

# A Study of Electrocardiographic Abnormalities in Patients with Acute Cerebrovascular Events

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## ABSTRACT

**Introduction:** Cerebrovascular accidents have long been recognised for their debilitating impact on one's life, posing a major contributor for morbidity and mortality. An array of cardiovascular events occur with an increased frequency among patients with cerebrovascular events in spite of no previous cardiac diseases. Electrocardiographic changes are well known to occur in patients with neurological disorders.

**Aim:** To identify the abnormal ECG patterns associated with the type of acute stroke and determine if the specific changes in ECG associated with elevated cardiac enzymes, echocardiographic abnormalities and the patient outcomes.

**Materials and Methods:** A total of 100 patients with no previous cardiac disease or ECG abnormality, admitted with acute stroke was enrolled in the study. All the patients underwent an electrocardiographic recording within the first two hours of admission and the abnormal findings were recorded and correlated in relation to the nature of stroke whether the ischaemic or the haemorrhagic type, the echocardiographic findings, cardiac biomarkers and the patient outcomes. The data were analysed with SPSS software and categorical variables with chi-square test. A p-value of <0.05 was considered statistically significant.

**Results:** Among the study population, 78 patients had ischaemic stroke while 22 patients had haemorrhagic stroke. ECG changes were noted among 97 patients. The common ECG changes among both the ischaemic and haemorrhagic groups were T wave inversion and ST depression. Thirty-three patients with ECG abnormalities also had echocardiographic abnormalities in ischaemic group while seven patients had ECG and echocardiographic abnormalities in the haemorrhagic group. Thirty-two patients with changes in the ECG had elevated cardiac biomarkers. ST depression was strongly associated with elevated troponin T, CPK-MB, BNP and abnormal echocardiographic findings with a p-value of  $\leq 0.001$ . Both ST segment depression on ECG and elevated CPK MB were strong predictors of mortality among patients with acute cerebrovascular events individually, with a p-value <0.001.

**Conclusion:** ECG abnormalities were commonly seen among patients with acute cerebrovascular accidents which vary from T wave inversion to ST segment depression. CPK MB, troponin T and BNP were elevated among 32 patients with ECG changes and 40% patients with ECG changes had abnormalities noted in their echocardiogram. Mortality was slightly higher among the haemorrhagic group compared to the ischaemic stroke group, though not significant.

**Keywords:** Acute stroke, Cardiac biomarkers, Cardiac enzymes, Cerebrovascular accident

## INTRODUCTION

Cerebrovascular accidents contribute largely to mortality and morbidity in medical field. They cause significant debility in both physical and emotional ways to the patients and their families [1]. The importance of investigations, early treatment and rehabilitation in a patient with acute cerebrovascular accident has been stressed in many studies. Stroke victims are prone to an array of cardiovascular events like arrhythmias, severe hypotension, cardiac arrest etc. Some of these patients who experience these cardiac events have no history of any cardiac disease [2].

Both the cerebral as well as the coronary arteriosclerotic diseases significantly contribute to the occurrence of sudden death in such individuals, as the risk factors for both these conditions are the same. Thus, screening of cardiac problems among patients with stroke helps us to reduce the mortality associated with the cerebrovascular accidents. ECG changes in patients with cerebrovascular accidents have included ST segment depression and T wave inversions as evidenced by previous studies [3-5]. This poses a challenge to the healthcare professionals to distinguish the stroke related ECG changes from those due to a concomitant ischaemic heart disease [3,4,6]. Furthermore, there have been gross variations among the findings reported in literature. Dogan A et al., found 65%, Goldstein DS, detected 39% of their study population to have ST segment depression, Mc Dermott MM et al., observed ST segment depression in 80% of patients without history of CAD and 60% of all patients to have ischemia like ECG changes [4,6,7], While Fure B et al., observed Qtc prolongation as the most common change [8].

The purpose of the present study was to reinforce the need for ECG in patients with acute cerebrovascular accident and stress the association of ST segment depression in ECG which can be easily identified by a medical graduate not requiring any expertise help for the same. The present study was undertaken to also study the pattern of ECG changes associated with the types of acute cerebrovascular accident, namely ischaemic and haemorrhagic among patients with no history of cardiovascular diseases and determine the correlation of ECG changes with the echocardiographic abnormalities, cardiac biomarkers and the patient outcome.

## MATERIALS AND METHODS

The prospective study was conducted in a tertiary care centre in Tamil Nadu, India over a period of 18 months from April 2017 to September 2018, which studied a total of 263 patients. They were included based upon the age (more than 18 years) and an acute onset of stroke either haemorrhagic or ischaemic. Among them, 161 patients were excluded due to the presence of either known coronary artery disease, previous documented abnormal echocardiographic findings or had electrolyte abnormalities while 2 patients were excluded as they were unwilling to be part of the study. Thus a total of 100 patients were included in the study. The study did not include patients with subarachnoid haemorrhage.

This study was approved by the Institutional Ethics Committee (approval letter: CSP-MED/17/APR/35/53) and written informed consent was obtained from all the patients enrolled in the study. A detailed history including their presenting complaints, duration and

co-morbidities was obtained. A thorough clinical examination was performed for all the patients. The observations were recorded in a pre-structured proforma. Their baseline investigations including the haemogram, sugars, lipid profile, renal and liver function tests, urine analysis, cardiac biomarkers like CPK MB, Trop I and BNP were carried on and documented. The patients underwent neuroimaging (CT/MRI brain) and based on the radiological findings were grouped as ischaemic or the haemorrhagic subtypes. All the patients underwent electrocardiogram within 2 hours of hospital admission and echocardiogram. The findings in relation to the type of stroke and the patients' outcome were documented and analysed.

## STATISTICAL ANALYSIS

The data was analysed using SPSS Software. The categorical variables were presented as frequency of occurrence and were analysed by Chi-square or Fischer-exact test. All tests were two tailed and a p-value <0.05 was considered statistically significant.

## RESULTS

A total of 100 acute stroke patients were included in the study among which 78 patients had cerebral infarct while 22 patients had haemorrhage as the cause for acute cerebrovascular event. The clinical and demographic data of patients from both the groups are presented in [Table/Fig-1]. Considering the age distribution, younger age was common among the patients with haemorrhage while infarctions were common among the geriatric population. Both the groups had slight male predominance. The occurrence of pre-existing co-morbidities like systemic hypertension, dyslipidemia were similar in both the groups, with a slightly higher occurrence of diabetes among the infarct group. Addiction to smoking, systolic and diastolic blood pressure was significantly higher among the patients with haemorrhagic stroke. However, there was no significant difference between the groups in terms of BMI and alcohol consumption.

Characteristics	Infarct (78)		Haemorrhage (22)		p-value
	No.	with%	No.	with%	
Age (Years)	<40	8 (10.26)	4 (18.18)		0.007
	40-60	25 (32.05)	7 (31.81)		0.672
	>60	45 (57.69)	11 (50)		0.580
Sex	Male	51 (65.38)	16 (72.73)		0.128
	Female	27 (34.61)	6 (27.27)		
Type II Diabetes mellitus	Yes	52 (66.66)	9 (40.91)		0.034
	No	26 (33.33)	13 (59.09)		
Systemic hypertension	Yes	51 (65.38)	14 (63.63)		0.573
	No	27 (34.61)	8 (36.36)		
Dyslipidemia	Yes	58 (74.36)	17 (77.27)		0.137
	No	20 (25.64)	5 (22.72)		
Smoking	Yes	25 (32.05)	13 (59.09)		0.004
	No	53 (67.95)	9 (40.91)		
Alcohol	Yes	25 (32.05)	6 (27.27)		0.421
	No	53 (67.95)	16 (72.73)		
	Mean	SD	Mean	SD	p-value
BMI	28.7	3.9	26.62	2.31	0.236
Systolic BP (mmHg)	151.5	27.6	170.8	30.40	<0.001
Diastolic BP (mmHg)	91.3	16.8	106.5	21.7	<0.001
Mean duration of stay	6.76	3.46	7.8	3.132	0.274

**[Table/Fig-1]:** Clinical and demographic characteristic of the study groups.

The [Table/Fig-2] compares the ECG findings among the two study group patients. T wave inversions were observed among 54 patients with stroke and were the most frequently occurring single ECG abnormality in stroke. No significant relationship was demonstrable between the type of stroke and the pattern of ECG abnormalities.

Parameters		Neuroimaging		p-value
		Infarct	Haemorrhage	
		No. with %	No. with %	
T wave inversions	Yes	40 (40)	14 (14)	0.217
	No	38 (38)	8 (8)	
ST segment elevation	Yes	12 (12)	4 (4)	0.488
	No	66 (66)	18 (18)	
ST segment depression	Yes	5 (5)	0	0.280
	No	73 (73)	22 (22)	
Others	Yes	19 (19)	3 (3)	0.222
	No	59 (59)	19 (19)	

**[Table/Fig-2]:** Correlation of ECG findings with the type of stroke.

\*Others\* denote Sinus tachycardia, sinus bradycardia, multifocal atrial tachycardia, left and right bundle branch block, ventricular arrhythmias

The [Table/Fig-3] correlates the ECG changes and the cardiac biomarkers and echocardiographic findings. ST segment depression was the single abnormal ECG finding which correlated significantly with elevated Troponin T, Creatinine Phosphokinase (CPK-MB), and Brain Natriuretic Peptide (BNP) as well as the presence of abnormal findings on 2d Echocardiogram.

The [Table/Fig-4] presents the impact of various parameters on the outcome of patients. The higher age at presentation, higher systolic and diastolic blood pressures, low haemoglobin, higher BNP levels were associated with poor outcome (higher mortality) during the hospital stay of the patients. Similarly, the presence of ST segment depression elevated CPK-MB and the occurrence of abnormalities in 2d echocardiogram were strongly associated with increased mortality of the patients.

## DISCUSSION

Among the 100 study patients, 67 were males and 33 were females with a male to female ratio of 2.03:1. This is similar to the observations made by Purshotahamam S et al., (2.4:1), Anand K et al., (1.7:1) and Nagaraja D et al., (2:1) [9-11]. Women have a lesser incidence of stroke compared to the males which could be partly attributed to the genetic susceptibility, lower blood pressure values and the effects of estrogen on cerebral circulation. The study comprised 78% of ischaemic stroke patients which was slightly higher compared to the observations of Kuruvilla T and Bharucha NE, and Kumar HH et al., which were 57.3% and 56%, respectively [12,13]. Haemorrhagic stroke was seen among 22% patients in the present study which was lower than the previous studies [12,13]. Atherosclerosis of the small and medium sized cerebral arteries is the most common cause of ischaemic stroke [14]. Haemorrhagic strokes though less common than ischaemic strokes cause significantly higher mortality and morbidity than the ischaemic strokes [15].

Acute coronary syndrome or myocardial damage due to either atherosclerotic or non-atherosclerotic aetiology will be associated with elevated cardiac biomarkers, ECG changes along with or without echocardiographic abnormalities. However, the cardiac events due to non-atherosclerotic causes were clinically ruled out while including the patients in the study. Further, the atherosclerotic aetiology was substantiated by carotid vertebral Doppler done in all these patients which showed plaques in the carotids.

A 73% of the present study population had ECG changes. This finding is similar to the observations made in the previous studies by Goldstein DS, (92%), Purushothaman S et al., (78%) and Bozluolcay M et al., (62%) [5,6,9]. The most common ECG abnormalities associated with acute stroke in the present study were T wave inversion, ST segment depression and ST segment elevation. There were other observations made in the ECG that included sinus tachycardia, sinus bradycardia, multifocal atrial tachycardia, left and right bundle branch blocks, ventricular arrhythmias and left ventricular hypertrophy. Most of these ECG changes could simulate

ECG changes		Troponin T			CPK-MB			BNP			2d ECHO		
		Elevated	Normal	p-value (chi-square)	Elevated	Normal	p-value (chi-square)	Elevated	Normal	p-value (chi-square)	Abnormal	Normal	p-value (chi-square)
T wave inversion	Yes	15	39	0.566	7	47	0.484	54	20	0.382	17	37	0.356
	No	13	33		7	39		6	20		29	17	
ST segment depression	Yes	14	2	<0.001	7	9	<0.001	16	0	<0.001	14	2	<0.001
	No	14	70		7	77		44	40		32	52	
ST segment elevation	Yes	3	2	0.132	2	3	0.143	5	2	0.467	3	2	0.145
	NO	25	70		12	83		55	38		43	52	
Others	YES	7	15	0.419	2	20	0.360	22	8	0.990	5	17	0.326
	NO	21	57		12	66		38	32		41	37	

**[Table/Fig-3]:** Correlation of ECG changes with cardiac enzymes and echocardiogram abnormalities.

\*Others\* denote Sinus tachycardia, sinus bradycardia, multifocal atrial tachycardia, left and right bundle branch block, ventricular arrhythmias

Parameters		Discharged	Expired	p-value
		No. with %	No. with %	
Sex	Male	64 (95.5)	3 (4.5)	0.361
	Female	30 (90.9)	3 (9.1)	
T2DM	Yes	56 (91.8)	5 (8.2)	0.241
	No	38 (97.4)	1 (2.6)	
SHT	Yes	60 (92.3)	5 (7.7)	0.312
	No	34 (97.1)	1 (2.9)	
LFT	Normal	88 (94.6)	5 (5.4)	0.338
	Abnormal	6 (85.7)	1 (14.3)	
T wave inversions	Yes	50 (92.6)	4 (7.4)	0.521
	No	44 (95.7)	2 (4.3)	
ST segment elevation	Yes	4 (80)	1 (20)	0.176
	No	90 (94.7)	5 (5.3)	
ST segment depression	Yes	12 (75)	4 (25)	<0.001
	No	82 (97.6)	2 (2.4)	
Others	Yes	19 (86.4)	3 (13.6)	0.088
	No	75 (96.2)	3 (3.8)	
Troponin T	Elevated	25 (89.3)	3 (10.7)	0.214
	Normal	69 (95.8)	3 (4.2)	
CPK-MB	Elevated	10 (71.4)	4 (28.6)	<0.001
	Normal	84 (97.7)	2 (2.3)	
CT/MRI	Infarct	74	5.1	0.089
	Haemorrhage	20	9.1	
2d ECHO	Normal	25	13.8	0.036
	Abnormal	69	2.8	
		<b>Mean</b>	<b>Std. dev</b>	
Age		58.84	7.250	0.013
Haemoglobin		12.146	1.1149	0.007
Total counts		8430.85	4101.544	0.690
BNP		216.614	270.4947	0.005
Duration of stay		8.52	3.782	0.102
Systolic BP		153.6	33.7	<0.001
Diastolic BP		90.9	20.3	<0.001

**[Table/Fig-4]:** Correlation of various parameters on patients outcome.

an acute coronary event or myocardial injury. The frequency of ECG changes was similar to the observations made in previous studies which showed ischaemic changes in ECG along with QTc prolongation in more than 90% patients with ischaemic/haemorrhagic stroke while 8-40% decrease in frequency of ECG changes happened among patients with known cardiac ailment [16-18]. Dogan A et al., observed ischaemia like changes in ECG in 65% of patients, 26% had QTc prolongation and arrhythmias in 44% in their study on ischaemic stroke patients without history of primary heart disease [4]. Similarly, Lindgren A et al., observed

transient ST-T changes among 54% ischaemic stroke patients with no primary heart disease [19].

The ECG changes are highly variable over time especially in the setting of acute stroke and standardising them cannot be done until continuous monitoring of the ECG is attempted. This explains the varied ECG changes among various studies [5,6,12]. Most of the ECG abnormalities described in literature after an acute cerebral event were associated with sub arachnoid haemorrhage. However, the present authors confined to ischaemic and haemorrhagic (intracerebral) stroke in the study.

Abnormal T wave was the most common abnormality observed among the ischaemic stroke patients. T wave inversions due to acute myocardial infarctions are classically narrow and symmetrical while those due to non-cardiac causes have low amplitude and are abnormally inverted [3]. ST-T changes in the ECG were observed among 59% of the study population; however, the frequency of these changes was higher among the ischaemic stroke patients compared to the haemorrhagic stroke patients (63.3% vs 57.69%). These observations are in disagreement with those made by Mc Dermott MM et al., and Ebrahim K et al., [7,20]. The ECG changes in acute stroke are transient which probably explains the Difference in findings. Fure B et al., observed ST depression and T wave inversions (24.5% and 17.8%) as the most frequent ECG changes while in our study, T wave inversions followed by the ST segment depression were the commonest findings (54% and 16%) [8].

Several studies have observed the prognostic importance of the ECG changes particularly the ST segment and QT intervals in ischaemic stroke patients [4,6]. Prolonged QTc interval, concurrent myocardial infarction and ventricular arrhythmias have been strongly associated with increased mortality among the stroke patients [21]. However, in the index study, ST segment depression showed significant correlation with the presence of abnormal echocardiogram and elevated cardiac enzymes viz., Troponin T, Creatinine phosphokinase-MB, and also Brain natriuretic peptide. ST segment depression was also associated significantly with poorer in-hospital patient outcome.

In a prospective study by Jensen JK et al., Troponin T and CPK-MB were found elevated among 10% and 9% of acute stroke patients respectively while 3% patients had both Troponin T and CPK-MB elevated along with electrocardiographic changes [22,23]. This is in contrast to the observations made in the present study wherein 32 patients had elevated cardiac enzymes and all of them had ECG changes; 42.3% patients in the ischaemic group and 31.82% haemorrhagic stroke patients had both ECG and echocardiographic abnormalities.

It is well known that Left Ventricular Hypertrophy (LVH) on echocardiogram is an independent risk factor for hypertension related target organ damage [24,25]. In stroke patients, the presence of LVH increases the risk of recurrent cerebrovascular accidents two folds [26]. It takes longer duration for LVH to develop; hence it may not be a new sign in acute stroke patients. Systemic

hypertension has a strong bearing on the occurrence of CVA as evidenced by the presence of left ventricular hypertrophy among 17% of the study population.

Stroke is one of the major causes of mortality and morbidity. This study highlighted many independent risk factors for mortality among patients with acute stroke. Higher age group, lower haemoglobin levels, elevated BNP levels, presence of abnormal findings on echocardiogram and CPK-MB elevations were significantly associated with higher rates of mortality among these patients. The mortality rates were not significantly altered by the presence of traditional risk factors like the male sex, presence of diabetes mellitus, systemic hypertension. The mortality rate was 9.1% among the haemorrhagic stroke patients while it was 5.1% among the ischaemic stroke patients. Though the rate seemed slightly higher in the haemorrhagic group, it was not statistically significant.

## LIMITATION

Serial ECGs were not recorded to document the occurrence of transient changes in the ECGs of patients with acute stroke. A control group was not studied where the presence of abnormal ECG patterns among normal population could have added more significance.

## CONCLUSION

Acute cerebrovascular accidents cause autonomic imbalance in the myocardium which causes many electrocardiographic abnormalities and predisposes these patients to increased mortality risk. Hence, irrespective of the presence of co-morbidities, ECG changes particularly ST segment depression and the presence of elevated CPK-MB serve as independent predictors of patients' outcome in acute stroke, especially in resource limited settings.

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