Case Report

Death Due to Lightning: A Case Report

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Abstract:
Lightning-related fatalities are not uncommon in tropical and subtropical regions. The medico-legal investigation of fatal lightning and electrocution incidents can be incredibly challenging as there may or may not be any physical findings at autopsy supporting the diagnosis. The investigation involves multidisciplinary forensic examination including case histories, site analysis, medical autopsies, lightning location system data analysis and voltage gradient estimations. Hence, it is imperative for forensic experts to thoroughly examine the case from various angles in order to arrive at a definitive conclusion.

Keywords: Autopsy, Lightning, Respiratory paralysis, Thunderstorm

Introduction:

Lightning is the discharge of atmospheric potential between clouds. The comprehension of the physics underlying a lightning strike is inherently intricate due to the involvement of immense voltages and amperages when a heavily charged thundercloud discharges through a substantial arc to the earth's surface resulting in the movement of a high number of electrons (30 kiloampere) between high-pressure differences (10-100 million volts).[1]

Lightning can harm a person by (a) a direct strike effect, (b) a contact effect when lightning strikes an object touched by a victim, (c) a side flash effect from a nearby object struck by lightning, (d) a step voltage or ground current effect from a lightning strike several meters away, and (e) upward streamer effect, related with injury by low energy.[2 - 5]

Sudden death due to lightning is common in tropical and subtropical areas. Lightning deaths cannot be other than accidental and provide no real problems for the forensic pathologist. Occasionally the nature of the death may be uncertain if a dead body is discovered in the open with no marks upon it, but usually there will be reports of a lightning strike nearby and artefacts, such as torn and scorched clothing and magnetized metallic objects in the pockets, may assist in explaining the event.

Reports showed lightning strikes killed 1,697 people in India between April 1, 2020, and March 31, 2021[6] and 1,285 people in 2022.[7] Around 85% of lightning fatalities involve men. The victims are young, active people who are stuck during various outdoor activities.[8,9] Death due to lightning is always accidental and injuries from it are unpredictable and inconsistent. The nature of death may be uncertain if the dead body is found in the open with no marks on it. In such cases, reports of thunderstorms and findings such as torn or scorched clothing and magnetized metallic

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objects in the pockets may assist in explaining the events.[10]

Case report:

The body of a 58-year-old male was found in the vicinity of a liquor store at night barefooted in a prone posture. He did not have a history of any medical illness. This raised suspicion as to the cause of death for which an autopsy was requested. Eyewitnesses confirmed him consuming alcohol the same evening. According to the statement provided by residents, a thunderstorm was experienced the same night.

During external examination, there were punctate tears on his clothing (Fig 1) and the skin underneath the punctate tears in the clothing were noted to be normal with no visible damage. The conjunctivae of both eyes were congested. Corneal opacity was observed bilaterally. (Fig 2). There was evidence of bleeding from the left ear. Oral mucosa and fingernail beds were pale. The body was stiff, and post-mortem lividity was present on the anterior aspect of body and was fixed. External injuries included a central lacerated nodule with everted edges of hardened skin, brown in colour with an areola of surrounding blanched skin measuring 0.5cm X 0.4cm situated 2cm proximal to the base of the great toe of the right foot (Fig 3). The observable manifestation of an exit wound, also known as the 'tip-toe' sign, is a distinct visual indication resulting from the passage of an electric current.[1,11-14]

No entry wound for the current was found anywhere over the body. Internally, the brain weighed 1185g and was congested and oedematous. The scalp showed no evidence of external trauma or burns. Subarachnoid haemorrhage was present in the left parietal-temporal region. Both the lungs were congested and oedematous; the right lung weighed 580g and the left lung weighed 600g (Fig 4). Mucosa of the stomach was congested and haemorrhagic and the stomach contained approximately 80ml of blood. (Fig 5).

Figure 1: Punctate tears on clothing

Figure 2: Bilateral cataract and scleral congestion

Figure 3: External Injury: 'CRATER' Central Lacerated nodules with everted edges of hardened skin with surrounding area of blanching

On histopathology of the injury, the epidermis was hyperkeratotic showing vesicle formation. It was separated from the lower epidermis with a tombstone appearance and nuclear streaming (palisading). Dermis showed coagulation

Figure 4: Lungs edematous & congested

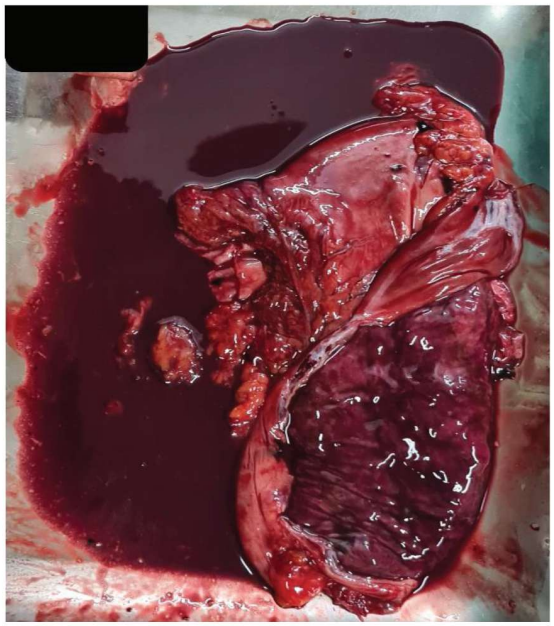

Figure 5: Stomach – Contained approximately 80ml of blood; Mucosa - congestion and hemorrhage

necrosis with sparse perivascular neutrophils (Fig 6). This confirmed that the injury was indeed caused by a lightning exit. Heart had myxoid degeneration at aortic valves and mild atherosclerosis in the right coronary artery. Toxicology revealed the presence of ethyl alcohol; with the quantum of ethyl alcohol being 44.7095mg/100ml of blood. The death was opined to be due to lightning.

Discussion:

Keraunopathology is the study of lightning-induced pathology or damage, (from the Greek: keraunos, thunderbolt + pathology). It is estimated that there are approximately 6000 to 24 000 lightning fatalities per year globally.[15]

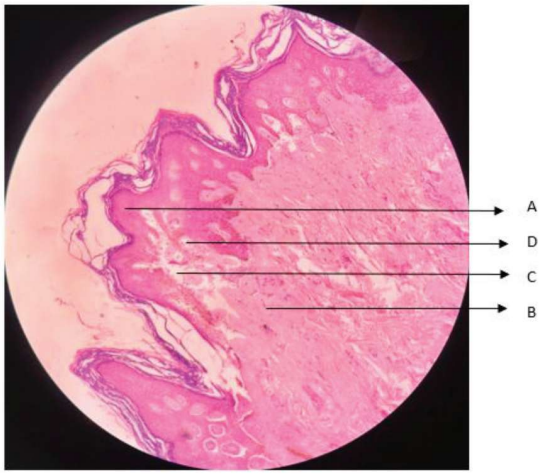

Figure 6: Skin tissue with foci showing vesicle formation, separated from lower epidermis with tombstone appearance and nuclear streaming (palisading). Dermis showed coagulation necrosis with sparse perivascular neutrophils.
A-Epidermis; B-Dermis; C-Vacoules; D-Steaming of nuclei

In a 15-year study in Maharashtra, among 47 cases, cardiopulmonary arrest was the leading cause of death (80.85%), followed by burns (10.65%), head injuries (4.25%), and pulmonary infarction (4.25%).[16]

Lightning injuries result from a combination of the light, heat, electrical, and barotrauma components. These mechanisms can mimic electrical trauma and may cause death even without a direct strike. Proximity to lightning can be fatal through mechanisms such as cardiac arrest or damage to the central nervous system, leading to respiratory paralysis.[17]

Electrical and Thermal Effects

Lightning currents peak at 20–35 kA, lasting a few hundred microseconds, with some cases reaching higher amplitudes. Continuing currents, though lower in amplitude (0.5–1 kA), carry significant energy. Skin injuries such as Lichtenberg figures (fern-like patterns) also known as Filigree marks are sometimes seen on the

skin which consists of a red line of width 2-8 cm extending in a craniocaudal direction from the vertex of the head or chin to ankles or heels. and stellate marks often indicate electrical effects. [18]

The thermal component can cause superficial burns, melting of synthetic fibres, and occasional singeing of hair. However, deep tissue burns are rare due to the brief exposure duration. Clothing damage often provides clues to lightning injuries. Clothes may be burnt at entry or exit points, stripped off, or thrown to some distance. Occasionally no such markings are found on the skin however the clothes appear scorched, this may be due to wet clothing acting as a good conductor. This case showed punctate tears in clothing, likely due to localized thermal effects of lightning on the fabric. This contrasts with the linear tears caused by blast pressure waves. Third-degree burns can also be found as a result of arcing, but they do not extend deep into the subcutaneous tissues and muscles. [19]

Metallization, crocodile skin, singeing of hair, osseous pearls, and fractures are mostly features of electric injury seldom found in cases of lightning. Apart from these, thermal lesions in the brain and spinal cord are rarely seen in lightning casualties owing to the short duration of exposure.[1]

Barotrauma and Blast Injuries:

Lightning strikes generate intense pressure waves capable of causing pulmonary and gastrointestinal injuries, pneumomediastinum, and tympanic membrane rupture. Secondary injuries, such as blunt force trauma from debris or "tip-toe" effects, are also observed. Victims can sustain fractures after being knocked down by the blast effect or the ‘wind’ of lightning called the ‘sledgehammer effect’. If the victim survives, he can develop ‘lightning syndrome’ characterized by loss of consciousness (keraunoparalysis), conduction deafness, and skin burn. The internal organs are usually spared.[1]

Gastrointestinal haemorrhage in this case is due to blast effect. However, haemorrhagic mucosa is also due to acute alcohol consumption.

Cardiac and Neurological Impact:

Cardiac arrest is the leading cause of death in lightning strikes, with complications including myocardial necrosis, conduction disturbances, and subendocardial ischemia. Neurological effects, such as cerebral salt-wasting syndrome, can lead to hyponatremia, brain edema, and seizures.[19]

Ocular and Otologic Manifestations:

Lightning strikes can cause various ocular injuries, including uveitis, macular edema, optic neuropathy, retinal detachment, and, most commonly, cataracts. Bleeding from the ear and subarachnoid haemorrhage may result from vascular rupture caused by the sudden pressure wave generated by the lightning strike. In this case, tympanic membrane rupture was evident, further supporting the hypothesis of vascular damage.

Additionally, the shock wave from lightning can harm nearby individuals, leading to skin damage, tympanic membrane rupture, hemotympanum, and radiation-induced cataracts. [19]

Histopathological examination of the skin lesion revealed hyperkeratosis, vesicle formation, and nuclear streaming, consistent with lightning injury.

While no significant cardiac histopathological findings were observed in this case, literature suggests that lightning strikes can result in myocardial necrosis, conduction disturbances, and subendocardial ischemia. Such effects may not always be apparent macroscopically but could contribute to cardiac arrest.

The autolytic changes observed in the lungs are consistent with the 48-hour postmortem interval and are unlikely to be indicative of poor preservation.

In the present case, typical injuries such as ruptured tympanic membrane, punctate burns and exit wound (crater) were seen along with gastro-intestinal bleed. On

account of the above-mentioned findings cause of death was opined as that due to lightning.

In the absence of physical evidence, lightning can be considered a diagnosis by exclusion. The presence of eyewitnesses, the testimony of a thunderstorm by locals, and a favourable weather report can substantiate lightning as the cause of death. Other reliable pieces of evidence are discovered on the ground like fused metallic objects, mobile phones, trees, buildings, and any material close to the affected individual.[1] The occurrence of lightning-related fatalities in our country is not far from reality, which emphasizes the need to recognize it as a public health issue and implement essential measures accordingly.[20]

Conclusion:

The cases of death caused by lightning demand a rigorous investigation that must be approached with scrutiny. Forensic experts must conduct scene visits, gather testimonies from residents regarding thunderstorms, and review weather reports from the meteorological department. This is critical as false claims of lightning strikes can be used to disguise homicides or misrepresent other causes of death.[10] Building public awareness is essential for preventing lightning-related injuries. Studies have shown that public education is a simple and cost-effective means of reducing such injuries. Therefore, government public health departments must address this issue by collaborating with NGOs, research institutions, and advocacy groups to develop effective strategies. These strategies should aim to ensure lightning safety, promote public education, and enhance the availability of facilities for injury prevention and post-injury rehabilitation.[18]

Underreporting of lightning fatalities can result from factors such as failure to report incidents or misdiagnosis. Hence, it is crucial for forensic pathologists to be well-versed in recognizing lightning-related deaths.

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