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CASE REPORT

UNUSUAL BONE INJURY IN A DIRECT LIGHTNING STRIKE: REVIEW OF A WITNESSED LIGHTNING-RELATED DEATH

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ABSTRACT

Introduction: Lightning strikes are a rare but often fatal natural phenomenon. A single strike can contain an energy level of 30 million volts, 50000 amperes, accompanied by an explosive thunder effect. Mechanisms of lightning injury are categorized as electrothermal effects- including direct strike, contact potential, side flash, step voltage, and upward streamer current- or the sixth mechanism known as pressure blast wave barotrauma.

Case Report: A 38-year-old lady was struck by lightning while crossing an open paddy field, an event witnessed by her daughter. The autopsy revealed torn clothing, superficial dry burns on the body, singeing of hair, and a split on the scalp with an associated linear skull bone fracture.

Conclusion: The blunt force trauma observed in this case is explained by the sixth mechanism (pressure blast wave barotrauma). The lightning bolt channel temperature is approximately 25000 K (24727 ºC). According to Charles' law, this extreme temperature causes a rapid expansion of air, resulting in a sudden increase of pressure, equivalent to a 10 kg TNT (2,4,6-Trinitrotoluene) explosion, generating a cylindrical-shaped pressure shock wave. This pressure shock wave is responsible for the torn clothing and blunt force trauma, either directly or as a result of a fall.

Keywords: *Blunt force trauma; lightning strikes; pressure blast wave barotrauma; sixth mechanism*

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INTRODUCTION

Anaphylaxis is a severe allergic reaction that can affect breathing and blood circulation. It requires immediate treatment with adrenaline[1,2]. Stress cardiomyopathy, also known as Takotsubo syndrome, is a temporary heart condition that mimics a heart attack but occurs without blockage of coronary arteries[3]. It can be triggered by physical or emotional stress, including high levels of catecholamines[3,4]. In medicolegal practice, complications that arise during the treatment of assault injuries may raise questions about the category of hurt. Proper evaluation depends on clear documentation of events and their sequence.

INTRODUCTION

Lightning current lasts a short duration (microseconds), which minimises the burning effect. However, flashover is highly likely, making internal conduction minimal. There are five mechanisms by which lightning current may impinge on a body. They are direct strike, contact potential, side slash, step voltage, and upward streamer[1].

Lightning strikes cannot be other than accidental, but sometimes they accompany with blunt force type trauma, which can complicate the diagnosis for the forensic pathologist. The prior five mechanisms are strictly electrical, and they cannot explain the blunt force trauma. The sixth mechanism, known as pressure blast wave barotrauma, is used to explain these blunt force type injuries witnessed in lightning strikes[2].

We present a case with blunt force type trauma in a lightning strike victim, which is explained by the sixth mechanism, pressure blast wave barotrauma.

CASE REPORT

The body of a 38-year-old female was brought in by the police for an autopsy. According to the history given by the daughter, the deceased was crossing an open paddy field with her during a thunderstorm. They were a few meters apart when the daughter witnessed a lightning strike the ground near her mother. The mother had collapsed in the paddy field and was found to have died. The autopsy revealed a moderately built female with torn clothing (Figure 1) and superficial dry burns on the chest, abdomen, and left thigh (Figure 2).

Figure 1: Torn skirt (arrow).

Figure 2: Superficial dry burns on the chest, abdomen, and left thigh (arrows).

Blood was noted in both ears, associated with ruptured tympanic membranes. There was singeing of head hair. A 4cm long linear laceration (Figure 3a) with an associated haematoma was observed on the right side of the back of the head, with an underlying 8cm long linear fracture of the right-side parietal bone (Figure 3b). No cerebral contusions, lacerations, or meningeal haemorrhages were noted during the autopsy.

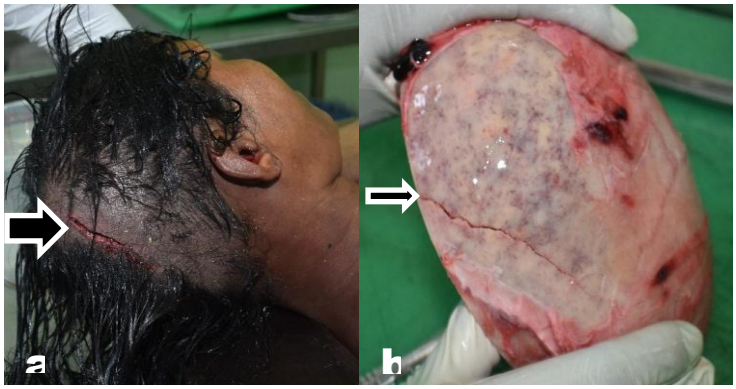

Figure 3: a) Scalp laceration (broad arrow), b) underlying linear skull bone fracture (thin arrow).

Internal examination revealed a lung contusion (Figure 4) without overlying soft tissue injury (other than burn) or rib fractures. There were no identifiable natural pathologies in the lungs, such as pulmonary infarction, coagulopathy, and all other internal organs were unremarkable. No visible exit mark was found on the body. The cause of death was concluded as a direct lightning strike. The absence of internal brain injury indicates a sudden death, specifically cardiac arrest, which prevented bleeding into the brain or meninges. The possible mechanism could be brain stem impairment and arrhythmogenic effects of the heart.

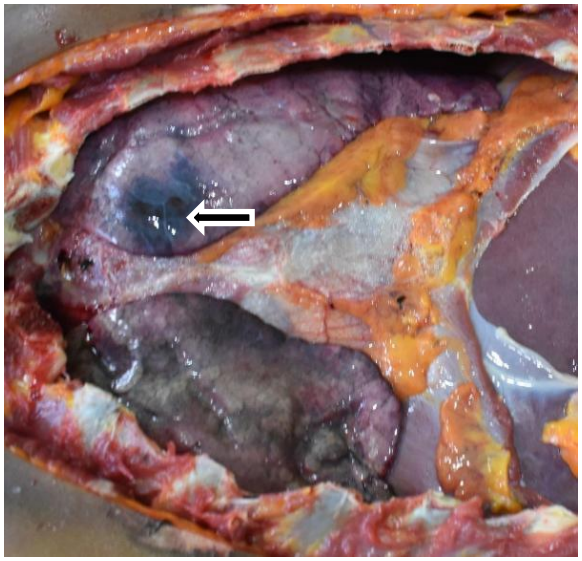

Figure 4: Contusion of the left lung (arrow).

DISCUSSION

"The temperature of the lightning bolt channel is raised to about 25000 K (24727 ºC) in a few microseconds. This causes the temperature around the channel to rise suddenly, meaning that the pressure in the channel suddenly increases to several atmospheres"[3]. Charles's law states that for a fixed amount of gas at constant pressure, its volume is directly proportional to its absolute temperature in Kelvin.

Therefore, the large increase in temperature results in a large increase in the volume of air. This sudden rise in volume causes a sudden cylindrical-shaped pressure shock wave, which may reach pressures of more than 10-20 atmospheres (1013.25 kPa – 2026.5 kPa) in the vicinity of the lightning bolt channel[4].

Lightning's pressure blast wave has been known to tear and tatter clothing, fracture bones, rupture a person's eardrums, and damage their lungs. The blast causes a pocket of air behind the sternum (pneumomediastinum)[5], and it may cause injury to the chest wall and lungs[6].

As lightning superheats, the air causing it to expand explosively, it generates a powerful pressure shock wave. The fact that thunder can be heard as far as 14 to 25 kilometres away indicates the tremendous amount of energy involved- a stark reminder of the energy contained in a lightning strike. Even before the noise is produced, this initial pressure blast wave can injure people or damage objects close to the lightning channel.

Differentiating whether the scalp laceration and skull fracture happened due to a direct result of the pressure blast wave or from a fall following the lightning strike is challenging. However, it can be hypothesised that the deceased fell as a direct consequence of the explosive force of the pressure blast wave. Torn clothing, ruptured tympanic membranes, and lung contusions are evidence of the barotrauma due to the lightning's pressure blast wave.

CONCLUSION

This case highlights the diagnostic challenge that lightning fatalities pose in forensic pathology, where coexisting blunt force injuries may obscure or mimic alternative causes of death. The pressure blast wave is capable of producing barotrauma independently of electrothermal injury. This blast wave can directly cause bone fractures or propel the victim in a fall that results in a fracture. The presence of torn clothing, tympanic membrane rupture, and pulmonary contusion without overlying chest wall injury should suggest consideration of this mechanism. Therefore, although bone injury from lightning is rare, it is essential to consider this mechanism when other signs of barotrauma are present in the absence of a clear alternative cause of injury.

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None.

CONFLICTS OF INTEREST

The authors declared no conflicts of interest.

ETHICAL ISSUES

The presented case was conducted for medicolegal purposes, and the findings were used for academic purposes, according to the institutional guidelines, without divulging the identity of the individual.

SOURCES OF SUPPORT

None.

AUTHOR CONTRIBUTIONS

LRW: Conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **AAMSS:** Conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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