

SPECTRUM OF ELECTROCARDIOGRAPHIC & CLINICAL MANIFESTATIONS AMONG THE SURVIVORS OF LIGHTNING INJURY

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ABSTRACT

Background: Lightning strike is a natural, unavoidable and unpredictable celestial phenomenon. Ventricular fibrillation and cardiac arrest due to depolarisation of cardiac myocardium is the most common cause of death after an episode of lightning. Around 70% victims survive from the episode of direct lightning injury. However splash of lightning leaves deep electrocardiographic imprints with devastating clinical sequelae in the survivors.

Objective: To assess electrocardiographic and clinical outcomes of the patients survived out of lightning injury.

Materials & Methods: A descriptive study taking a series of cases suffered from lightning injury was conducted in VIMSAR, Burla, between May 2020 to May-2021. Eight patients those who survived from lightning injury and presented to the emergency department (ED) with abnormal ECG findings were finally chosen as the study participants.

Results: Patients, those who survived from lightning injury were found to present with electrocardiographic (ECG) pictures of myocardial ischemia or infarction with dreadful complications like left ventricular failure, cardiac arrest and fatal arrhythmias like ventricular tachycardia. Echocardiographic findings, biomarker values were found to be normal in some cases despite characteristic electrocardiographic findings of ischemia or infarction. Angiogram findings were found to be invariably normal in all cases. Abnormal ECG/Echo findings reverted back to normal spontaneously or after intervention during hospitalisation. **Conclusion:** Mechanisms other than coronary athero-thrombosis i.e coronary vasospasm, autonomic stimulation, local thermal injury can have important roles in the pathogenesis of electrocardiographic manifestations in patients survived from lightning injury. Therefore these manifestations most often transient and can be discordant to echocardiographic and laboratory findings like cardiac biomarkers. Patient can develop fatal complications during this transient period. Hence timely appropriate interventions and close follow up can save many lives.

Keywords: Angiography, Biomarker, Electrocardiography, Echocardiography, Lightning injury

Introduction:

Lightning strike is a natural unavoidable and unpredictable celestial phenomenon. Odisha, a coastal state of India, has been considered as a disaster hub of India due to higher occurrence of cyclones, trending towards as a lightning hub in the early 21st century.¹ Lightning is considered as one of the major natural disasters in Odisha. The typical subtropical geo-climate of Odisha with hilly terrains and mountains makes it more susceptible for lightning. As a substantial proportion of population of the state are farmers, thus they are more susceptible to lightning, while working in their field mostly during monsoon. In the state of Odisha, on an average 350 lives lost every year due to lightning, which is higher than the number of fatalities due to other types of disasters.¹ The state itself contributes 13.36% of death which accounts about 9.4 lakhs deaths due to lightning in India has been recorded in the year 2019(1) Ventricular fibrillation and cardiac arrest due to depolarisation of cardiac myocardium is the most common cause of death after an episode of lightning.² Lightning is deadliest among types of current injury due to its unique unidirectional high voltage splash of current.³ Around 70% victims survive from the episode of direct lightning injury.⁴ However splash of lightning leaves deep

electrocardiographic imprints with devastating clinical sequelae in the survivors. Present study will throw some light on the clinical presentations of the cases, those who have survived an episode of lightning injury and presented to the emergency department, with abnormal electrocardiographic manifestations and clinical sequelae.

Methods: A descriptive study taking a series of cases suffered from lightning injury was conducted in the department of cardiology, VIMSAR, Burla, between May-2020 to May-2021. The patients survived out of the episode of lightning injury, were presented within 12 hours of the episode to the emergency department and underwent urgent electrocardiography. Patients having abnormal ECG finding were enrolled in the study. Patients with previous history of any cardiac disease were excluded. A total of 8 patients were finalized as the study participants considering the above inclusion and exclusion criteria and the detailed clinical profile was studied from the series of cases after obtaining written informed consent from the participants. During general examination exit and entry mark of lightning injury, extent and degree of burn were noted. Presenting clinical symptoms e.g., chest pain, dyspnoea, palpitation, fatigability, syncope and signs e.g., s3, crepitation were noted in each patient. Blood samples were collected and sent to the diagnostic laboratory in every patients to evaluate cardiac biomarkers (like CK, CKMB, myoglobin, troponin etc.), serum electrolyte (sodium, potassium, calcium, and magnesium), Liver function test, renal function test etc. All patients underwent urgent bedside echocardiography to evaluate regional wall motion abnormality, EF and any other abnormal findings. Patients underwent coronary angiography as per the department guideline.

Observation:

Case 1: A 21 year male presented to the ED with chief complain of chest pain and dyspnoea after lightning injury having second-degree burns on back of his chest. Vital signs recorded at the time of presentation revealed; pulse rate of 156/ beats per minute, irregularly irregular and blood pressure of 166/98 mm of Hg. During cardiovascular (CVS) examination, S3 and basal crepitation were found. Electrocardiogram (ECG) of the patient showed ST elevation in leads II, III, aVF, V5 and V6 with atrial fibrillation (figure IA). Initial laboratory findings demonstrated significant elevation in cardiac enzymes, i.e troponin-I (6048 IU/L),CKMB(812 IU/L). Other lab findings showed leucocytosis (18,750/ μ L), liver enzymes elevated but Serum electrolytes were within normal range. Regional wall motion abnormality was observed in infero-posterior wall during bedside echocardiography. Patient was treated with antiplatelet, atorvastatin, oral nitroglycerine, metoprolol and low molecular weight heparin. Patient underwent urgent coronary angiography, which was found to be absolutely normal (Figure Ib,Ic). RWMA disappeared after 24 hours during repeat echocardiography. ECG findings reverted back to normal on 4th day and patient discharged after seven days of hospitalisation.

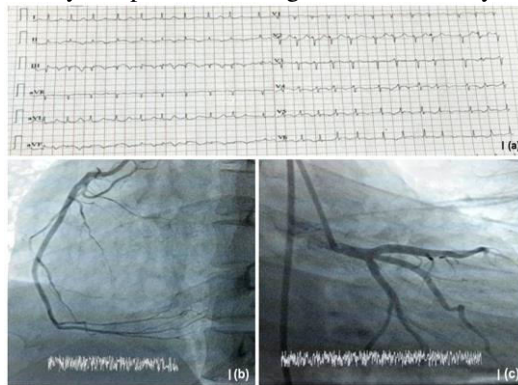


Figure I(a):ECG showing ST elevation with T wave inversion in infero-lateral leads with atrial fibrillation, Figure I(b,c): showing normal angiogram in the same patient.

Case 2: A 42-year-old male reached ED with severe angina having a history of lightning injury. On general examination, linear burn injuries found involving right side front of shoulder. Vitals at that time of presentation revealed pulse rate of 54 beats per minute, regular and blood pressure of 148/90 mm Hg. ECG showed T-wave inversion in inferior leads along with prolonged QT interval (Figure II); CK-MB was 820U/L. Blood sample for Troponin I was sent after 6 hours of incident, which was found to be 860 U/l. All other blood investigations including serum electrolytes were normal. Echocardiography showed normal contractility of left ventricle without any regional wall motional abnormality. Patient was treated with antiplatelet drugs, atorvastatin, oral nitroglycerine and low molecular weight heparin. Coronary angiography showed normal coronaries. His ECG findings reverted back to normal on 6th day and Patient discharged on 10th post admission day.

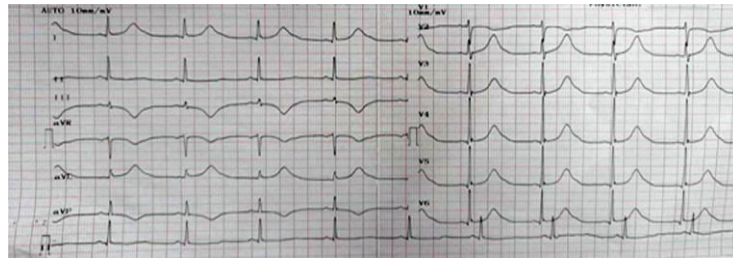


Figure II : ECG showing T wave inversion in inferior leads along with prolonged QT interval

Case 3: An 27 year-old male was brought to the emergency room due to lightning strike with presenting chief complaint of palpitation. Erythematous marks were present on the soles of his feet, right side of head. His blood pressure was non recordable and pulse was feeble, HR was 256/minute regular. ECG showed features of wide QRS regular tachycardia (Figure III a), which was reverted to normal sinus rhythm after cardioversion. ECG after reversion was normal. However deep T-wave inversion with QT prolongation in infero-lateral leads noted (Figure III b), which reverted back to normal on 7th day of hospitalisation. The initial laboratory investigation including cardiac biomarkers and serum electrolytes were normal. No regional wall motion abnormality observed during echocardiography.

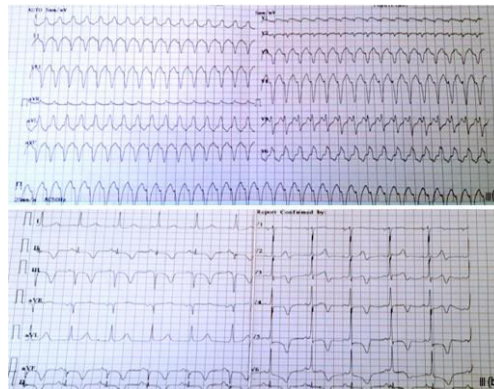


Fig III a: ECG showing wide QRS tachycardia in a patient after lightening injury. Figure IIIb: Showing deep T wave inversion with QT prolongation in infero-lateral leads with normal sinus rhythm after DC cardioversion

Case 4: A 40 year female came to the ED with severe chest pain after lightening injury. She was hemodynamically stable (BP= 136/84 mmHg, pulse = 96/min). On general examination there were serpiginous burns on ventral aspect of left arm. ECG was performed, which revealed symmetrical T-wave inversion in the anterior leads with prolonged QT interval (Figure IV). Echocardiographic findings and early cardiac biomarker values were found to be normal. Patient was treated with antiplatelet, atorvastatin, oral nitroglycerine, metoprolol and low molecular weight heparin. ECG findings reverted back to normal after 24 hours of admission.

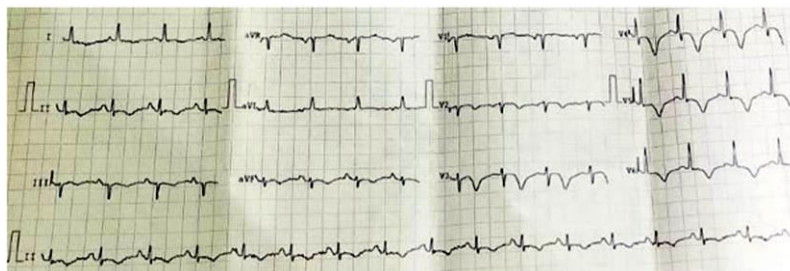


Figure IV: ECG of a case revealing symmetrical T-wave inversion in the anterior leads with prolonged QT interval

Case 5: A 37 year old patient was struck by a lightning, while standing below a tree due to heavy rain. He felt palpitation and reached the ED within two hours of episode. During General examination, no physical injuries or entry and exit mark noted. His pulse was feeble. Heart rate was irregularly irregular with rate 246/beats per minute and blood pressure was 88/64 mm of Hg. ECG revealed atrial fibrillation (Figure V). Rhythm reverted back to normal sinus rhythm after DC cardioversion. Echocardiographic finding of the patients were normal without having RWMA, LV dysfunction. All the laboratory investigations including Cardiac biomarkers were normal. He was treated with oral beta blocker and anticoagulant. Patients discharged after 7 days of observation.

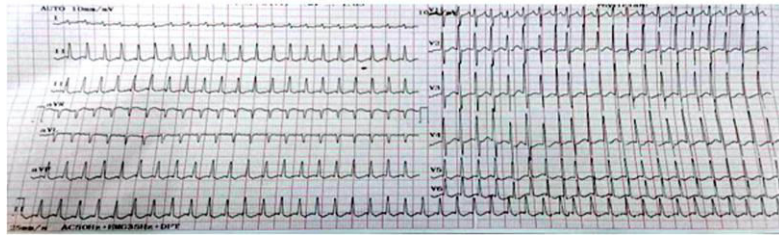


Figure V: showing atrial fibrillation in a patient after lightning injury

Case 6: A 52-year-old male was exposed to lightning strike while working in the field and reached the emergency department with severe chest pain. On general examination second-degree burn noticed on the front of both legs. ECG revealed RBBB with ST coving with deep T wave inversion in anterior leads along with prolonged QT interval (Figure VI). Patient's BP was 150/100 and pulse rate was 106 /minute, regular. Patient was given antiplatelet, atorvastatin, oral nitroglycerine, intravenous furosemide and anticoagulant. Urgent bedside echocardiography done and RWMA noticed in anterior wall. Cardiac marker values were high i.e CKMB(622 IU/L), troponin-I (8032 IU/L). Patient developed cardiac arrest within 30 minutes of admission. Cardiopulmonary resuscitation (CPR) was performed. The patient responded to CPR and was admitted to the ICU. Bedside X-ray showed feature of pulmonary oedema. Urgent angiography was performed, and found completely normal. Next day morning ECG was repeated and found normal. Therefore a repeat echocardiography was done. There was no RWMA in LAD territory.

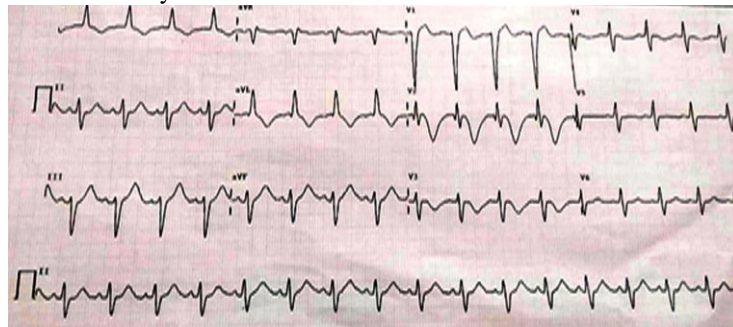


Figure VI (a) : ECG picture showing deep symmetrical T wave inversion in anterior leads with QT prolongation and loss of R wave in V1

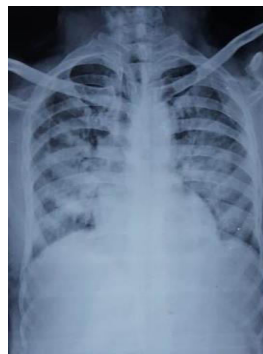


Figure VI (b): X-ray picture showing batwing appearance, suggestive of pulmonary oedema

Case 7. A 41 year male patient attended ED for lightning burn injury on front of both the legs and routinely underwent ECG, which revealed multiple VPC with bigeminal rhythm (FIGURE VII). On monitor there was intermittent non sustained ventricular tachycardia. However patient was completely asymptomatic. Patient's vitals were normal (BP = 112/84 and pulse rate = 86 /minute, irregularly, irregular). All laboratory investigations including cardiac biomarker and serum electrolyte were normal. Patients was treated with beta blocker and discharged after reversion of rhythm on 7th post admission day.

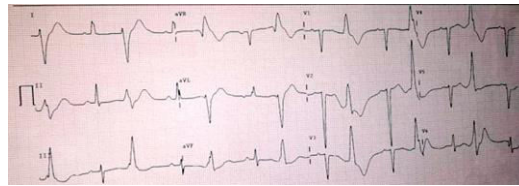


Figure VII: ECG feature of a patient showing multiple VPC with ventricular bigeminy

Case 8.A 31 year female patient attended with chief complaint of severe palpitation after exposure to lightning injury. On general examination, both exit or entry marks noticed over right hand and right parietal area of head respectively. Blood pressure of the patients was 118/86 mmHg, pulse was 184/minute, regular. ECG revealed narrow QRS regular tachycardia (Figure VIII), which reverted after adenosine therapy. All laboratory investigations including cardiac biomarker and serum electrolyte were normal. Patient discharged on request after 48 hours.

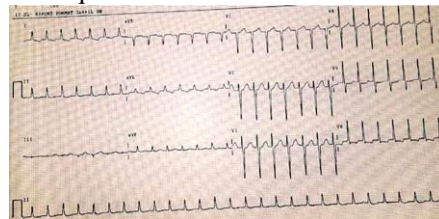


Figure VIII: ECG of a patients showing narrow QRS tachycardia.

Table I. case wise clinical and investigational findings in patients survived after lightning injury

Case serial number	Electrical Injury mark	Electrocardiographic presentation	Clinical presentation	Echocardiographic presentation	X-ray finding	Biomarker value	Coronary angiogram
1.	Second-degree burns on back of his chest	ST elevation in leads II, III, aVF, V5 and V6 with atrial fibrillation	Chief complain-angina with dyspnoea O/E- pulse = 156/ minute, irregularly irregular and blood pressure= 166/98 mm of Hg, S3 and basal crepitation	Regional wall motion abnormality was observed in infero-posterior wall	Feature of pulmonary oedema	elevated	Normal
2.	Linear burn injuries involving right side front of shoulder	T-wave inversion in inferior leads along with prolonged QT interval, bradycardia	Chief complain-angina, O/E Pulse=54/minute, regular Blood pressure =148/90 mm Hg, CVS exam-no obvious abnormality	normal contractility of left ventricle without any regional wall motional abnormality	No obvious abnormality	Within normal range	Normal
3.	Erythematous marks on the soles of his feet, right side of head.	Wide QRS regular tachycardia, reverted after DC cardioversion to normal sinus rhythm	Chief complain-Palpitation O/E -Blood pressure- non recordable, pulse - feeble, HR -256/ min	normal contractility of left ventricle without any regional wall motional abnormality	No obvious abnormality	Within normal range	Normal

		with T wave inversion and QT prolongation in inferolateral leads	regular				
4.	Serpiginous burns on ventral aspect of left arm	Symmetrical T-wave inversion in the anterior leads with prolonged QT interval	Chief complain-angina, O/E-BP= 136/84 mmHg, pulse = 96/min, CVS exam-no obvious abnormality	Normal contractility of left ventricle without any regional wall motional abnormality	No obvious abnormality	Within normal range	Normal
5.	No physical injuries or entry and exit mark noted	Atrial fibrillation, Reverted to normal sinus rhythm after DC cardioversion	Chief complain-Palpitation, O/E-Pulse - feeble. Heart rate= 246/minute irregularly irregular, Blood pressure= 88/64 mm of Hg	Normal contractility of left ventricle without any regional wall motional abnormality	No obvious abnormality	Within normal range	-
6.	Second-degree burn on the front of both legs.	RBBB with ST coving with deep T wave inversion in anterior leads along with prolonged QT interval	BP was 150/100 and pulse rate was 106 /minute, regular,S3,Lung crepitation	Regional wall motion abnormality in anterior wall	Feature of pulmonary oedema	Elevated	Normal
7.	Burn injury on front of both the legs	Multiple VPC with bigeminal rhythm with intermittent non sustained ventricular tachycardia	Asymptomatic, BP = 112/84 and pulse rate = 86 /minute, irregularly, Irregular	Normal contractility of left ventricle without any regional wall motional abnormality	No obvious abnormality	Within normal range	-
8.	both exit or entry marks noticed over right hand and right parietal area of head respectively	Narrow QRS regular tachycardia	Chief complain-Palpitation, O/E-Blood pressure =118/86 mmHg, pulse = 184/minute, regular. CVS exam-no obvious abnormality	Normal contractility of left ventricle without any regional wall motional abnormality	No obvious abnormality	Within normal range	-

[O/E-On examination, BP- Blood pressure, CVS-Cardiovascular system, VPC-Ventricular premature contraction, DC-Direct current)

Discussion:

In the present series of cases, wide and diverse electrocardiographic (ECG) manifestations were observed in patients after exposure to lightning injury. Most of them are lethal and can lead to complications like LVF, pulmonary oedema and death. Different mechanisms like coronary artery spasm, catecholamine-mediated, direct thermal damage, myocardial ischemia etc are responsible for the pathophysiology of wide varieties of lethal ECG manifestations in patients after lightning injury.⁵ ECG abnormality mimicking myocardial infarction or ischemia is a rare finding after lightning injury^{6,7} In the present case series, ECG manifestation suggestive of inferior wall ischemic or infarction observed in case 1,2 (Figure Ia, II). Such changes are more common in patients after lightning injury as compared to anterior wall electrocardiographic changes, due to closer proximity of right coronary artery to chest wall as compared to left anterior descending artery.⁸ In the present study, anterior wall ECG changes with prolonged QT interval also observed in case 4 and 6 (Figure IV, VI). In all the above cases, prolonged QT interval was the most consistent finding. Above electrocardiographic findings is also more specific for lightning injury.⁹ The pathophysiologic mechanism for QT prolongation may be due to delayed repolarisation as a result of alterations in intracellular calcium metabolism.^{10,11} Ischemic ST-T changes along with prolonged QT interval can predispose to deadly arrhythmia.¹² Therefore although prevalence of myocardial infarction or ischemia is rare in cases after lightning injury, however ECG is a very essential tool to exclude such disastrous ischemic electrocardiographic changes having arrhythmic potential. Cardiac biomarkers values and echocardiographic findings have an important role in diagnosing and prognosticating patients of acute myocardial injury. However in the present study, such findings found to be discordant with the electrocardiographic findings. In case 4, despite symmetrical T wave inversion with prolonged QT interval in anterior leads (Figure IV), cardiac biomarkers values and echocardiographic findings found to be within normal limits. Such disparity can be observed in some cases after lightning injury, when ECG changes solely occur due to autonomic stimulation.¹³ In present study, typical ECG features of ischemia or infarction (Figure IA,VI) along with RWMA and elevated biomarker mimicking myocardial infarction were observed in cases 1,6, however coronary angiograms of patients were found to be normal. Above abnormal electrocardiographic and echocardiographic findings also disappeared after few days of treatment, which can be explained with the facts below. Ischemic changes in myocardium after lightning injury occurs most commonly due to coronary vasospasm rather than coronary atherosclerosis^{14,15,16}, therefore electrocardiographic, echocardiographic changes after lightning injury can be transient^{17,18} However case 2 presented with significant T wave inversion in inferior leads (Figure II) with elevated biomarkers, but without any RWMA on echocardiography. This type of finding can be observed rarely in patients after direct and localised thermal injury due to high voltage electrical current as a result of lightning.¹⁹ Beside ischemic changes on ECG, arrhythmia also observed in Cases 3,5,7,8. The pathogenesis of arrhythmia in cases after lightning injury can be multifactorial. Direct or indirect cardiomyocyte injury becomes a substrate for re-entrant circuit, which can predispose patients to arrhythmia like ventricular and supraventricular tachycardia.²⁰ QT prolongation, that arise after delayed depolarisation, also can cause dreadful arrhythmias like torsades de pointes in patients, leading to sudden cardiac death.¹² Thirdly heterogeneity in myocytes after local injury can initiate a trigger mechanism for arrhythmia like AF.²⁰ Above discussion implies that, cardiovascular complications like LVF, cardiogenic shock, sudden cardiac death can arise in patients due to either ischemic or arrhythmic episode, even after survived an episode of lightning injury. ECG manifestations depends upon the mechanism of origin. Mechanisms other than coronary atherosclerosis i.e coronary vasospasm, autonomic stimulation, local thermal injury can have important roles in the pathogenesis of ECG manifestations. Although these presentations are transient, however can be lethal, if neglected. Echocardiographic findings and biomarker values can be discordant with electrocardiographic findings. Therefore early and appropriate intervention along with close follow up is extremely essential in patients after lightning injury, so that deadly complications arising after lightning injury can be anticipated and managed with an early appropriate treatment strategy.

Conclusion: Patients exposed to lightning injury can present with wide spread and diverse electrocardiographic (ECG) manifestations. Mechanisms other than coronary atherosclerosis i.e coronary vasospasm, autonomic stimulation, and local thermal injury can have important roles in the pathogenesis of ECG manifestations. Therefore ECG manifestations most often transient and can be discordant to echocardiographic and laboratory findings (like RWMA, cardiac biomarkers etc). Patients can develop devastating complications like LVF, dreadful arrhythmia and cardiac arrest, even after

survived of the episode of lightening injury during this transient period .Therefore timely appropriate intervention and close follow up can save many lives.

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