Prevalence and Prognostic Features of ECG Abnormalities in Acute Stroke

Findings From the SIREN Study Among Africans

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ABSTRACT

Background: Africa has a growing burden of stroke with associated high morbidity and a 3-year fatality rate of 84%. Cardiac disease contributes to stroke occurrence and outcomes, but the precise relationship of abnormalities as noted on a cheap and widely available test, the electrocardiogram (ECG), and acute stroke outcomes have not been previously characterized in Africans.

Objectives: The study assessed the prevalence and prognoses of various ECG abnormalities among African acute stroke patients encountered in a multisite, cross-national epidemiologic study.

Methods: We included 890 patients from Nigeria and Ghana with acute stroke who had 12-lead ECG recording within first 24 h of admission and stroke classified based on brain computed tomography scan or magnetic resonance imaging. Stroke severity at baseline was assessed using the Stroke Levity Scale (SLS), whereas 1-month outcome was assessed using the modified Rankin Scale (mRS).

Results: Patients' mean age was 58.4 ± 13.4 years, 490 were men (55%) and 400 were women (45%), 65.5% had ischemic stroke, and 85.4% had at least 1 ECG abnormality. Women were significantly more likely to have atrial fibrillation, or left ventricular hypertrophy with or without strain pattern. Compared to ischemic stroke patients, hemorrhagic stroke patients were less likely to have atrial fibrillation (1.0% vs. 6.7%; p = 0.002), but more likely to have left ventricular hypertrophy (64.4% vs. 51.4%; p = 0.004). Odds of severe disability or death at 1 month were higher with severe stroke (AOR: 2.25; 95% confidence interval: 1.44 to 3.50), or atrial enlargement (AOR: 1.45; 95% confidence interval: 1.04 to 2.02).

Conclusions: About 4 in 5 acute stroke patients in this African cohort had evidence of a baseline ECG abnormality, but presence of any atrial enlargement was the only independent ECG predictor of death or disability.

Stroke is a common neurologic condition in all regions of the world. Of the 14.1 million people who died of cardiovascular diseases (CVD) in 2012 in the world, stroke accounted for 6.7 million deaths [1]. Many people who suffer acute stroke have underlying CVD such as hypertension, atrial fibrillation, and ischemic heart disease [2].

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These underlying CVD are associated with several pre-existing electrocardiographic (ECG) anomalies such as rhythm and conduction abnormalities, and left ventricular hypertrophy (LVH) with or without St-T wave changes.

However, several researchers have postulated the existence of a brain-heart axis whereby structural brain lesions by themselves result in electrocardiographic changes [3]. The precise mechanism that leads to the development of these ECG changes is still uncertain, though increasing evidence suggests that it is mainly due to autonomic nervous system dysregulation [3,4]. Whereas some authors attribute these ECG changes in acute stroke to underlying CVD, others have demonstrated their presence in acute stroke patients without underlying CVD [5,6].

Irrespective of pre-existing cardiac diseases or not, observing an abnormal ECG in an acute stroke patients more than doubled their mortality rate at 6 months [5] and these abnormal ECG changes have not been shown to be perfect predictive tool for stroke subtypes [6,7]. Although cardiac arrhythmia, such as atrial fibrillation, and LVH have been linked with the occurrence and prognosis of acute stroke, the prognostic value of repolarization changes commonly seen after stroke such as ST-segment depression as well as T-wave and U-wave abnormalities still remains unclear [8,9].

Despite the common occurrence of stroke in Africa, there is sparse data on the prevalence and prognostic significance of ECG abnormalities in acute stroke in the region. In addition, there is inadequate data on the contributions of cardiac arrhythmias, conduction abnormalities, LVH, QTc prolongation, and QRS prolongation on 1-month case fatality in acute stroke especially in the African context. Understanding these interactions will help develop interventions to reduce the morbidity and mortality associated with acute stroke.

We investigated the prevalence of specific baseline ECG abnormalities in Africans with acute stroke and their prognostic effect on severe disability or death at 1-month after stroke.

METHODS

Study design

Design of the SIREN (Stroke Investigative Research And Education Network) study has been described elsewhere [10]. It is a multicenter case-control study involving several sites in Nigeria and Ghana, which has been running since August 2014. Ethical approval was obtained from the institutional ethical committees of all study sites and written informed consent was obtained from all subjects.

Cases included consecutively consenting adults (18 years of age or older) with first clinical stroke within 8 days of current symptom onset, or "last seen without deficit" with cranial computer tomography or magnetic resonance imaging scan performed to confirm diagnosis within 10 days of symptom onset. We excluded those with stroke mimics, primary subarachnoid hemorrhage and previous strokes that were not radiologically ascertained. Stroke severity was assessed at baseline using the Stroke Levity Scale (SLS) [11]. One-month outcome was assessed using the modified Rankin scale (mRS) [11]. Other clinical and laboratory information were obtained according to the SIREN protocol [10].

Electrocardiography

A standard (resting) 12-lead ECG was performed in each subject using a commercially available ECG machine at 25 mm/s and 1 mV/cm calibration. All the 12-lead ECGs were obtained within 24 h after the onset of stroke. The ECG tracings were independently analyzed by the cardiologists who were unaware of the details of the clinical status of the patients. Abnormalities obtained from the ECGs were defined according to standard criteria as shown in Table 1 [12,13]. Left ventricular hypertrophy was diagnosed using the following criteria: Sokolow-Lyon voltage (sum of the amplitudes of S-wave in V1 and R-wave in V5 or V6 $\geq$3.5 mV), sex-specific Cornell voltage (sum of the amplitudes of S-wave in V3 and R-wave in aVL of 2.0 mV in women and of 2.8 mV in men). Cornell's product (CP) was calculated as the product of Cornell voltage times QRS duration. Repolarization abnormalities in leads V5 or V6 indicated typical strain when there was down-sloping convex ST segment with an inverted asymmetrical T-wave opposite to the QRS axis [14,15]. QT interval was determined using the tangent method [16]. The measured QT interval was corrected for heart rate using the Bazett's formula. Prolonged QT interval was considered present when the QTc was >450 ms and >440 ms in women and men, respectively. Presence of other St-T wave changes were documented according to standard criteria [12]. ECG definitions of criteria are in Table 1.

Data management and analysis

Quantitative variables were summarized using mean $\pm$ SD for normally distributed and median for asymmetric variables. Frequency and percentage was computed for categorical variables. To investigate the statistical significance of the difference in continuous variables according to sex and stroke type, independent samples Student t test was used. For categorical variables, the chi-square test for the comparison of proportions was used.

Total mRS scores of 0 to 3 and 4 to 6 were categorized as good and poor, respectively. Association among selected demographic, clinical characteristics, and ECG findings was investigated at bivariate and multivariate levels. For bivariate analysis, chi square test was used while binary logistic regression was used for multivariate. Criteria for inclusion of variables in the logistic regression model was a p value <0.05 in the bivariate or previous report in literature or basic demographic factors (age and sex). Goodness of fit was assessed using the Hosmer-Lemeshow test.

TABLE 1. Definitions of ECG variables

ECG Variables	Definitions
Rhythm	
Atrial fibrillation	Absent P waves and an irregular ventricular rate
Atrial flutter	Rate >100/min and saw tooth appearance of the P waves
Sinus rhythm	Regular P-wave with rate between 60 and 100/min
Sinus bradycardia	Regular P-wave with rate <60/min
Sinus tachycardia	Regular P-wave with rate >100 min
Sinus arrhythmia	Beat-to-beat variation in normal P-P interval
Atrial enlargement	
Right atrial enlargement	P-wave amplitude >2.5 mm in lead II and duration <120 ms
Left atrial enlargement	Bifid P-wave in lead II with duration >120 ms and amplitude less than >2.5 mm in lead II
Biatrial enlargement	P-wave amplitude >2.5 mm in lead II + Bifid P-wave with duration >120 ms in lead II
Indeterminate	None of above evidence of atrial enlargement
Presence of other arrhythmias	
Premature ventricular contraction	QRS interval >120 ms and bizarre QRS shapes
Supraventricular tachycardia	Evidences of sinus tachycardia, AVNRT complexes, atrial fibrillation, atrial flutter, multifocal atrial tachycardia, accelerated junctional tachycardia, atrial tachycardia
Ventricular tachycardia	Sustained (≥5 consecutive beats) or nonsustained tachycardia (<5 consecutive beats)
None	None of above other arrhythmias
Presence of conduction abnormalities	
First-degree AV block	PR duration >0.20 s with normal P and QRS waves
Second-degree AV block	Progressive PR interval prolongation (>200 ms) with intermittent failed P-wave conduction or wide QRS (greater than 120 ms) with dropped QRS complex no prior PR prolongation or evidence of advanced block
RBBB	Deep S-wave in leads I and V6 and tall late R-wave in V_I
LBBB	Tall R-wave in leads I and V_6 and deep S-wave in VI
Left anterior hemiblock	QRS interval <120 ms; left axis deviation; qR pattern in leads I and aVL; rS wave pattern in leads II, III, and aVF; and R-wave peak time in aVL
Left posterior hemiblock	QRS interval <120 ms; right axis deviation; qR pattern in leads I and aVL; rS pattern in leads II, III, and aVF; and R-wave peak time in aVL
Bifascicular block	RBBB with left anterior hemiblock
Trifascicular block	RBBB, left anterior hemiblock with primary AV block (or RBBB + left anterior hemiblock + left posterior hemiblock)
Complete AV block	Evidence of AV dissociation
Indeterminate intraventricular block	>110 ms with absence of RBBB and LBBB
None	None of the above conduction abnormalities
QT dispersion	
QTc interval	Prolonged, if duration is greater than >440 ms in men or >460 ms in women
LVH	
Cornell product criteria	(V3-S + aVL-R wave) × QRS duration >2,440 mms (men) (V3-S + aVL-R wave) × QRS duration >2,440 mms + 8 (women)
Sokolow-Lyon criteria	V1-S + RV-5 or RV 6 if addition ≥35 mm (whether male or female) there is LVH
Cornell voltage criteria	V3-S + aVL-R wave if addition ≥20 mm (women) or ≥28 mm (men) there is LVH

AV, atrioventricular; AVNRT, atrioventricular nodal re-entry tachycardia; ECG, electrocardiographic; LBBB, left bundle branch block; LVH, left ventricular hypertrophy; RBBB, right bundle branch block.

TABLE 2. Demographic and clinical characteristics according to sex

Variable	Total (N = 890)	Men (n = 490)	Women (n = 400)	p Value
Age, yrs	58.4 ± 13.4	57.6 ± 12.0	59.3 ± 14.9	0.057
Height, m	164.7 ± 7.8	167.7 ± 7.2	160.9 ± 6.8	<0.0001
Weight, kg	72.4 ± 14.3	72.7 ± 13.6	72.1 ± 15.1	0.678
Body mass index, kg/m^2	26.7 ± 5.3	25.7 ± 4.7	27.8 ± 5.7	<0.0001
Systolic blood pressure, mm Hg	162.3 ± 32.6	163.1 ± 31.3	161.2 ± 34.1	0.413
Diastolic blood pressure, mm Hg	97.2 ± 19.2	98.9 ± 19.5	95.1 ± 18.6	0.004
Heart rate	91.3 ± 27.4	89.3 ± 23.9	93.7 ± 30.8	0.042
Mean arterial pressure, mm Hg	97.4 ± 24.6	97.1 ± 23.6	97.8 ± 25.9	0.682
Pulse pressure, mm Hg	65.0 ± 22.4	64.1 ± 21.7	66.2 ± 23.3	0.205
Stroke type				
Ischemic	403 (65.5)	216 (63.3)	187 (68.3)	
Hemorrhagic	212 (35.5)	125 (36.7)	87 (31.8)	0.203

Values are mean ± SD or n (%).

RESULTS

The 12-lead ECGs of 890 subjects were analyzed. There were 490 men (55.1%) and 400 (44.9%) women. The overall mean age of all patients was 58.4 ± 13.4 years with women showing a nonstatistically significant trend toward being older (p = 0.057). Variables with statistically significant sex difference included body mass index, diastolic blood pressure, and heart rate. These are shown in Table 2. Men were less likely to have atrial fibrillation. The 4 cases of ventricular tachycardia occurred only in women. Women also had nonsignificant longer QT intervals and were more likely to have LVH diagnosed by Cornell voltage or product criteria. Atrial enlargement was significantly more common in men (Tables 3 and 4).

Tables 5 and 6 depict the comparison of demographic and clinical as well as ECG abnormalities according to stroke types. Subjects with hemorrhagic stroke were significantly younger (by about 7 years) than those with ischemic stroke. They also had higher blood pressures (systolic and diastolic blood pressure, mean arterial pressure, and pulse pressure). In terms of ECG abnormalities, atrial fibrillation was significantly more common in those with ischemic stroke, whereas LVH was significant in hemorrhagic stroke by any of the ECG-LVH criteria. LVH with strain, QTc duration, QRS duration, and axis were comparable across stroke types.

Table 6 shows the demographic and some clinical characteristics of the subjects according to 1-month disability status. The presence of sinus rhythm was associated with good mRS score. Severe SLS score and atrial enlargement on the 12-lead ECG was associated with poor mRS score.

In a multivariate logistic regression analysis (Table 7), only severe SLS score and presence of atrial enlargement were the independent predictors of 1-month outcome.

DISCUSSION

In this ongoing African stroke study, women with stroke appeared older than their male counterparts with higher frequencies of tachycardia, atrial fibrillation, and ventricular tachycardia. Men with stroke had higher mean diastolic blood pressure. ECG LVH was more common in

TABLE 3. ECG abnormalities according to sex

Variable	Total (N = 890)	Men (n = 490 [55.1])	Women (n = 400 [44.9])	p Value
Atrial fibrillation	36 (4.2)	12 (2.5)	24 (6.2)	0.009
Atrial flutter	4 (0.5)	2 (0.4)	2 (0.5)	0.846
Other arrhythmias	75 (8.9)	38 (8.2)	37 (9.6)	0.466
Conduction abnormality	106 (12.7)	55 (12.0)	51 (13.5)	0.539
Atrial enlargement	466 (55.1)	273 (59.1)	193 (50.4)	0.011
LVH*	397 (54.8)	192 (48.7)	205 (61.9)	<0.001
LVH with St-T wave changes	219 (25.5)	124 (26.2)	95 (24.7)	0.607
Prolonged QTc interval	235 (28.6)	138 (30.3)	97 (26.5)	0.228
Short QTc interval	49 (6.0)	26 (5.7)	23 (6.3)	0.732
Any ECG abnormality	708 (85.4)	381 (84.5)	327 (86.5)	0.410

Values are n (%).
ECG, electrocardiographic; LVH, left ventricular hypertrophy.
*Either Sokolow or Cornell voltage or product.

TABLE 4. Demographic and clinical characteristics according to stroke type

Variable	Total	Ischemic	Hemorrhagic	p Value
Age, yrs	58.3 ± 13.2	60.7 ± 13.1	53.7 ± 12.2	<0.001
Height, m	164.9 ± 7.8	165.1 ± 8.0	164.4 ± 7.4	0.405
Weight, kg	73.1 ± 14.2	73.2 ± 14.7	72.8 ± 13.1	0.795
Body mass index, kg/m^2	26.7 ± 5.3	26.7 ± 5.3	26.9 ± 5.2	0.768
Systolic blood pressure, mm Hg	161.0 ± 19.7	154.1 ± 30.3	173.6 ± 34.1	<0.001
Diastolic blood pressure, mm Hg	96.8 ± 19.7	92.6 ± 18.4	104.5 ± 19.8	<0.001
Heart rate	92.1 ± 28.7	90.6 ± 27.5	94.8 ± 30.6	0.118
Mean arterial pressure, mm Hg	96.5 ± 25.0	92.4 ± 23.2	103.9 ± 26.5	<0.001
Pulse pressure, mm Hg	64.2 ± 22.9	61.5 ± 21.5	69.1 ± 24.6	<0.001

Values are mean ± SD.

women and in those with hemorrhagic stroke. There was no significant difference in the occurrence of conduction abnormalities or QT abnormalities according to sex or stroke type [13,17]. The pathologic mechanism by which acute stroke generates various ECG abnormalities is still not clear. However, autonomic dysregulation due to sympathetic overactivity have been proposed. Some authors have implicated insular irritation to be responsible for the abnormal cardiac function in acute stroke [18-23]. This is thought to be mediated by impaired inhibition of the sympathetic nervous system leading to increased release of cathecholamines [20,23].

The management of patients with an acute stroke demands assessment of risk for morbidity and mortality, of which hypertension is major determinant. Studies have shown that elevated blood pressure in acute stroke is associated with poor prognosis [24]. Increased blood pressure increase the risk of bleeding in thrombolytic treatment [25] and increases the bleeding tendency in hemorrhagic stroke [26]. In our study, both systolic and diastolic blood pressures were elevated. The subjects with hemorrhagic stroke had higher mean blood pressure parameter compared with ischemic stroke. This is similar to the findings by Quresh et al. [26].

Although the studies on the pathophysiology of acute hypertensive response in stroke have not been exhaustive, severely high blood pressure irrespective of mechanism is associated with poor outcome [27]. Whether the high blood pressure reported in the current study was acute hypertensive response or poorly controlled chronic blood pressure was difficult to decipher since pre morbid cardiac state was not known. The same explanation may go for high rate of abnormal ECG findings reported in our study. About 4 of 5 stroke patients studied had at least 1 abnormal ECG finding. Irrespective of mechanism, abnormal ECG findings is associated with poor outcome.

Over 20% of our stroke subjects had prolonged QTc. This is not different in men and women and according to stroke type. Previous studies in patients with hypertensive heart diseases or diabetes mellitus have shown that QTc prolongation and QT interval dispersion are related to increased risk of all-cause and cardiovascular mortality through malignant

TABLE 5. ECG abnormalities according to stroke type

Variables	Total	Ischemic	Hemorrhagic	p Value
Atrial fibrillation	28 (4.7)	26 (6.7)	2 (1.0)	0.002
Atrial flutter	4 (0.7)	4 (1.0)	0 (0.0)	0.304*
Other arrhythmias	46 (7.8)	34 (8.8)	12 (5.9)	0.222
Conduction abnormality	71 (12.3)	47 (12.4)	24 (12.1)	0.906
Atrial enlargement (any)	340 (58.0)	228 (58.9)	112 (56.3)	0.541
LVH†	297 (55.8)	181 (51.4)	116 (64.4)	0.004
LVH with strain	156 (26.2)	94 (24.0)	62 (30.2)	0.102
Prolonged QTc	171 (29.6)	118 (31.3)	53 (26.4)	0.216
Short QTc	34 (5.9)	19 (5.0)	15 (7.5)	0.238
Median QRS duration	84.0	84.0	84.0	0.672
Median QRS axis	24.0	25.0	23.6	0.321
Any ECG abnormality	488 (84.7)	316 (83.9)	172 (87.3)	0.213

Values are n (%) unless otherwise indicated.
ECG, electrocardiographic; LVH, left ventricular hypertrophy.
*Fisher's exact test.
†Either Sokolow-Lyon, Cornell voltage, or Cornell product criteria.

TABLE 6. Demographic and selected clinical characteristics according to 1-month disability status

Variable	Good mRS (n = 254)	Poor mRS (n= 421)	Test statistic	p Value
Age, yrs	58.1 ± 12.1	58.8 ± 14.0	0.746	0.456
Male	161 (59.2)	288 (54.5)	1.574	0.21
Hypertension	255 (93.8)	496 (93.9)	0.011	0.916
Diabetes	106 (38.9)	187 (35.4)	0.977	0.323
Severe SLS	105 (45.5)	294 (60.6)	20.946	0.001
Sinus rhythm	239 (87.9)	427 (80.9)	6.302	0.012
Atrial fibrillation	8 (3.1)	24 (4.7)	1.147	0.284
Other arrhythmias	24 (9.2)	45 (9.0)	0.013	0.961
Conduction abnormality	33 (13.3)	66 (13.1)	0.003	0.960
Atrial enlargement	101 (38.7)	243 (48.8)	7.046	0.008
LVH	138 (52.9)	276 (53.2)	0.007	0.936
LVH with strain	70 (26.9)	119 (23.3)	1.231	0.267
Prolonged QTc interval	72 (27.6)	139 (29.0)	0.17	0.68
Short QTc interval	13 (5.0)	27 (5.6)	0.142	0.706
Any ECG abnormality	212 (83.5)	421 (86.5)	1.193	0.275

Values are mean ± SD or n (%).
mRS, modified Rankin Scale; SLS, Stroke Levity Scale.

arrhythmias. In a study, it was shown that idiopathic abnormal QTc prolongation was associated with a 5-fold increase in the probability of sudden cardiac death [28].

Except for 4 cases of ventricular tachycardia (all occurred in women), no case of polymorphic tachycardia especially torsades de pointes were recorded. This is similar to previous reports [13]. However, this may not have been picked up because continuous ECG monitoring was not carried out in our subjects. Atrial fibrillation is the most common sustained cardiac arrhythmia [29] and its presence increases stroke risk 5-fold [30]. Interestingly, the prevalence of atrial fibrillation in our study was low. This is in contrast to earlier studies that reported high prevalence of atrial fibrillation especially in ischemic stroke among non-African populations [30,31]. The lower prevalence of atrial fibrillation in African stroke patients may be due to their relatively younger age, or genetic influences. Certain genetic variants have been associated with the occurrence of atrial fibrillation, especially the familiar type [32]. Also, earlier studies have shown a paradoxical relationship between established AF risk factors and AF incidence in people of African descent compared with those of European ancestry. Despite a higher prevalence of many traditional risk factors for AF, including hypertension, diabetes mellitus, heart failure, and higher body mass index in African Americans, people of European ancestry had higher incidence of atrial fibrillation [33]. These discrepancies allows for further genomic studies in atrial fibrillation among indigenous African populations that the SIREN study will explore.

TABLE 7. Independent factors associated with 1-month disability

Variable	AOR (95% CI)	p Value
Age, yrs	1.01 (0.99—1.02)	0.471
Male	1.04 (0.75—1.44)	0.806
Hypertension	1.24 (0.62—2.48)	0.549
Diabetes	0.86 (0.61—1.20)	0.377
Stroke severity (SLS)		
Mild	1.00	
Moderate	1.17 (0.73—1.87)	0.506
Severe	2.25 (1.44—3.50)	0.001
Atrial enlargement	1.45 (1.04—2.02)	0.030

AOR, adjusted odds ratio; CI, confidence interval; SLS, Stroke Levity Scale.

Furthermore, in this study more than half of the patients had LVH. LVH is a well-recognized independent risk factor for hypertensive target organ damage including stroke [34-36] and when found with stroke it doubles the risk of repeat stroke [37]. Therefore, in acute stroke it may not be a new development as it takes long period of blood pressure elevation for clinical LVH to develop; more so that more than half of the stroke patients had atrial enlargement. This suggests that probably more of our subjects had preexisting cardiac anomalies. Our findings are similar to a study by Familoni et al. [38], who found 63% pre-existing cardiac disorder in stroke patients with higher prevalence of long QT interval and reported more mortality in patients with pre-existing cardiac conditions.

In our study atrial enlargement and severity of stroke were major predictors of 1-month severe disability or death. Although stroke severity is a recognized predictor of stroke outcome with more severe strokes recovering more slowly, atrial enlargement may indicate pre-existing cardiovascular morbidity, which impairs stroke recovery at 1-month.

Strengths and limitations

This is the largest study so far of the prognostic implication of ECG abnormalities among indigenous African stroke

patients. We provided evidence that any atrial enlargement on baseline ECG is an independent predictor of 1-month outcome in this population.

It is not clear if the ECG abnormalities observed in our cohort were related to the acute stroke event because we did not have access to their ECGs prior to the stroke event. Follow-up ECG was also not obtained in order to document whether the abnormalities were transient.

CONCLUSION

Various ECG abnormalities were observed in our stroke subjects. However, only atrial enlargement was an independent ECG predictor of 1-month stroke outcome. We recommend baseline ECG not only as a tool for detecting cardiac abnormalities in acute stroke patients but also to prognosticate 1-month outcome. We will explore this and other ECG variables further when data collection is complete in the SIREN study.

REFERENCES

1. World Health Organization. The 10 Leading Causes of Death in the World, 2000 and 2012. Geneva, Switzerland: WHO; 2014.
2. Wira CR 3rd, Rivers E, Martinez-Capolino C, et al. Cardiac complications in acute ischemic stroke. West J Emerg Med 2011;12:414–20.
3. Manea MM, Comsa M, Minca A, Dragos D, Popa C. Brain-heart axis—review article. J Med Life 2015;8:266–71.
4. Kocan MJ. The brain-heart connection: cardiac effects of acute ischemic stroke. J Cardiovasc Nurs 1998;13:57–68.
5. Bozluolcay M, Ince B, Celik Y, Harmanci H, Ilerigelen B, Pelin Z. Electrocardiographic findings and prognosis in ischemic stroke. Neurol India 2003;51:500.
6. Purushothaman S, Salmani D, Prarthana KG, Bandelkar SMG, Varghese S. Study of ECG changes and its relation to mortality in cases of cerebrovascular accidents. J Nat Sci Biol Med 2014;5:434.
7. Takeuchi S, Nagatani K, Otani N, Wada K, Mori K. Electrocardiograph abnormalities in intracerebral hemorrhage. J Clin Neurosci 2015;22:1959–62.
8. Iranmanesh F. Prognostic value of electrocardiography and electroencephalography in patients with ischemic stroke. Acta Neurol Taiwan 2008;17:228–32.
9. Lazar JM, Salciccioli L. Prognostic value of QT dispersion in acute stroke. Int J Cardiol 2008;129:1–2.
10. Akpalu A, Sarfo FS, Ovbiagele B, et al. Phenotyping stroke in sub-Saharan Africa: Stroke Investigative Research and Education Network (SIREN) phenomics protocol. Neuroepidemiology 2015;45:73–82.
11. Owolabi MO, Platz T. Proposing the Stroke Levity Scale: a valid, reliable, simple, and time-saving measure of stroke severity. Eur J Neurol 2008;15:627–33.
12. Prineas RJ, Crow RS, Zhang Z-M. The Minnesota Code Manual of Electrocardiographic Findings. New York: Springer Science & Business Media; 2009.
13. van Bree MD, Roos YB, van der Bilt IA, et al. Prevalence and characterization of ECG abnormalities after intracerebral hemorrhage. Neurocrit Care 2010;12:50–5.
14. Roman MJ, Kligfield P, Devereux RB, et al. Geometric and functional correlates of electrocardiographic repolarization and voltage abnormalities in aortic regurgitation. J Am Coll Cardiol 1987;9:500–8.
15. Okin PM, Devereux RB, Nieminen MS, et al. Relationship of the electrocardiographic strain pattern to left ventricular structure and function in hypertensive patients: the LIFE study. J Am Coll Cardiol 2001;38:514–20.
16. Lepeschkin E, Surawicz B. The measurement of the QT interval of the electrocardiogram. Circulation 1952;6:378–88.
17. Tatschl C, Stöllberger C, Matz K, et al. Insular involvement is associated with QT prolongation: ECG abnormalities in patients with acute stroke. Cerebrovasc Dis 2006;21:47–53.
18. Samuels MA. The brain—heart connection. Circulation 2007;116:77–84.
19. Christensen H, Boysen G, Christensen A, Johannesen H. Insular lesions, ECG abnormalities, and outcome in acute stroke. J Neurol Neurosurge Psychiatr 2005;76:269–71.
20. Cechetto DF. Experimental cerebral ischemic lesions and autonomic and cardiac effects in cats and rats. Stroke 1993;24(Suppl 12):I6–9. discussion I10—2.
21. Colivicchi F, Bassi A, Santini M, Caltagirone C. Cardiac autonomic derangement and arrhythmias in right-sided stroke with insular involvement. Stroke 2004;35:2094–8.
22. Oppenheimer SM, Wilson JX, Guiraudon C, Cechetto DF. Insular cortex stimulation produces lethal cardiac arrhythmias: a mechanism of sudden death? Brain Res 1991;550:115–21.
23. Oppenheimer SM. Neurogenic cardiac effects of cerebrovascular disease. Curr Opin Neurol 1994;7:20–4.
24. Leonardi-Bee J, Bath PM, Phillips SJ, Sandercock PA. Blood pressure and clinical outcomes in the International Stroke Trial. Stroke 2002;33:1315–20.
25. Ahmed N, Wahlgren N, Brainin M, et al. Relationship of blood pressure, antihypertensive therapy, and outcome in ischemic stroke treated with intravenous thrombolysis retrospective analysis from Safe Implementation of Thrombolysis in Stroke—International Stroke Thrombolysis Register (SITS-ISTR). Stroke 2009;40:2442–9.
26. Qureshi AI, Ezzeddine MA, Nasar A, et al. Prevalence of elevated blood pressure in 563704 adult patients with stroke presenting to the ED in the United States. Am J Emerg Med 2007;25:32–8.
27. Qureshi AI. Acute hypertensive response in patients with stroke pathophysiology and management. Circulation 2008;118:176–87.
28. Chugh SS, Reinier K, Singh T, et al. Determinants of prolonged QT interval and their contribution to sudden death risk in coronary artery disease: the Oregon Sudden Unexpected Death Study. Circulation 2009;119:663–70.
29. Wattigney WA, Mensah GA, Croft JB. Increasing trends in hospitalization for atrial fibrillation in the United States, 1985 through 1999 implications for primary prevention. Circulation 2003;108:711–6.
30. Go AS, Hylek EM, Phillips KA, et al. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the AnTicoagulation and Risk Factors in Atrial Fibrillation (ATRIA) Study. JAMA 2001;285:2370–5.
31. Kannel WB, Wolf PA, Benjamin EJ, Levy D. Prevalence, incidence, prognosis, and predisposing conditions for atrial fibrillation: population-based estimates. Am J Cardiol 1998;82:2N–9N.
32. Chugh SS, Blackshear JL, Shen W-K, Hammill SC, Gersh BJ. Epidemiology and natural history of atrial fibrillation: clinical implications. J Am Coll Cardiol 2001;37:371–8.
33. Marcus GM, Alonso A, Peralta CA, et al. European ancestry as a risk factor for atrial fibrillation in African Americans. Circulation 2010;122:2009–15.
34. Wolf PA, D'Agostino RB, Belanger AJ, Kannel WB. Probability of stroke: a risk profile from the Framingham Study. Stroke 1991;22:312–8.
35. Bikkina M, Levy D, Evans JC, et al. Left ventricular mass and risk of stroke in an elderly cohort: the Framingham Heart Study. JAMA 1994;272:33–6.
36. Kannel WB. Prevalence and natural history of electrocardiographic left ventricular hypertrophy. Am J Med 1983;75:4–11.
37. Pop GA, Koudstaal PJ, Meeder HJ, Algra A, van Latum JC, van Gijn J. Predictive value of clinical history and electrocardiogram in patients with transient ischemic attack or minor ischemic stroke for subsequent cardiac and cerebral ischemic events. The Dutch TIA Trial Study Group. Arch Neurl 1994;51:333–41.
38. Familoni OB, Odusan O, Ogun SA. The pattern and prognostic features of QT intervals and dispersion in patients with acute ischemic stroke. J Natl Med Assoc 2006;98:1758–62.