

Lightning Injuries in an In-door Setting: A Case Report and Review of the Literature

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Abstract Lightning injuries are not an infrequent occurrence, but casuistic is mainly related to the outdoor environment. Lightning injuries are also becoming uncommon due to better safety measures in electrical power supplying; nevertheless we refer a very rare case of a fatality due to lightning occurring inside home. Full forensic expertise was made to the corpse of a Caucasian 46 year old male, who died inside his kitchen room due to electrical discharge transmitted via the chimney of the home, whose external part was shocked from a lightning. Macroscopic changes following the electrical shock and images from the scene were registered. Although less frequently nowadays, Albanian families nevertheless still use to some extent wood stoves for heating. Chimneys that are mainly hand-made and non-professionally mounted have been imputed for carbon monoxide intoxication, but in rare unfortunate circumstances these chimneys might serve as electrical current transmitters, thus exposing users to very high risk. Lightning injuries transmitted via a rotten chimney whose external part is shocked from an electrical discharge, might quite well penetrate in their respective internal parts and get transmitted to humans in an indoor setting. Particular precautions are needed during mounting of chimneys that might serve as electricity transmitters, since casualties due to lightning in these circumstances are rare, but anyhow occurring.

Keywords: lightning injuries, electrical discharge, in-door setting, chimneys, electrocution

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1. Introduction

Lightning injuries are a frequent cause of severe wounds, of burns and fatalities in out-door settings, with particularities of corporal injuries related to the specific character of the electrical discharge. A clap of thunder is decomposed in two elements: lightning, and the thunder itself [1]. When the victim survives, he or she generally becomes competence of burn treatment centers, although burns are only the visible sign of a highly devastating injury [2]. In a fundamental forensic textbook published almost one and a half century before, death by lightning was grouped together with the death by fire and spontaneous combustion, albeit considered independently [3]. The occurrence is still classified within the thermal injuries, but other mechanisms of injuries have been implied, such as that of blunt trauma. The intensity of the electrical current flowing inside the body is much higher than in other cases of electrocution, but the deep burns are more frequent in high-voltage electrocution rather than in lightning casualties [4,5,6].

In fact, lightning injuries have panoply of clinical signs and several pathologies might follow, among which brain injury; sensorineural hearing loss; esophageal perforation; and even polyradiculoneuritis [7,8,9,10]. If this list of

particularities is incomplete, nevertheless it is clear that cardiac arrest or fatal arrhythmias represent the main cause of immediate or sudden death; but renal failure, septicemia and other complications might have their role [11].

Generally, under the term 'electrocution' authors include lesions caused from the accidental contact with an electricity conductor (fulguration); lesions related with the discharge of atmospheric electricity (lightning); and tissue damage due to the creation of an electrical arc (burn) [12]. Authors have as well classified through a diversity of ways the electrical lesions that lead to thermal tissue damage and depending on the gravity of the situation; with the lesions classified in electrical petechiae; erosive lesions; necrotic wounds and carbonization of the corpse in extremely severe electrical shocks [13,14,15,16]. Apart from all this obvious external signs, lightning is notorious as well for a very particular cutaneous sign, namely the Lichtenberg figures, which are not burns, but arborescent red areas on the skin following such an injury, described initially from the German physicist Georg Christoph Lichtenberg in 1777 [17].

Electrocution and lightning injuries are obviously much more frequent in out-door settings. The injuries have as well an annual curve of partition, with the majority of deaths occurring in summer months [11]. Even the data referring annual death rates have sometimes impressive

discrepancies, with figures reaching to 0.73/100 000 for pediatric casualties related to electrocution in United States, when Canada reports a much lower death rate, amounting only to 0.045/100 000, in the same age groups [18,19].

Electrical injuries in an in-door setting are frequently reported as part of electrical accidents starting inside houses due to unsafe appliances. We are referring in this case report a very rare case of a thunderstorm-lightning, striking the external part of a chimney in a rural house, with the tube serving as electrical conductor and transmitting the electrical discharge of the lightning inside the house, and the aftermath of the event.

2. Case Report

The corpse of a 46 years old Caucasian male was brought to a district forensic facility in central Albania. The unlucky person was stroke from electricity while in contact with a wood stove, serving as a heating device, in a rural area. The kitchen of the home (Figure 1) illustrates the low economic level of the family, with the victim being an occasional hand worker. In the image are shown the wood stove and an almost rotten tube connecting the furnace with the external area where the striking took place.



Figure 1. Internal view of the kitchen. The wood stove had an internal part of the tube serving as a connector with the chimney (the black hole in the right-above part of the image, **arrow**). Consider the blast effects that interrupted the tube carrying off the smoke, with fragments of blackened walls

The electrical discharge was transmitted herein via the external part of the chimney tube, which was struck from the lightning. There were visible signs of fire and

carbonization in the alley next to the wall of the kitchen, where parts of the decomposed and burned tube were found on the ground (Figure 2).



Figure 2. Aftermath of the lightning strike, with the burning of the external part of the chimney tube coming out from the wall (**left part of the figure**), and carbonized parts of the latter found on the ground nearby (**right part of the figure**)

Post-mortem changes and surrounding blast effects were found in the corpse of the victim (Figure 3).



Figure 3. Post-mortem changes in the dorsum of the corpse, with environmental blast effects in dorsal cervical area, due to the lightning-related explosion inside the kitchen

The only small wound found in the victim, that served as the entry point for the electrical current transmitted through the stove, and the chimney tube of the latter, was found in his left leg, laterally and immediately below the

patellar bone. Obviously in a sitting position in close contact with the stove, the physical contact was consistent enough to allow the electrocution event to occur.



Figure 4. Entry sign of the electrical current just below and laterally the left patellar region

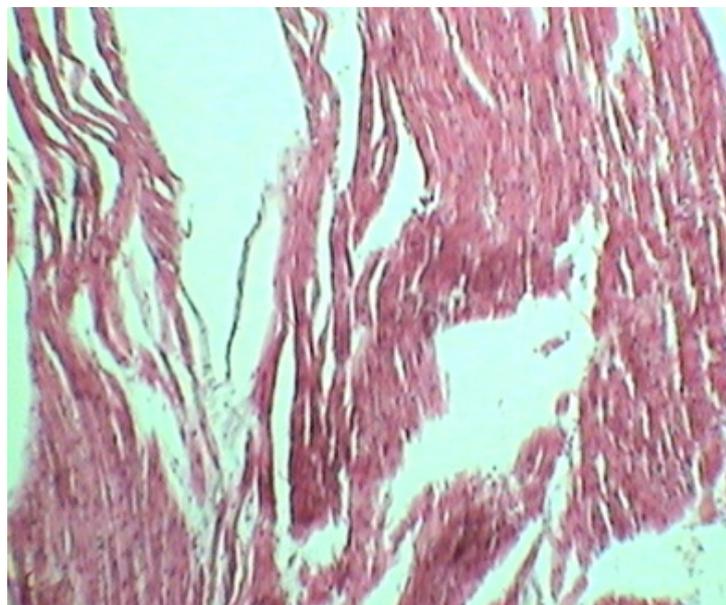


Figure 5. Autoptic findings in the myocardium, with loss of structural continuity of fibers, and post-mortem lymphocytic infiltration (Hematoxylin – Eosin, 160X)

3. Discussion

The first case of technical electrocution was reported more than 130 years before, with the electrical accidents being continuously a concern for public health bodies in general, regarding the proposal of safety measures and aiming at better injury prevention [20]. Very different is the case of the lightning injuries; always electrical in their nature, it seems that records of lightning strikes are old as the civilization itself [21]. Lightning and thunder strikes have been interpreted as divine punishment, with animistic rituals performed around lightning survivors [22]. Irrational beliefs surrounded such a natural phenomenon, until Benjamin Franklin discovered in 1752 that lightning itself was electricity.

As discussed above in the introduction, thermal effects of lightning are sometimes astonishingly minimal and confined at the site of contact, or mainly related to the clothing ignition, or blast effects following the event [23]. An overview of the body of the victim whose case we described above illustrates the fact how superficial and non-extensive might be the contact wound. Such a minimal entry point of the current will produce logically minimal thermal injuries; however the mechanism of death is related with the amount of current flow. Lightning strike produces a huge electrical current flow inside the body of the victim, with figures surpassing several hundred thousands of amperes, within an instantaneous time lapse [24]. It is obvious therefore, that in view of such an impressive electrical shock, will follow asystole rather than ventricular fibrillation, with very high mortality levels [24].

Alternating current is found in household appliances and high-voltage lines of technical electricity, and its pathophysiological effects differ to some extent with those of the direct current. Direct current injuries are strictly related to lightning events, since very few appliances produce an electrical current of this type, such as defibrillators [25]. A thorough discussion of physical features characterizing each type of current is beyond the scope of this paper; however direct current injuries, typical of lightning strikes, will throw away the victim, thus shortening the time of contact with the source of electricity, which is as well of an instantaneous form [26]. On the other hand, alternating current will provoke muscle contraction with flexors of the hand going into tetanic depolarization if the source is gripped by hand; this will deleteriously increase the time lapse of contact between the victim and the source [27,28].

Tetany is therefore more usual to alternating current accidents hence the latter produce intrinsically a higher risk for ventricular fibrillation; whereas the direct current following a lightning strike, through other mechanisms of action, will produce blast effects, and immediate death mainly due to asystole. The long-term after-effects might be lethal as well, due to their severity and persistence [2]. Thorough and extensive studies have described cardiovascular effects of lightning strikes [29]. A considerable amount of work regarding neurologic manifestations of lightning injuries and respective neuropathological alterations is available as well [30,31].

There have been reports suggesting a decrease in the overall number of injuries related to lightning;

nevertheless the issue still represents a major concern to public health safety and to medical or other staff dealing with electrocution [32]. A clear necessity to emphasize interventions toward a proactive position has been formulated, mainly through advance planning or recognition of potential threats [33]. Guidelines to prevent lightning strikes, injuries related to the latter and advices regarding on-site treatment of victims are available [34,35]. Best and safest practices have been recommended from authorities and consensus panels, pointing among others, over a better education and toward a higher awareness [36,37].

Although less frequently nowadays, Albanian families nevertheless still use to some extent wood stoves for heating. Chimneys that are mainly hand-made and non-professionally mounted have been imputed for carbon monoxide intoxications, but in rare misfortunate circumstances those chimneys might serve as electrical current transmitters, thus exposing users to very high risk. Lightning injuries transmitted via a rotten chimney are not the only way through which a lightning striking a house might penetrate in-door. Other plumbing fixtures might transmit as well the electrical energy of the lightning, such as sinks, showers, or toilets [38]. The case we described above illustrates fairly well the fact that lightning injuries are also an in-door occurrence, with authors suggesting almost one-third of these events penetrating inside houses [33]. Hand-made and unearthed chimneys, especially when close to high trees and in areas where there is a presence of extensive rainfalls, should be cautiously controlled and duly modified.

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