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RESEARCH ARTICLE

Early ECG Patterns in Acute Cerebrovascular Events: A Prospective Study Correlating Clinical Findings with Mortality and Medico-Legal Considerations

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ABSTRACT

Objective: Acute cerebrovascular events (CVE), such as strokes, often manifest with early electrocardiographic (ECG) changes. These ECG patterns can provide crucial insights into the patient's prognosis and are essential in medico-legal cases. Understanding the correlation between these early patterns and patient outcomes, especially mortality, is vital for improving care and providing forensic clarity. To assess early ECG changes in patients with acute cerebrovascular events, correlating clinical findings with mortality, and exploring their medico-legal implications.

Materials and Methods: This hospital-based prospective study involved 100 patients admitted with acute stroke to the Medical Intensive Care Unit and Medicine Department at a tertiary care center from 2020 to 2021. Participants were selected through simple random sampling, ensuring equal inclusion chances. Data were collected within 24 hours of admission, including ECGs, clinical histories, and demographic details, and analyzed using SPSS.

Results: The study highlighted critical medico-legal implications, finding that 78% of 100 patients with acute cerebrovascular events exhibited ECG changes. Notably, 89% of hemorrhagic stroke patients showed abnormalities. Statistical analysis revealed significant correlations between early ECG findings and clinical severity, with a Chi-square value of $x^2 = 13.14$ ($p=0.001396$). At the same time, mortality differences based on ECG status were not statistically significant ($p=0.079$).

Conclusion: This study emphasizes the importance of early ECG abnormalities in acute cerebrovascular events, linking them to clinical severity and mortality. Findings suggest a higher mortality rate in patients with abnormal ECGs, but further research is necessary to strengthen these associations and improve care. Medico-legal aspects involve the timely interpretation of ECGs, ensuring informed consent, accurate record-keeping, and maintaining accountability to prevent negligence and malpractice.

Keywords: Acute cerebrovascular accident, electrocardiogram (ECG) changes, mortality, medico-legal considerations, prognostic indicators, stroke outcomes

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INTRODUCTION

Stroke is a leading cause of death and disability in India, with an estimated prevalence rate that varies significantly between rural and urban areas. Reports indicate prevalence rates of 84 to 262 strokes per 100,000 individuals in rural regions and 334 to 424 per 100,000 in urban locales.[1] Notably, the case fatality rates also differ widely, with Kolkata reporting the highest at 42%.[2] In response to this growing public health crisis, the Government of India has initiated the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke (NPCDCS).[3] This program aims to enhance early diagnosis, improve management strategies, develop healthcare infrastructure, raise public awareness, and build capacity across various healthcare levels for non-communicable diseases, including stroke.[4] The stroke epidemic necessitates a concerted

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effort from both government and private sectors to mitigate its impact.[5] Beyond mortality, stroke is a primary cause of functional impairments, with approximately 20% of survivors requiring institutional care three months post-event and 15% to 30% facing permanent disability. The consequences of stroke extend beyond the affected individuals, impacting their families and caregivers as well.[1,6] Recent reports reveal that the incidence and 30-day case fatality rates for stroke in India are higher than those observed in developed nations.[7] The rising prevalence of non-communicable diseases, such as stroke and coronary artery disease, is evident in both rural and urban India. Electrocardiographic (ECG) changes associated with acute stroke have been documented since 1947, leading to numerous case reports and studies detailing arrhythmias, conduction abnormalities, and repolarization changes in patients experiencing various forms of stroke, including subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH), cerebral infarction (CI), and transient ischemic attacks (TIA).[8–10] In 2002, a group of cerebrovascular experts proposed redefining TIAs from an arbitrary time-based definition to a more precise tissue-based definition. This new definition characterizes TIA as a "brief episode of neurological dysfunction caused by focal brain or retinal ischemia, with clinical symptoms typically lasting less than one hour and without evidence of acute infarction.[11] Acute cerebrovascular events, commonly referred to as strokes, significantly contribute to global morbidity and mortality. Recognizing the early clinical manifestations of strokes is essential for prompt intervention and improved patient outcomes.[12] Recent studies have underscored the importance of electrocardiography (ECG) in detecting cardiac abnormalities that may accompany acute cerebrovascular incidents.[13] Early identification of specific ECG patterns can provide valuable insights into the pathophysiological processes occurring during a stroke, potentially influencing treatment strategies and prognostic evaluations.[14] It is widely understood that reduced cardiac output—common in conditions like heart failure, myocardial infarction, and various rhythm or conduction disturbances—can lead to cerebral hemodynamic and metabolic abnormalities.[15] However, the reciprocal adverse effects of stroke on cardiac function are less frequently acknowledged. Clinical studies indicate that stroke patients may experience unexpected cardiac events, including arrhythmias or severe hypotension, even in the absence of pre-existing heart conditions.[16] While numerous studies have documented ECG abnormalities in stroke patients, these findings have often been incidental, based primarily on sporadic ECG recordings. The medico-legal aspect of "Early ECG Patterns in Acute Cerebrovascular Events" revolves around timely diagnosis, accurate interpretation, and proper documentation.[17,18] Healthcare providers have a legal obligation to recognize abnormal ECG findings that may indicate impending strokes or ischemic events.[19] Misinterpretation or delayed action could result in medical negligence claims, especially if it leads to death or serious injury.[20] Additionally, informed consent plays a vital role, as patients must be aware of the risks associated with cerebrovascular events and their ECG findings.[21] In forensic cases, ECG patterns can be key evidence in determining the cause and timing of death, emphasizing the need for accurate medical record-keeping to ensure legal accountability and avoid malpractice claims.[22] ECG changes in CVA patients are important because they can identify arrhythmias or ischemia, and even predict outcomes. ECG also aids in detecting stroke causes like atrial fibrillation and provides vital insights for better patient care and documentation.[19,22]

Aims

To assess early ECG changes in patients with acute cerebrovascular events, correlating clinical findings with mortality, and exploring their medico-legal implications.

Objectives

1. To evaluate ECG changes observed in the first 24 hours in patients with CVA.
2. To study the relationship between ECG changes and mortality in patients with acute cerebrovascular accidents.

MATERIALS and METHODS

Study Design

This hospital-based prospective study was conducted on 100 patients admitted with acute stroke to the Medical Intensive Care Unit (MICU) and the Department of Medicine wards of a tertiary care center between 01 February 2020 and 31 July 2021. The study received approval from the Institutional Ethics Committee (reference number MMC/IEC/2020/68). Informed consent was obtained from all participants before data collection, and participants were assured that their responses would remain confidential and anonymous throughout the research. A simple random sampling technique was employed to select participants for the study, ensuring each eligible patient had an equal chance of being included.

Inclusion Criteria

The inclusion criteria for the study were as follows: patients aged 18 years and above, of both sexes, admitted

Table 1. Incidence of abnormal ECG in the study group

Study froup	No of cases	Abnormal cases	%
Cerebral infarction	54	38	70
Cerebral hemorrhage	40	34	89
Subarachnoid hemorrhage	6	6	100
Total	100	78	78

ECG: Electrocardiographic

within 24 hours of the onset of neurological deficits. Additionally, patients who developed a stroke during their hospital stay and had an ECG taken within 24 hours, which was compared to previous ECGs, were also included. Those patients whose detailed neurological and cardiovascular examination was performed and whose prior ECGs were reviewed were also included. Patients with a history of risk factors such as hypertension, diabetes, ischemic heart disease (IHD), and alcohol use were also part of the study. Furthermore, patients who underwent blood tests, lumbar punctures, and cardiac marker testing were included, provided they had a diagnosis of non-embolic ischemic stroke confirmed by CT or MRI.

Exclusion Criteria

Patients with a known history of coronary artery disease (CAD), structural heart disease, atrial fibrillation, or previously abnormal ECGs were excluded. However, underlying conditions that went undetected due to the absence of prior ECGs may have been overlooked. Patients admitted more than 24 hours after the onset of symptoms were also excluded, as ECG changes tend to diminish beyond this time frame. Additionally, cases with neurological deficits caused by infections, neoplasms, or trauma were excluded. Patients who recovered within 24 hours (transient ischemic attacks, TIA) were excluded as well. Subarachnoid hemorrhage cases requiring emergency surgery were excluded, along with large hemorrhagic strokes presenting with midline shifts greater than 5 mm.

Data Collection

Detailed clinical histories were taken, and electrocardiographic (ECG) recordings were performed within 24 hours of admission. Additional data were also collected, including demographic details, comorbidities, and clinical outcomes.

Statistical Analysis

Data were analyzed using SPSS (Statistical Presentation System Software). (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) Descriptive statistics were used to summarize the patient characteristics, and chi-square tests were employed to correlate ECG findings with mortality outcomes. A p-value <0.05 was considered statistically significant.

RESULTS

The study revealed critical medico-legal implications regarding ECG findings in acute cerebrovascular events (CVA). Among the 100 patients enrolled, 78% exhibited some form of ECG changes. Specifically, abnormal ECG findings were documented in 89% of patients with hemorrhagic strokes, 70% of those with infarcts, and 100% of patients with subarachnoid hemorrhage (SAH) (Table 1). Early ECG patterns were analyzed within the first 24 hours of hospital admission, revealing that ST-segment changes were most common following cerebral hemorrhage. Notably, 33% of patients with infarction presented with ST depression, while 50% of those with intracerebral hemorrhage (ICH) displayed ST elevation (Table 2 and Fig. 1). Statistical analysis demonstrated a strong correlation between early ECG abnormalities and clinical severity, assessed using the National Institutes of Health Stroke Scale (NIHSS). The Chi-square value was x^2 =13.14 (p=0.001396),

Table 2. Incidence of ST segment changes in the study group

Study group	Total no cases	Standart segment elevation		Standart depression segment		Percentage with ST-segment changes	
		n	%	n	%	n	%
Cerebral infarction	54	2	3	18	33. 3	20	37
Cerebral hemorrhage	40	20	50	4	10	26	60
Subarachnoid hemorrhage	6	2	33. 3	0	0	2	33. 3

ST: Standart

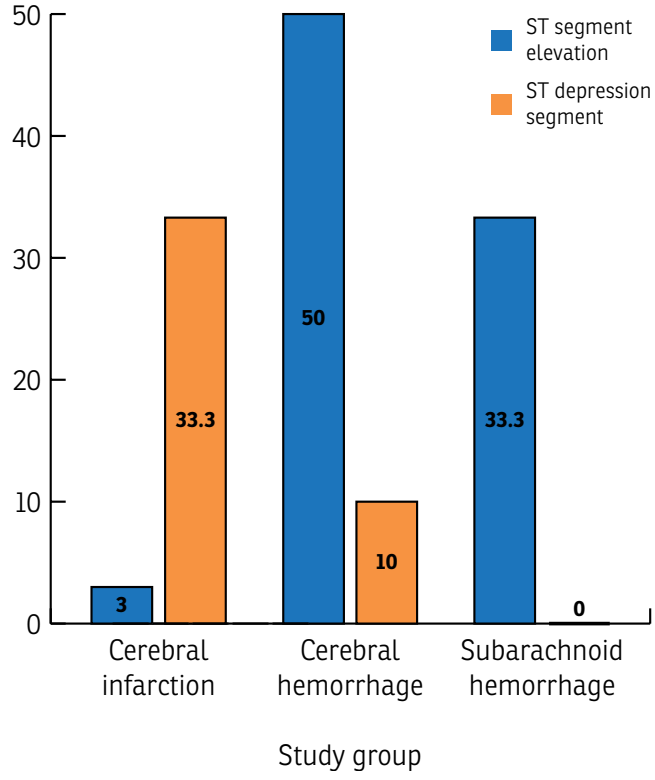

Figure 1. Incidence of ST segment changes in the study group

ST: Standart

indicating significant differences in mortality among various stroke types, with SAH showing the highest mortality rates (Table 3). Regarding mortality outcomes, although a trend suggested increased mortality among patients with abnormal ECGs, the analysis resulted in a Chi-square value of x^2=3.0811 (p=0.079), indicating that the difference in mortality between patients with normal and abnormal ECGs was not statistically significant. This suggests that, while there may be an association, it is insufficiently robust to establish a definitive link within this study (Table 4).

DISCUSSION

Clinical violence in the form of psychological trauma and stress indeed affects the cardiovascular system. The sympathetic nervous system activates due to stress, producing physiological responses such as tachycardia, high myocardial oxygen demand, and altered repolarization patterns. The common ECG abnormalities include sinus tachycardia, ST-segment elevation, or depression, indicative of ischemia. These ECG findings are significant biomarkers of stress or injury, with important medico-legal implications that offer corroborative evidence in clinical violence cases. These patterns are important for clinicians and forensic experts in assessing violence's physiological impact and contribute to medical management and legal investigations.[23,24]

Another study conducted by Lee et al.[25] in 2024 found that ECG abnormalities, such as left atrial enlargement, left ventricular hypertrophy, atrial fibrillation, and significant Q-wave and ST-T abnormalities, were linked to increased cardiovascular mortality even in a low-risk population.

In 2024, de Alencar Neto et al.[26] described primary T waves as symmetrical with broad bases and variable QT intervals, reflecting ischemia, electrolyte imbalances, or channelopathies. Secondary T waves are asymmetric with minimal QT changes, linked to depolarization or structural alterations. We propose a unified ECG analysis framework to improve diagnosis beyond ischemia.

A study conducted by Sebastian et al.[27] in 2023 found that ECG changes are frequently observed in acute stroke cases, regardless of the type of stroke. Specifically, ST and T wave inversions were commonly seen in ischemic strokes, while T wave inversions and arrhythmias were more prevalent in hemorrhagic strokes. Additionally, the study highlighted that mortality rates were higher in patients who exhibited abnormal ECG findings following an acute cerebrovascular event.

Table 3. Mortality in stroke types

Cases	Cerebral infarction (n=54)		Cerebral hemorrhage (n=40)		Subarachnoid hemorrhage (n=6)	
	No	%	No	%	No	%
Alive	44	81.48	32	80	1	16.66
Dead	10	18.51	8	20	5	83.33

Chi-square value p=0.001396 (p<0.05 is significant). x^2=13.14

Table 4. Relationship of mortality with abnormal ECG in stroke patients

Cases	Electrocardiogram			
	Normal (n=22)		Abnormal (n=78)	
	No	%	No	%
Alive	20	90.90	57	82.05
Dead	2	9.09	21	17.95

Chi-square value p=0.079 (p>0.05 is not significant). χ^2=3.0811. ECG: Electrocardiographic

A study conducted by Sinai Talaulikar et al.[28] in 2013 highlighted that most medico-legal cases share common issues, which can be attributed to several factors, including a) difficulty in interpreting fetal heart rate (FHR) tracings, b) inappropriate actions taken during care, c) technical shortcomings, and d) inadequate record-keeping.

In a 2009 study by Kaikkonen et al.[29] survivors (n=644) and victims (n=425) of sudden cardiac death (SCD) from acute coronary events were compared. Risk factors for SCD included family history, male gender, smoking, cardiac hypertrophy, and CAD severity. When all factors were present, 100% mortality occurred. In familial SCD cases, the risk was tied to CAD severity, suggesting genetic factors accelerate CAD progression, contributing to SCD.

In a 2023 study by Montisci et al.[30] the authors emphasize the importance of collaboration between forensic pathologists and experts in cardio pathology, cardiology, or cardiac surgery, particularly in cases of alleged medical malpractice in the cardiology field. Adhering to established guidelines for investigating deaths related to cardiac disease is crucial for minimizing criticism of case analyses in medico-legal contexts and promoting consistency in the handling of medical malpractice lawsuits from both legal and medical perspectives.

In a 2014 study conducted by Purushothaman et al.[31] 100 cases were examined, revealing 58 ischemic and 42 hemorrhagic strokes. ECG changes were observed in 78 patients. In the ischemic group, the following ECG changes were noted: T wave inversion (34.48%), ST segment depression (32.75%), QTc prolongation (29.31%), and U waves (27.58%). For the hemorrhagic stroke cases, the changes included: T wave inversion (33.33%), arrhythmias (33.33%), U waves (30.95%), and ST segment depression (23.80%). Mortality rates were higher in the ischemic group among patients with ST-T changes (66.66%) and in the hemorrhagic group among those with positive U waves (60%).

A study by Prosser et al.[32] in 2007 found that serious cardiac events are common shortly after a stroke. Patients at the highest risk can be identified and may benefit from more aggressive treatment strategies to enhance their chances of survival.

A study by Khechinashviliet al.[33] in 2002 found that over 90% of unselected patients with ischemic stroke and intracerebral hemorrhage exhibited specific ECG changes. However, this prevalence decreased significantly in patients without preexisting heart disease. While these ECG changes showed high sensitivity, they had very low specificity compared to other cardiac abnormalities. In cases of subarachnoid hemorrhage, such changes are largely due to cerebral conditions, and their absence indicates no cardiac issues. In ischemic stroke and intracerebral hemorrhage, these abnormalities typically indicate preexisting coronary artery disease, and their specificity for diagnosing acute myocardial infarction is low during an acute stroke.

Limitations

The study has several limitations. The sample size of 100 patients and the single-center design may limit the generalizability of the findings. The strict exclusion criteria could introduce selection bias, omitting relevant comorbidities. Evaluating ECG changes solely within the first 24 hours restricts the comprehensiveness of the data, and the lack of longitudinal follow-up prevents insights into long-term outcomes. No additional analyses have been conducted regarding the specificity and sensitivity of ECG changes. Additionally, while a correlation between ECG abnormalities and clinical severity was noted, the lack of statistical significance in mortality outcomes (p=0.079) necessitates cautious interpretation. Finally, the study emphasizes the need for further research and practical recommendations regarding integrating ECG analysis into clinical practice.

CONCLUSION

This study underscores the significant role of early ECG abnormalities in patients with acute cerebrovascular events (CVA), highlighting their implications for clinical assessment and medico-legal considerations. With 78% of patients exhibiting ECG changes, particularly notable in those with hemorrhagic strokes and subarachnoid hemorrhage, early detection of these abnormalities can provide critical insights into the severity of the condition. The strong correlation between ECG findings and clinical severity, as evidenced by the NIHSS, emphasizes the importance of integrating ECG analysis into standard evaluation protocols for CVA patients. However, while a trend suggests higher mortality among those with abnormal ECGs, the lack of statistically significant findings in this study indicates that further research is needed

to explore the underlying mechanisms and strengthen the association. Understanding these dynamics is essential for improving patient outcomes and enhancing the quality of care in acute stroke management. Additionally, the implications of ECG findings in medico-legal contexts necessitate careful documentation and consideration in cases of CVA, as they can influence legal outcomes related to patient care standards and liability. Overall, this research highlights the need for continued investigation into the prognostic value of ECG patterns in cerebrovascular events, aiming to refine diagnostic and therapeutic approaches in clinical practice.

Recommendation

Based on the study's findings, it is recommended that healthcare facilities incorporate routine ECG monitoring for patients with acute cerebrovascular events to enhance early detection of abnormalities. Training programs should be developed for medical staff to improve ECG interpretation skills. Further research is needed to explore the prognostic value of specific ECG patterns in stroke outcomes. Clinical guidelines should be updated to emphasize the importance of ECG assessments, and stringent documentation practices must be established for medico-legal purposes. Finally, fostering interdisciplinary collaboration between cardiologists and neurologists can improve the overall management of CVA patients.

Disclosures

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REFERENCES

1. Taylor FC, Suresh Kumar K. Stroke in India factsheet (updated 2012). South Asia Network for Chronic Disease, IIPH Hyderabad. India: Public Health Foundation of India; 2012.
2. Ray BK, Hazra A, Ghosal M, Banerjee T, Chaudhuri A, Singh V, Das SK. Early and delayed fatality of stroke in Kolkata, India: results from a 7-year longitudinal population-based study. J Stroke Cerebrovasc Dis 2013;22:281–9. [CrossRef]
3. Kashyap VH, Shivaswamy MS. Assessment of implementation of the national program for the prevention and control of cancer, diabetes, cardiovascular diseases, and stroke at subcenters of Belagavi taluka: A cross-sectional study. Indian J Health Sci Biomed Res KLEU 2019;12:21–7. [CrossRef]
4. Haque M, Islam T, Rahman NA, McKimm J, Abdullah A, Dhingra S. Strengthening primary health-care services to help prevent and control long-term (chronic) non-communicable diseases in low-and middle-income countries. Risk Manag Healthc Policy 2020;13:409–26. [CrossRef]
5. Hachinski V, Donnan GA, Gorelick PB, Hacke W, Cramer SC, Kaste M, et al. Stroke: working toward a prioritized world agenda. Stroke 2010;41:108–499. [CrossRef]
6. Tour PG. 27. European Stroke Conference, Athens, Greece 2018 Scientific Programme Overview-Friday 13 April 2018. Scientific Programme-Abstract E-book 2018. Cerebrovasc Dis 2018;45(Suppl 1):1–485. [CrossRef]
7. Das SK, Banerjee TK, Biswas A, Roy T, Raut DK, Mukherjee CS, et al. A prospective community-based study of stroke in Kolkata, India. Stroke 2007;38:906–10. [CrossRef]
8. Pandian JD, Srikanth V, Read SJ, Thrift AG. Poverty and stroke in India: A time to act. Stroke 2007;38:3063–9. [CrossRef]
9. Byer E, Ashman R, Toth LA. Electrocardiograms with large upright T waves and long QT intervals. Am Heart J 1947;33:796–806. [CrossRef]
10. Burch GE, Meyers R, Abildsokv JA. A new electrocardiographic pattern was observed in cerebrovascular accidents. Circulation 1954;9:719–23. [CrossRef]
11. Wasserman F, Choquette G, Cassinelli R Bel-let S. Electrocardiographic observations in patients with cerebrovascular accidents: report of 12 cases. Am J Med Sci 1956;231:502–10. [CrossRef]
12. Prabhakaran S, Ruff I, Bernstein RA. Acute stroke intervention: a systematic review. JAMA 2015;313:1451–62. [CrossRef]
13. Ceasovschih A, Şorodoc V, Covantsev S, Balta A, Uzokov J, Kaiser SE, et al. Electrocardiogram features in non-cardiac diseases: From mechanisms to practical aspects. J Multidiscip Healthc 2024;17:1695–719. [CrossRef]
14. Silva MS, Resende EH, Silva JT. The importance of early diagnosis and treatment of atrial fibrillation for the prevention of ischemic stroke [A importância do diagnóstico e tratamentoprecoces da fibrilação atrial para a prevenção do acidente vascular cerebral isquêmico]. Rev Med (São Paulo) 2024;103:224916. [Portuguese] [CrossRef]
15. Singh RR, Yadav PK, Jaiswal S, Singh S, Dixit A, Tripathi SK. Distribution of association between basic knowledge of chest pain and myocardial infarction (heart attack) and demographic variables: A survey-based study. J Cardiol 2024;8:1–6. [CrossRef]
16. Sposato LA, Hilz MJ, Aspberg S, Murthy SB, Bahit MC, Hsieh CY, et al; World Stroke Organisation Brain & Heart Task Force. Post-stroke cardiovascular complications and neurogenic cardiac injury: JACC state-of-the-art review. J Am Coll Cardiol 2020;76:2768–85. [CrossRef]
17. Singh RR, Jha S, Mittal R, Tripathi SK, Kumari S, Yadav PK. Ethical Dilemmas in Emergency Anesthesia: A systematic review. International Medicine 2023;9:1–6.
18. sede di Grosseto SE. Pathology/Biology 2022, Meeting and surpassing the challanges of a modern. Forensic Sci World 2022:737.

19. Jauch EC, Saver JL, Adams Jr HP, Bruno A, Connors JJ, Demaerschalk BM, et al. Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2013;44:870–947. [CrossRef]
20. Kachalia A, Gandhi TK, Puopolo AL, Yoon C, Thomas EJ, Griffey R, et al. Missed and delayed diagnoses in the emergency department: a study of closed malpractice claims from 4 liability insurers. Ann Emerg Med 2007;49:196–205. [CrossRef]
21. Easton JD, Saver JL, Albers GW, Alberts MJ, Chaturvedi S, Feldmann E, et al; American Heart Association; American Stroke Association Stroke Council; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular Nursing; Interdisciplinary Council on Peripheral Vascular Disease. Definition and evaluation of transient ischemic attack: a scientific statement for healthcare professionals from the American Heart Association/American Stroke Association Stroke Council; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular Nursing; and the Interdisciplinary Council on Peripheral Vascular Disease. The American Academy of Neurology affirms the value of this statement as an educational tool for neurologists. Stroke 2009;40:2276–93. [CrossRef]
22. Darnell C. Forensic Science in Healthcare: Caring for Patients, Preserving the Evidence. Boca Raton, FL, USA: CRC Press; 2018.
23. Murali R, Chen E. Exposure to violence and cardiovascular and neuroendocrine measures in adolescents. Ann Behav Med 2005;30:155–63.
24. Gottman JM, Jacobson NS, Rushe RH, Shortt JW, Babcock J, La Taillade JJ, et al. The relationship between heart rate reactivity, emotionally aggressive behavior, and general violence in batterers. InDomestic Violence (pp. 161–182). London: Routledge; 2017. [CrossRef]
25. Lee SH, Lee MY, Kang J, Choi HI, Lee SJ, Lee JY, et al. Association between ECG abnormalities and mortality in a low-risk population. J Am Heart Assoc 2024;13:e033306. [CrossRef]
26. de Alencar JN, de Andrade Matos VF, Scheffer MK, Felicioni SP, De Marchi MFN, Martínez-Sellés M. ST segment and T wave abnormalities: A narrative review. J Electrocardiol 2024;85:7–15. [CrossRef]
27. Sebastian S, Roy JS. Electrocardiographic changes in acute cerebrovascular accidents-a tertiary center experience in South India. IP J Nutr Metab Health Sci 2023;3:132–4. [CrossRef]
28. Sinai Talaulikar V, Arulkumaran S. Medico-legal issues with CTG interpretation. Curr Women's Health Rev 2013;9:145–57. [CrossRef]
29. Kaikkonen K. Risk factors for sudden cardiac death from an acute ischemic event in the general population: a case-control study. Oulu, Finland: University of Oulu; 2009.
30. Montisci R, Licciardi M, Cecchi R, Kondo T, Gerosa G, Casula R, et al. Malpractice claims in cardiology and cardiac surgery: A medico-legal issue. Legal Med 2023;65:102319. [CrossRef]
31. Purushothaman S, Salmani D, Prarthana KG, Bandelkar SM, Varghese S. Study of ECG changes and its relation to mortality in cases of cerebrovascular accidents. J Nat Sci Biol Med 2014;5:434–36. [CrossRef]
32. Prosser J, MacGregor L, Lees KR, Diener HC, Hacke W, Davis S. Predictors of early cardiac morbidity and mortality after ischemic stroke. Stroke 2007;38:2295–302. [CrossRef]
33. Khechinashvili G, Asplund K. Electrocardiographic changes in patients with acute stroke: a systematic review. Cerebrovasc Dis 2002;14:67–76.