Differences of the means between groups were compared with the independent Student's T-test.

For discrete variables, distributions between groups were compared with chi-square test and Fishers exact test as appropriate. Multivariate Pearson's correlation coefficient analysis was used to evaluate relationship between ECG dispersions (P wave, dispersion, QRS and QTc dispersion) and clinical parameters.

All statistical analyses were conducted using the statistical packages for social sciences (SPSS Inc. Chicago Illinois) software version 22.0. Statistical tests at 95% confidence interval with probability values less than 0.05 were considered statistically significant.

Intra-observer variability of manual ECG measurements was quantified by blinded and randomly sorted repeat measurements of 30 tracings a month after the original measurements were made. There was no statistically significant intra-observer variability.

Results

The anthropometric and blood pressure indices of the participants are compared in Table 1 and Table 2. The elderly subjects had significantly higher body mass index (BMI) compared to the young subjects. Blood pressure indices were comparable in the two groups.

Table 1: Age, gender and anthropometry.

Parameters	Young Mean (SD)	Elderly Mean(SD)	T-Test	P-Value
Age (years)	28.37 (5.91)	68.68 (7.92)	32.471	< 0.0001*
Gender {frequency (%)}				
Male	31 (50)	46	4.386	0.362[a]
Female	31 (50)	20		
Total	62	66		
Weight (kg)	67.35 (8.37)	66.50 (11.40)	0.478	0.6333
Height (m)	1.72 (0.07)	1.62 (0.13)	5.369	< 0.0001*
Body mass index (Kg/m²)	23.87 (3.22)	25.38 (4.31)	2.234	0.0272*

*: Statistically significant

[a]: Chi-square

Table 2: Blood pressure indices in the elderly and young.

Parameters	Elderly Mean (SD)	Young Mean (SD)	T-Test	P-Value
Pulse rate (beat/min)	67.76 (13.74)	72.13 (6.79)	2.258	0.0256*
Brachial systolic BP (mmHg)	125.02 (17.27)	121.2 (8.97)	1.521	0.131
Brachial diastolic BP (mmHg)	78.88 (11.07)	76.88 (6.18)	1.264	0.2087
Brachial pulse pressure (mmHg)	46.14 (12.27)	44.31 (10.91)	0.890	0.3754
Mean brachial arterial BP (mmHg)	94.26 (12.16)	91.71 (5.47)	1.513	0.1327

*: Statistically significant

Table 3: Comparison of electrocardiographic characteristics of the elderly and controls.

Variables	Values (Mean SD)		T- Test	P- Value
	Elderly	Young		
Heart rate (beat/min)	67.76 (13.74)	68.98 (4.24)	6.327	< 0.001*
P-wave duration (msec)	117.42 (14.48)	90.30 (14.84)	10.463	< 0.0001*
P-wave dispersion (msec)	58.18 (22.94)	34.7 (17.41)	6.488	< 0.0001*
PR-interval (msec)	175.53 (26.70)	161.3 (27.13)	2.990	< 0.0001*
QRS duration (msec)	84.08 (15.19)	81.5 (15.82)	0.941	0.3484
QRS dispersion (msec)	45.45 (18.02)	33.3 (14.57)	4.325	< 0.0001*
QTc-interval (msec)	411.91 (31.13)	393.5 (21.46)	3.872	< 0.0002*
QTc-dispersion	66.64 (11.61)	47.8 (21.23)	6.280	< 0.0001*

*: Statistically significant

Table 4: Gender variation in ECG parameters.

Variables	Values (Mean SD)		T- Test	P- Value
	Male	Female		
Heart rate (beat/min)	67.07 (15.27)	69.35 (9.48)	0.739	0.463
P-wave duration (msec)	117.22 (15.26)	117.90 (12.86)	0.175	0.862
P-wave dispersion (msec)	58.13 (3.74)	58.30 (4.96)	0.027	0.978
PR-interval (msec)	176.80 (29.91)	172.60 (17.51)	0.585	0.561
QRS duration (msec)	86.43 (10.77)	78.65 (8.88)	2.835	0.0061*
QRS dispersion (msec)	44.78 (2.73)	47.00 (3.42)	2.802	0.0067*
QT-interval (msec)	391.41 (44.65)	389.20 (23.93)	.208	0.836
QTc-interval (msec)	408.65 (15.18)	419.40 (14.81)	2.680	0.0099*
QTc- dispersion	52.57 (2.95)	63.00 (5.85)	9.652	< 0.0001*

*: Statistically significant

However, the younger participants had higher pulse rate (Table 2). The dispersions of P-wave, QRS and QT on 12-lead electrocardiography were all significantly increased in the elderly, (Table 3). Significant gender variations were noted in QRS dispersion, QTc and QT dispersion measurement which were all significantly increased in women than men (Table 4). A significant correlation was noted between QT dispersion and BMI (r = 280; p = 0.023).

The distributions of minimum and maximum P-waves, QRS and QT in 12-lead electrocardiogram in the elderly are shown in Table 5.

Maximum values of P-wave were mainly located in Lead II (63.64%), while minimum values were mainly found in the right precordial Leads V1 and V2 in 37.28% and 19.79% of the participants respectively. For QRS duration, maximum values occurred in the frontal Leads 1, II, III, while minimum parameters occurred in Leads I (19.715) and AVR (36.36%). Maximum QT were mainly located in Leads I, II, III and V2, while minimum values were observed in leads I (22.73%) and V1 (16.67%).

Discussion

Increased dispersion of durations of the P wave, QRS complex, and QT-interval has been associated with the risk of atrial fibrillation, ventricular arrhythmias, sudden cardiac death, as well as with a general negative prognosis in various settings [1-4].

Our study revealed increase in these non-invasive

Table 5: The distributions of minimum and maximum P-waves, QRS and QT in 12-lead electrocardiogram in the elderly.

Lead	Frequency (%)					
	P-Wave Max	P-Wave Min	QRS Max	QRS Min	QT Max	QT Min
V1	0 (0)	25 (37.88)	4 (6.06)	3 (4.55)	1 (1.52)	15 (22.73)
V2	0 (0)	13 (19.70)	9 (13.64)	1 (1.52)	8 (12.12)	3 (4.55)
V3	0 (0)	2 (3.03)	6 (9.09)	0 (0)	3 (4.55)	0 (0)
V4	1 (1.52)	0 (0)	1 (1.52)	2 (3.03)	3 (4.55)	4 (6.06)
V5	0 (0)	2 (3.02)	2 (3.03)	2 (3.03)	4 (6.06)	3 (4.55)
V6	2 (3.03)	1 (1.52)	3 (4.55)	4 (6.06)	5 (7.58)	1 (1.52)
I	0 (0)	8 (12.12)	3 (4.55)	13 (19.70)	9 (12.64)	11 (16.67)
II	42 (63.64)	0 (0)	7 (10.61)	2 (3.03)	12 (18.18)	4 (6.06)
III	1 (1.52)	2 (3.03)	11 (16.67)	2 (3.03)	11 (16.67)	3 (4.55)
aVF	4 (6.06)	3 (4.55)	5 (7.58)	1 (1.52)	6 (9.09)	3 (4.55)
aVR	7 (10.61)	1 (1.52)	1 (1.52)	24 (36.36)	3 (4.55)	5 (7.58)
aVL	0 (0)	0 (0)	5 (7.58)	3 (4.55)	1 (1.52)	4 (6.06)

electrocardiographic markers in the elderly subjects. Similar impact of aging on these parameters has been reported [8,9].

The increased P-wave dispersion in the elderly may be related to the dilatation of the atria and associated altered cardiac pre-load and after-load characteristics predisposing to atrial fibrillation [10,11]. The value of increased P-wave duration and P-wave dispersion as independent predictors of atrial arrhythmias has been confirmed in several studies [10,11]. The mean value for P-wave dispersion (PWD) in the elderly participants in our study is 58.18 ± 22.94 milliseconds. This is significantly higher than the normal value of PWD of 29 ± 9 ms [10,11]. PWD values ≥ 40 ms has been shown to indicate the presence of heterogeneous electrical activity in different regions of the atrium that might cause atrial tachyarrhythmias [10].

The mean QRS dispersion (QRSd) in our elderly participants was 44.78 ± 2.73 and 47.00 ± 13.42 milliseconds in males and females respectively. A cut-off value of 46 milliseconds for QRSd has been used to identify chronic heart failure patients with high risk of death in three years [2,12].

In studies of patient with chronic heart failure, myocardial infarction and arrhythmogenic cardiomyopathy, the cut-off value of 40 milliseconds for QRSd separated the patients in two groups with significant structural differences on cardiac imaging [13,14].

Increased QT-dispersion was noted in our elderly subjects with mean QT dispersion of 52.57 ± 2.95 and 63.00 ± 5.85 milliseconds in males and females respectively. Literature reviews found the QT dispersion to vary mostly between 30 and 60 ms in normal subjects [15,16]. Age-related differences were reported to be statistically significant in some studies [17,18].

Previous studies showed that women have longer QT dispersion values than men [19,20]. This gender-related difference is probably due to sex hormone mediated prolongation of the duration of ventricular repolarisation in women and is manifests only after puberty [21-23].

Several large prospective studies have assessed the predictive value of QT dispersion for cardiac and all-cause mortality in the general population. Data from these studies have consistently validated the significant independent prognostic value of QT-dispersion in a wide range of clinical settings [24,25]. Body mass index is the only anthropometric variable found to determine the variability of cardiac repolarization and depolarization. Our observation is similar to those of Mangoni AA, et al. [9] and Hanci V, et al. [26] who independently reported significant correlation between QT dispersion and body mass index. This relationship may be due to increase in cardiac output in subjects with higher body mass index and subsequent development of subclinical cardiac hypertrophy [27].

Classification and quantification of the regional information on ECG dispersion indices in the 12-lead ECG remains a challenge. This study observed maximum values for P-wave, QRS, QT in the frontal leads I, II, and III in the elderly. It is difficult to explain the significance and implications of this finding. Previous studies have demonstrated that the duration and dispersion of the QRS were higher in the ECG leads showing acute ischaemias, suggesting that that the odds of ventricular arrhythmias during the occurrence of an acute myocardial infarction are much higher when the duration and dispersion of the QRS are higher [28,29].

Kors, et al. [30] found that QT dispersion was significantly different between patients with narrow (54.2 ± 27.1 ms) and wide T loops (69.5 ± 33.5 ms, $p < 0.001$). They also showed that in each of the six limbs as well as the six precordial leads, the difference between the QT interval in a lead and the maximum QT interval was dependent on the angle between the axis of the lead and the axis of the terminal part of the T loop. Regions of shortest QT intervals always coincided with the location of the isoelectric zero potential line [31]. These studies have shown that the interlead differences of the QT intervals are a reflection of the morphology of the T wave loop.

Conclusion

Age, gender and body mass index are significant determinants of P-wave, QRS, and QTc dispersion in the adult population. Identification of high risk individuals for cardiovascular disease for prompt preventive intervention is of prime importance.

Conflict of Interest

The authors have no potential conflict of interests.

Declarations of Interest

None.

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