

Beyond the Bolt: A Case Report of Unconventional Injuries in Lightning

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Abstract:

Determination of the cause of death in case of death due to lightning strikes is easy if the typical features and history come from direct witnesses. But, on the contrary at times post-mortem features and history might not be of a usual routine lightning strike case. A dead body of a 19-year-old young adult, who died following an incident of the lightning strike was brought for post-mortem examination. The autopsy revealed typical lightning strike injuries with superficial to deep burns, involving the skull to lower limb in a patterned manner. Histopathological studies conducted on postmortem samples of lungs and heart also showed findings associated with electrical/thermal injuries-induced change. Postmortem findings with supportive pathological findings need to be reported as they can provide dependable findings to resolve such cases, especially in case of unwitnessed incidents or atypical post-mortem findings.

Keywords: lightning; injuries; lightning strike; unusual injuries

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Introduction:

In the Indian context, the National Crime Records Bureau (NCRB), which is the information technology division of the Ministry of Home Affairs, has the authority to publish statistical data on unnatural deaths every year. According to the recorded data, the average annual deaths associated with lightning exceeds 2234, with a higher prevalence among males. The fatality rates associated with lightning strikes amount to 30%, primarily affecting the cardiopulmonary system, followed by nervous and integumentary systems¹. Lightning exposes the body to 100,000-200,000 volts in a short time, causing minimal internal injury. Most of the voltage

is dissipated externally as a flashover effect on the victim's body. Injuries secondary to extreme temperatures (up to 30,000°C) and blast waves although rare, occurs².

Apropos to the above context, we hereby present case of a 19-year-old male who tragically lost his life after being struck by lightning while bathing. This incident resulted in distinctive patterns of injuries across his body which contrasts with the typical keraunographic marks seen in other cases.

Case report:

The case entails the history of a 19-year-old young adult who sustained life threatening complications following lightning strike. The body was shifted to the mortuary and a detailed external, internal examination with necessary ancillary investigations was performed prior to giving a cause of death.

External examination: External examination revealed the complexion ranging in between wheatish to dark, moderately built and nourished. A silver-

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colored metallic chain was present in situ around the waist. Rigor was present all over with post-mortem lividity present over the back and not fixed. Bilateral conjunctivae were pale. The following external injury was present over the body:

1. Superficial to deep burns were present involving occipital region on either side, back of chest on either side, back of abdomen in midline and on either side, groin over right side, bilateral buttocks, front and outer aspect of right thigh, outer aspect of right knee joint and right leg, with associated singeing of scalp hair.

Internal Examination:

1. Cranium: Brain weighed around 1211 g with marked congestion and oedema. 70 ml of frank blood was present in the base of the skull.
2. Thorax: 20 ml of straw-colored fluid was present in bilateral pleural cavities. Both the lungs were soft, congested, edematous and crepitant with blood-stained frothy fluid oozing out on cut section. The pericardial sac contained 45 ml of straw-colored fluid. The heart weighed 263 g; Contusion, over an area of 10 x 8 cm, was present involving the back of the right ventricle, back and outer aspect of left ventricle with overlying multiple patches of epicardial hemorrhages. Subendocardial hemorrhages were present involving the entire right and left ventricles on cut section.
3. Abdomen: 100 ml of straw-colored fluid was present in the peritoneal cavity and contusion was present along right iliac vessels. The stomach mucosa was congested with hemorrhagic areas on the cut section.

All the other organs were intact and unremarkable.

The following postmortem tissue samples were sent to the Department of Pathology for histopathological examination that revealed:

Gross examination:

- i. Piece of lung: Cut section revealed congested spongy lung parenchyma.
- ii. Entire heart: Externally showed areas of congestion.

Microscopy:

- i. Lung parenchyma composed of distended air spaces with few showing haemosiderin-laden macrophages.
- ii. Section from right ventricular wall showed sensation of cardiac myocytes with disarray of the cardiac myofibres with interstitial hemorrhage, and oedema. The myocytes showed coagulative necrosis with pale eosinophilic cytoplasm, with some cytoplasmic vacuolation, and disrupted sarcolemma with pale nucleus (suggestive of an electric/thermal injury-induced change).



Figure 1: Superficial to Deep burns

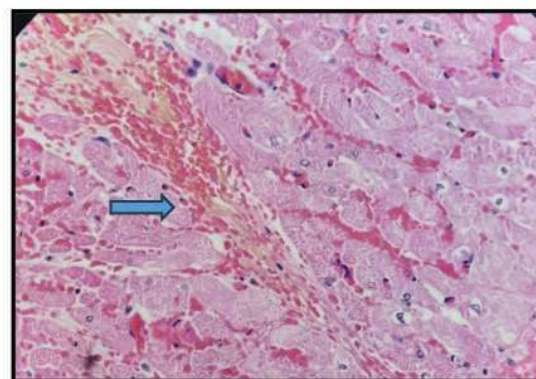


Figure 2: Heart sections showing secondary to a lightning strike. myocardial fibers with sarcolemma break and necrosed myocytes with interstitial hemorrhage. (H&E 40x).

Discussion:

Lightning constitutes a distinct form of kinetic energy, bearing a direct current of at least one million volts, approximately 4000 times the voltage of domestic supply, and an estimated 20,000 amperes. When an individual is impacted by a lightning strike, it can manifest in a variety of ways, encompassing direct strike, touch voltage, step voltage, subsequent strokes, side flash, connecting leaders, and shock waves³. The current entering the body causes potential alteration in the physiochemistry of human such as transmuting the tissues by heating, electrolysis and permutating the electrical state of excitable tissues³. Lightning strikes have the potential to cause both full thickness (third-degree) and partial thickness (second-degree) thermal burns. These burns occur due to the high temperature generated by the electrical discharge when lightning strikes the human body, leading to tissue damage and potential complications. Linear burns are partial thickness burns that occur over moist areas of the body⁴. The "flashover effect" is a phenomenon in which wet skin enables lightning strikes to travel over the skin's surface without penetrating it. Full thickness burns may lead to bilateral gangrene extending to both elbows⁴. When the electric current from the atmosphere falls over a solid surface, a voltage gradient of around 10 Volts is generated across a thin film of gas and aerified solid matter. The thermogenesis in this gaseous layer commensurate to the net charge passing through this film leading to full-thickness burn in the victim's body following contact. The shock waves may be associated with pressure effect as high as 10-20 atm in the vicinity that can account for major blunt trauma over the body of the victim involving barotrauma, fractures or rupture of internal organs³. *Rakov and Uman* delineate four distinct types of cloud-to-ground lightning discharges: (1) downward negative lightning, (2) upward negative

lightning, (3) downward positive lightning, and (4) upward positive lightning⁵.

Injuries due to Heat Component:

Linear, first-degree burns, characteristically aligned with skin creases, may present as centimeter-long superficial charring along the body's longitudinal axis, predominantly observed on the trunk with associated singeing⁵.

Injuries due to Electrical Component:

The electrical component may lead to the development of Lichtenberg figures (named after Georg Christoph Lichtenberg) that depict vital reactions. The electromagnetic nature of lightning can result in atypical, spark-shaped lesions on the skin of the affected person⁵.

Cardiac Presentation of Lightning Injury:

The impact on the cardiovascular system can manifest as either transient or life-threatening. The foremost catastrophic effects entail rhythm disturbances, with the most prevalent manifestation being arrhythmias. The series of events may include direct shock, shock causing hyperstimulation of the autonomic system, or with cumulative effect of catecholaminergic surge leading to sinister arrhythmias. The autopsy espial the presence of cardiac contusions in the majority of cases⁵. *Hayashi and colleagues, as well as Dundon et al.*, have documented instances of Takotsubo cardiomyopathy leading to cardiogenic shock in a few cases. The histopathological examination indicates a wavy pattern of myofibers and the presence of myocardial hemorrhages⁷. The effects on other bodily systems may encompass a range of manifestations, including salt-wasting syndrome as a result of neurological impact, barotrauma affecting the auditory apparatus, as well as potential damage to hollow organs such as the stomach and intestine. Moreover, barotrauma may lead to pneumomediastinum and subsequent organ rupture due to blast effect⁵.

Conclusion:

The dermal manifestations of lightning strike may sometime present as atypical injuries resembling blunt force trauma thereby seeking meticulous inspection of the injuries which is usually associated with singeing. The histopathological diagnosis eases the approach toward giving an appropriate cause of death aiming at the cardiac myocyte and myofiber permutations⁶.

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