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Electrocardiographic and Echocardiographic Alterations in Patients with Acute Cerebrovascular Stroke

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Abstract: Background: Stroke, a leading cause of morbidity and mortality, is often accompanied by significant cardiovascular changes, which may complicate management and affect patient outcomes. This study explores electrocardiographic (ECG) and echocardiographic changes in patients during the acute phase of stroke, focusing on the prevalence, types, and implications of these findings.

Methods: This hospital-based, cross-sectional study was conducted at ESIC Medical College & PGIMSR, enrolling 76 patients with acute ischemic or hemorrhagic stroke. Each patient underwent 12-lead ECG, cardiac troponin-I testing, and echocardiographic evaluation, including assessments for left ventricular ejection fraction, left ventricular hypertrophy (LVH), and regional wall motion abnormalities (RWMA). Data were analyzed to identify the prevalence and types of ECG and echocardiographic changes and their association with patient demographics and stroke type.

Results: The study population's largest age group was 71–80 years (30.3%), with 61.8% male participants. Most patients (81.6%) had hypertension, 42.1% were smokers, 32.9% had type 2 diabetes, and 78.9% had ischemic stroke. Common ECG findings included prolonged QTC (46%), T-wave abnormalities (42.1%), and ST-segment depression (28.9%). Atrial fibrillation was the most common arrhythmia (13.2%), followed by sinus arrhythmia and sinus bradycardia (each 6.6%). Echocardiographic findings showed LVH in 25% of patients, RWMA in 19.7%, and left atrial thrombus in 6.6%. Patients with hemorrhagic stroke demonstrated higher rates of prolonged QTC and T-wave abnormalities compared to ischemic stroke patients.

Conclusion: This study highlights a high prevalence of ECG and echocardiographic changes in acute stroke patients, particularly in those with hemorrhagic stroke. These findings underscore the importance of routine cardiovascular evaluation in stroke patients to detect and manage cardiac complications early. Further studies are warranted to explore the implications of these cardiac abnormalities on stroke outcomes and recovery.

Keywords: cardiac, ischemic, echocardiographic, thrombus

INTRODUCTION

Stroke is a major cause of morbidity and mortality worldwide, affecting millions each year and often leading to significant long-term disability. Stroke not only disrupts neurological function but also initiates complex physiological responses that can impact other systems, especially the cardiovascular system. Recent studies have shown that acute stroke is frequently accompanied by various cardiac complications, ranging from arrhythmias to myocardial ischemia, which may influence patient outcomes. Understanding these cardiac changes in the acute phase of stroke is essential for comprehensive management, as they may contribute to an increased risk of mortality and adverse events during recovery.

Electrocardiographic (ECG) and echocardiographic evaluations are valuable tools for identifying cardiovascular alterations in stroke patients. Previous research has documented numerous ECG changes in this population, including ST-segment and T-wave abnormalities, prolonged QTC intervals, and arrhythmias such as atrial fibrillation. Echocardiography further reveals structural and functional changes, such as left ventricular hypertrophy (LVH), regional wall motion abnormalities (RWMA), and left ventricular (LV) systolic dysfunction,

which may occur as secondary effects of stroke or reveal underlying cardiovascular issues. However, the exact prevalence, types, and clinical implications of these cardiac abnormalities in stroke patients remain areas of active investigation.

In this study, we aim to systematically assess ECG and echocardiographic changes in patients experiencing acute stroke, focusing on both ischemic and hemorrhagic types. By evaluating cardiac changes across a diverse patient population, this study seeks to clarify the prevalence, characteristics, and potential risk factors associated with these cardiovascular manifestations in stroke patients. Identifying these patterns could guide clinicians in early detection and management of cardiac complications, ultimately improving patient outcomes in the critical period following a stroke.

AIM AND OBJECTIVES :

This study aims to explore and characterize the electrocardiographic (ECG) and echocardiographic changes observed in patients during the acute phase of stroke, focusing on their types and prevalence.

Primary Objectives:

- To identify and analyze the electrocardiographic (ECG) alterations present in patients experiencing an acute stroke.

- To assess and document echocardiographic abnormalities in acute stroke patients, including both structural and functional cardiac changes.

Secondary Objectives:

- To examine the prevalence and types of arrhythmias detected via ECG in acute stroke patients.

- To determine the occurrence of repolarization abnormalities and myocardial ischemia-like changes on ECG (such as ST-segment changes and T-wave inversions) in this population.

- To assess the prevalence of left ventricular (LV) systolic dysfunction on echocardiography in acute stroke patients and investigate if this post-stroke LV dysfunction is linked to a specific pattern of regional wall motion abnormalities.

MATERIALS AND METHODS

Study Site

Department of General Medicine, ESIC Medical College & PGIMSR

Study Duration

The study was carried out from October 2022 to May 2024.

Type of Study

This was a hospital-based, cross-sectional, observational study.

Sample Size

The sample size consisted of 76 participants.

Sampling Method

Simple random sampling was employed.

Inclusion Criteria

Participants included in the study were:

1. Patients with a confirmed diagnosis of acute ischemic or hemorrhagic stroke, as determined by clinical assessment and imaging studies (CT or MRI).

2. Adults aged between 20 and 80 years.

3. Individuals presenting within 24 hours of the onset of stroke symptoms (i.e., within 24 hours from when last seen normal), allowing for the study of acute-phase changes.

4. Patients capable of providing informed consent, either personally or through a legally authorized representative.

Exclusion Criteria

1. Those with a history of previous strokes.

2. Patients presenting more than 24 hours after the onset of stroke symptoms.

3. Individuals with strokes of traumatic origin.

4. Patients with non-cardiac causes of ECG or echocardiographic changes, such as electrolyte imbalances, severe pulmonary disease, or thyroid disorders.

5. Pregnant women, due to potential risks to the fetus and the requirement for specialized care.

6. Patients who were unwilling to participate in the study.

METHODS

Upon admission, a detailed clinical history of the stroke was recorded, including risk factors such as hypertension, diabetes mellitus, smoking, and a history of ischemic heart disease or structural heart disease (including rheumatic heart disease). A brief cardiovascular and neurological examination was performed for all patients. During the initial assessment, the level of consciousness was evaluated using the Glasgow Coma Scale (GCS), which ranges from 3 to 15. The level of mentation was classified as alert, drowsy, stupor, semi-coma, or coma. A diagnosis of cerebrovascular accident (CVA) was confirmed through CT or MRI imaging of the brain.

For each patient, 12-lead ECGs, cardiac troponin-I (cTnI) levels, and other routine blood investigations (including total cholesterol levels) were obtained on the day of admission. Echocardiographic evaluations, including 2D echocardiography and color Doppler studies, were performed according to the study protocol using a Siemens Acuson NX3 ultrasonography machine, conducted within one week after managing the stroke. For patients who could not be transported from the ICU to the echocardiographic laboratory due to conditions such as mechanical ventilation or hemodynamic instability, portable echocardiography was utilized.

Regional wall motion abnormalities (RWMA) were evaluated and scored through visual assessment in accordance with the established guidelines from the American Society of Echocardiography. Left ventricular ejection fraction (LVEF) was determined using the modified Simpson's method, while left ventricular mass was estimated using the Devereux formula and indexed to body surface area.

RESULTS :

In our study of 76 stroke patients, the largest age group represented was 71–80 years, comprising 30.3% of the participants. This was followed by the 51–60 age group at 26.3%, the 61–70 age group at 23.3%, and the 41–50 age group at 14.5%. The smallest group was aged 31–40, making up only 5.3% of the study population.Regarding gender distribution, 61.8% of the participants were male, while 38.2% were female, indicating a higher proportion of men among stroke patients in our sample.Systolic Blood Pressure (SBP) among patients varied widely, ranging from 106 to 221 mm Hg. The average SBP was 157 mm Hg, with a standard deviation of 25.7 mm Hg. The majority of patients (34.2%) fell within the 161–180 mm Hg range, followed by 22.4% in both the 121–140 mm Hg and 141–160 mm Hg ranges. Additionally, 13.2% had SBP levels above 180 mm Hg, while only 7.9% were in the 101–120 mm Hg range, representing the smallest group.(Fig.1) The diastolic blood pressure (DBP) ranged from 68 to 130 mm Hg, with a mean of 94.3 mm Hg and a standard deviation of 13.6 mm Hg. The majority of patients (28.9%) had a DBP between 91–100 mm Hg, followed by 26.3% with DBP levels exceeding 100 mm Hg, 23.7% in the 81–90 mm Hg range, and 15.8% in the 71–80 mm Hg range. Only 5.3% of patients had a DBP between 61–70 mm Hg. (Fig.2)

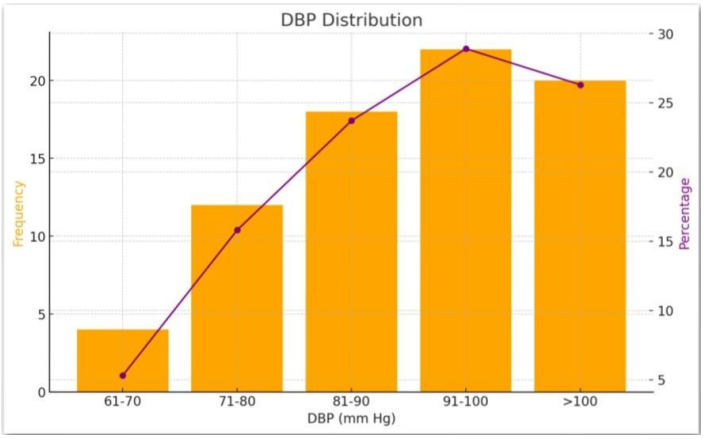

Fig.1

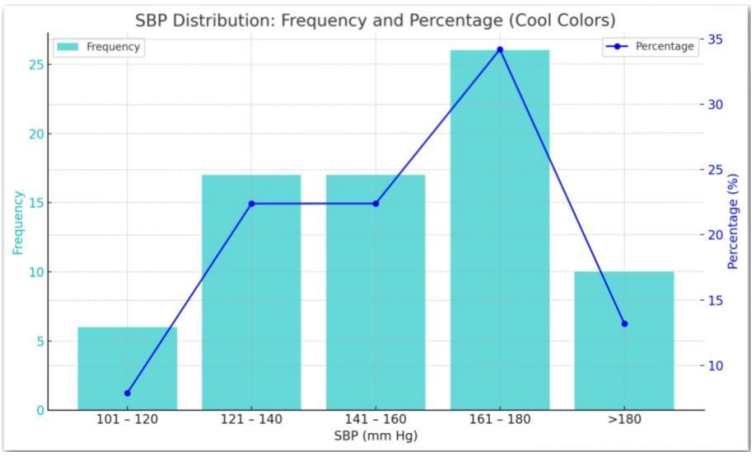

Fig.2

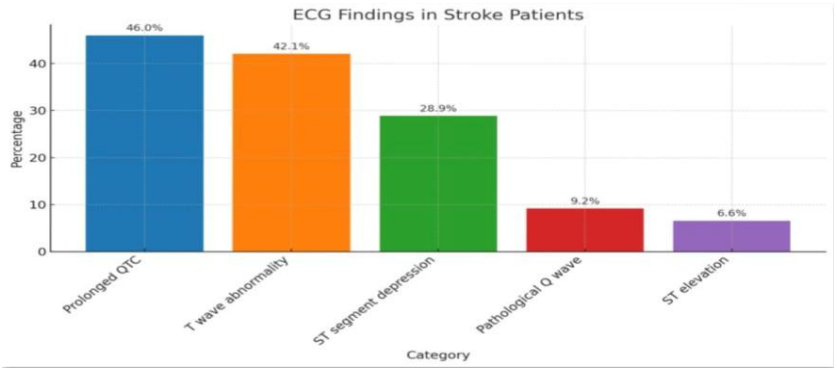

Fig.3

Comorbidities were prominent in our study group, with hypertension affecting 81.6% of the patients, 42.1% identified as smokers, 32.9% having type 2 diabetes mellitus, and 21.1% with a history of prior heart disease.Of the total stroke cases, ischemic strokes were much more prevalent than hemorrhagic, accounting for 78.9% compared to 21.1%.

Electrocardiographic findings revealed prolonged QTC as the most frequent abnormality, occurring in 46% of patients. This was followed by T-wave abnormalities in 42.1% of cases, ST-segment depression in 28.9%, and pathological Q waves in 9.2%. The least common finding was ST-segment elevation, seen in 6.6% of patients. (Fig.3)

Among arrhythmias, atrial fibrillation was the most commonly observed, affecting 13.2% of patients. Sinus arrhythmia and sinus bradycardia each were observed in 6.6% of patients, sinus tachycardia in 5.3%, and left bundle branch block (LBBB), the least common arrhythmia, in 1.3%.On echocardiographic evaluation, left ventricular hypertrophy (LVH) was noted in 25% of patients, left atrial (LA) thrombus in 6.6%, and regional wall motion abnormalities (RWMA) in 19.7%.Specific ECG findings varied significantly based on the history of heart disease. Among patients with a history of heart disease, 25% showed ST-segment depression, 43.75% had T-wave abnormalities, 18.75% had prolonged QTC, 25% had ST-segment elevation (p<0.001), 43.75% had pathological Q waves (p<0.001), 50% had left ventricular (LV) dysfunction (p<0.001), and 56.25% had arrhythmias (p<0.001). Among those without a history of heart disease, 30% exhibited ST-segment depression, 41.66% had T-wave abnormalities, 53.33% had prolonged QTC, 1.66% had ST-segment elevation (p<0.001), none had pathological Q waves, 11.66% had LV dysfunction (p<0.001), and 26.66% had arrhythmias (p<0.001).(Fig.4)

History of Heart Disease	ECG and Echo Findings						
	ST Segment Depression	T wave Abnormality	Prolonged QTc	ST elevation	Pathologic Q wave	LV dysfunction	Arrhythmia
Present	4 (25%)	7 (43.75%)	3 (18.75%	4 (25%)	7 (43.75%	8 (50%)	9 (56.25%
Absent	18 (30%)	25 (41.66%)	32 (53.33%	1 (1.66%)	0	7 (11.66%)	16 (26.66%
P value	0.695	0.852	0.046	<0.001	<0.001	<0.001	<0.001

Fig.4

Differences in cardiac findings were also noted between ischemic and hemorrhagic stroke patients. Among ischemic stroke patients, 26.66% exhibited ST-segment depression, 40% showed T-wave abnormalities, 38.33% had prolonged QTC, 8.33% had ST-segment elevation, 11.66% had pathological Q waves, 20% showed LV dysfunction, and 35% had arrhythmias. In contrast, among hemorrhagic stroke patients, 37.5% had ST-segment depression, 50% displayed T-wave abnormalities, 75% had prolonged QTC, with no cases of ST-segment elevation or pathological Q waves, 18.75% had LV dysfunction, and 25% exhibited arrhythmias.

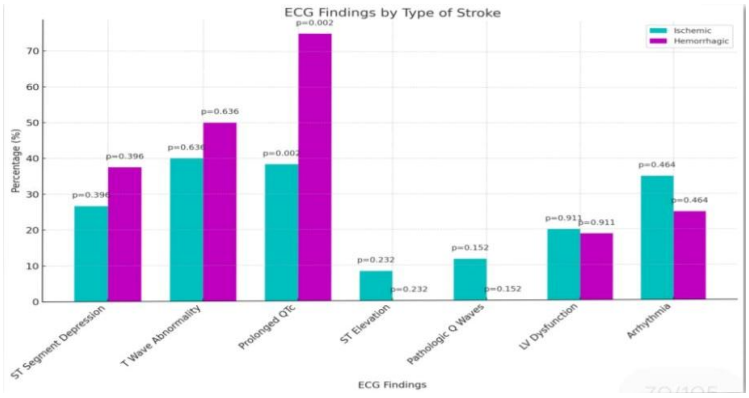

Fig.5

Seven patients (9.2%) were diagnosed with acute cardiac dysfunction (ACD) based on medical history, ECG, cardiac enzymes, and echocardiography. Comparing those with ACD to those without showed no significant differences in age, gender, blood pressure, diabetes, smoking status, or prior heart disease. However, hypertension was significantly more common in patients with ACD (100% vs. 79.71%, p<0.00001). Elevated cardiac troponin

I (cTnI) levels were also significantly higher in ACD patients (100% vs. 28.99%, p<0.001), indicating a strong association between elevated cTnI and ACD.

In terms of RWMA patterns among ACD patients, 4 (57.14%) displayed an apex-sparing RWMA pattern, while 3 (42.85%) exhibited RWMA involving the apex of the left ventricle. Importantly, the study found that RWMA patterns in ACD patients with acute stroke extended beyond a single coronary artery territory, suggesting these cardiac changes were more likely a consequence of the stroke itself than underlying coronary artery disease.

DISCUSSION

This study explores the prevalence and types of cardiovascular abnormalities in patients experiencing an acute stroke. The findings highlight a significant incidence of electrocardiographic (ECG) and echocardiographic abnormalities among stroke patients, emphasizing the potential for cardiac complications in the acute phase of cerebrovascular events. These insights contribute to a deeper understanding of the cardiac impact of both ischemic and hemorrhagic strokes and underline the importance of integrating cardiovascular assessment in the management of stroke patients.One of the key findings in this study is the high frequency of repolarization abnormalities and ischemia-like ECG changes in acute stroke patients. QTc prolongation was observed in 46% of the patients, while T-wave abnormalities and ST-segment depression were seen in 42.1% and 28.9% of cases, respectively. These findings are consistent with prior studies indicating that stroke, particularly in the acute phase, can induce significant ECG changes that resemble ischemic heart disease. The pathophysiology underlying these changes likely involves a combination of autonomic dysregulation and neurogenic injury, both of which are heightened in the acute phase of a stroke. The autonomic nervous system plays a vital role in cardiac function, and during a stroke, the increased sympathetic activity can lead to myocardial damage and alterations in cardiac repolarization, leading to QTc prolongation, T-wave changes, and ST-segment shifts.Interestingly, these ischemia-like ECG changes were more prevalent among patients with hemorrhagic stroke compared to those with ischemic stroke. Hemorrhagic stroke tends to provoke more pronounced autonomic dysregulation, resulting in heightened catecholamine release. This surge in catecholamines can directly impact cardiac myocytes, contributing to ECG abnormalities that mimic myocardial ischemia. These findings align with previous studies, where hemorrhagic stroke patients demonstrated a greater tendency toward ECG abnormalities than those with ischemic stroke. This differential prevalence of cardiac abnormalities between stroke subtypes underscores the need for distinct clinical approaches to managing ischemic versus hemorrhagic stroke patients, especially in terms of cardiovascular monitoring.The study also observed a notable prevalence of arrhythmias, with atrial fibrillation (AF) being the most frequent arrhythmia, detected in 13.2% of the patients. AF is a well-documented risk factor for ischemic stroke, as it can contribute to thromboembolism formation and increase the likelihood of a cerebrovascular event. However, the presence of AF in this study was not limited to patients with a previous history of cardiovascular disease, indicating that AF can also emerge as a secondary manifestation of acute stroke. The relationship between stroke and AF appears to be bidirectional; while AF increases the risk of ischemic stroke, stroke-induced autonomic disturbances and stress may precipitate AF as well. This reciprocal relationship underscores the need for close cardiac monitoring in acute stroke patients, as identifying AF early on can help reduce the risk of recurrent stroke and guide appropriate anticoagulation therapy.Despite excluding patients with pre-existing heart disease, the study found that ECG and echocardiographic abnormalities remained prevalent in acute stroke patients. This finding reinforces the hypothesis that the observed cardiovascular changes are not simply a reflection of underlying heart disease but may instead be triggered directly by the stroke event itself. Such changes may occur due to neurogenic myocardial injury, which is increasingly recognized as a phenomenon in acute neurological disorders, including stroke. Neurogenic myocardial injury, often mediated by excessive sympathetic stimulation, can lead to cardiac dysfunction and even mimic acute coronary syndrome. Therefore, recognizing these stroke-induced cardiac changes is essential for differentiating them from primary cardiac conditions, which can alter the management approach and avoid unnecessary cardiac interventions.Another significant finding in this study is the incidence of Acute Cardiac Dysfunction (ACD) in 9.2% of stroke patients, manifesting as left ventricular (LV) systolic dysfunction. Notably, the LV dysfunction observed in this study differed from that typically seen in Takotsubo Syndrome (TTS). Unlike TTS, which often displays a pattern of LV apical ballooning, ACD in these stroke patients exhibited a higher rate of apex-sparing LV dysfunction. This unique pattern suggests that the cardiac dysfunction associated with acute stroke may have a distinct

pathophysiological basis, perhaps more related to diffuse sympathetic stimulation rather than regional coronary ischemia. Additionally, ACD was observed equally among men and women in this study, which is another contrast to TTS, where women are more commonly affected.This study's echocardiographic findings further emphasize the spectrum of cardiac abnormalities in acute stroke patients. Left ventricular hypertrophy (LVH) was present in 25% of patients, and regional wall motion abnormalities (RWMA) were noted in 19.7%. LVH in stroke patients may be indicative of longstanding hypertension, which is a major risk factor for both stroke and cardiac remodeling. Meanwhile, RWMA, particularly when present without prior heart disease, suggests that acute stroke may indeed lead to myocardial dysfunction independent of coronary artery disease. These structural and functional cardiac changes highlight the complex interplay between cerebrovascular and cardiovascular health, necessitating a multidisciplinary approach to stroke management.The clinical implications of these findings are substantial. The high prevalence of cardiovascular changes in acute stroke patients calls for routine cardiac assessment, including ECG and echocardiography, during the initial evaluation and management of stroke. Recognizing these changes can help clinicians better assess the patient's risk profile, identify those at greater risk for adverse cardiac events, and guide therapeutic decisions, such as anticoagulation and monitoring for arrhythmias. Moreover, understanding the unique characteristics of ACD associated with stroke, particularly in the context of apex-sparing LV dysfunction, can help avoid misdiagnosis and inappropriate interventions.In conclusion, this study highlights the critical need to consider cardiac evaluation as an integral part of stroke care. The significant prevalence of ECG abnormalities, arrhythmias, and echocardiographic findings in acute stroke patients underscores the interconnected nature of cerebrovascular and cardiovascular health. Future studies are warranted to further explore the underlying mechanisms of stroke-related cardiac dysfunction and to develop targeted strategies for managing these complex patients.

CONCLUSION :

In this study, the most common ECG changes identified in acute stroke patients were repolarization abnormalities, particularly QTc prolongation (46%), along with ischemia-like changes, including T-wave abnormalities (42.1%) and ST-segment depression (28.9%). These ECG alterations were more frequently observed in patients with hemorrhagic stroke than those with ischemic stroke. Atrial fibrillation emerged as the most prevalent arrhythmia. Notably, even after excluding patients with a prior history of heart disease, ECG changes and echocardiographic abnormalities remained significantly present in acute stroke cases.Furthermore, 9.2% of acute stroke patients in this study displayed Acute Cardiac Dysfunction (ACD) associated with stroke. In contrast to Takotsubo Syndrome, ACD occurred at similar rates among both men and women, with a notable pattern of apex-sparing LV systolic dysfunction.

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