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CASE REPORT

Rhabdomyolysis and vascular thrombosis supporting the electrocution related death

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Abstract

Introduction: Electrocution related death remains an ambiguous judgement and requires numerous valid evidence for proper medico-legal diagnosis. While the presence of electrical burn marks is a significant macroscopic indicator, it can be absent, especially on moist skin. The electrical mark still represents a fundamental indicator above all in the medico-legal field, but the identification of pathognomonic elements and signs not limited to the skin alone could be a valid help in the future, especially in unclear cases. *Case Report:* The deceased was brought-in-dead to the hospital from their workplace, with no signs of fatal natural diseases. External examination revealed a Y-shaped burn mark on the right side of the neck and collapsed blisters with greying rings on both heels. Internal examination showed no alarming findings. Further, histopathological analysis of the foot blisters and neck burn revealed intraepidermal detachment, elongated nuclei, and coagulative necrosis. Notably, the presence of muscle fibre casts in kidney tubules and microthrombi in lung sections which indicate rhabdomyolysis and vascular thrombosis supported electrocution-related death. *Conclusion:* These positive findings of the electrical burn marks externally and significant histopathological changes, collectively support the death was due to electrocution, after excluding any major, fatal injuries. Albeit, a detailed inspection of the crime scene plays an important role, in order to classify the electrocution related death.

Keywords: Electrocution, rhabdomyolysis, vascular thrombosis, electrical burn mark, case report

INTRODUCTION

Electrocution related death remains an ambiguous judgement and requires numerous valid signs for the correct medico-legal diagnosis. While the classification of death can be influenced by the macroscopic appearance of an electrical burn mark, it should be noted that this finding, although significant, can sometimes lead to misleading conclusions.[1] Nevertheless, under certain circumstances, no electrical burn mark can be found when death occurs in or near moist and water places. This is due to the fact that water lowers the resistance and density of electricity.[2]

It is necessary to distinguish other similar lesions with similar morphological aspects such as abrasions, thermal burns, etc.[1] The histopathological examination of the skin and other organs coupled with the circumstantial evidence, proper and complete inspection of the crime site can be very helpful to the forensic pathologist in arriving at the diagnosis of electrocution related death.[2]

In this report, we present a case illustrating the connection between rhabdomyolysis, vascular thrombosis, and death caused by electrocution.

CASE REPORT

A 43-year-old Republic of China citizen- a factory worker with no known comorbidities was found unresponsive at his workplace while he was handling a water pump. He was pronounced dead on the day of the incident after resuscitation failed to return a spontaneous circulation. The history provided much later by the relevant parties indicates that the deceased might have suffered electrocution while working on a wet metal floor due to flooding caused by heavy rain in the factory.

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The body was that of a male Chinese, 168cm height and medium body build with the weight of 69kg. Rigor mortis was established and hypostasis was noted on his back apart from the contact area. There was no sign of decomposition. External examination of the body revealed a Y-shaped burn mark over the right side of the neck (FIG. 1). Multiple collapsed blisters (FIG. 2) with raised greying rings were found over the bilateral heels, ranging from 2cm×2cm to pin-point in sizes. There was also a bite mark with lacerated bruise seen on the inner mucosa of lower lip (FIG. 3) measuring about 4cm×1cm in size. Otherwise, there were no fatal injuries found externally.

Internal examination showed nothing alarming despite most of the internal organs appeared congested. The routine toxicology investigations were negative for alcohol and common drugs in both blood and urine samples.

Histopathological examination of the right and left foot blisters and the Y-shaped burn mark over the right side of the neck revealed intraepidermal detachment with streaming and elongated pattern of the nuclei and coagulative necrosis. (FIG. 4 A&B and FIG. 5).

Furthermore, there were casts of muscle fibres in some of the kidney tubules and it was confirmed by the Desmin immunohistochemistry stain (FIG. 6). Sections from the lungs showed the presence of microthrombi (FIG. 7). Otherwise, other organs appeared congested and did not exhibit any significant pathological changes.

FIG. 1: Y-shaped burn mark on the right side of the neck (black arrow).

FIG. 2: Multiple collapsed blisters on the left heel.

FIG. 3: Bite marks with lacerated bruise on the mucosa of lower lip.

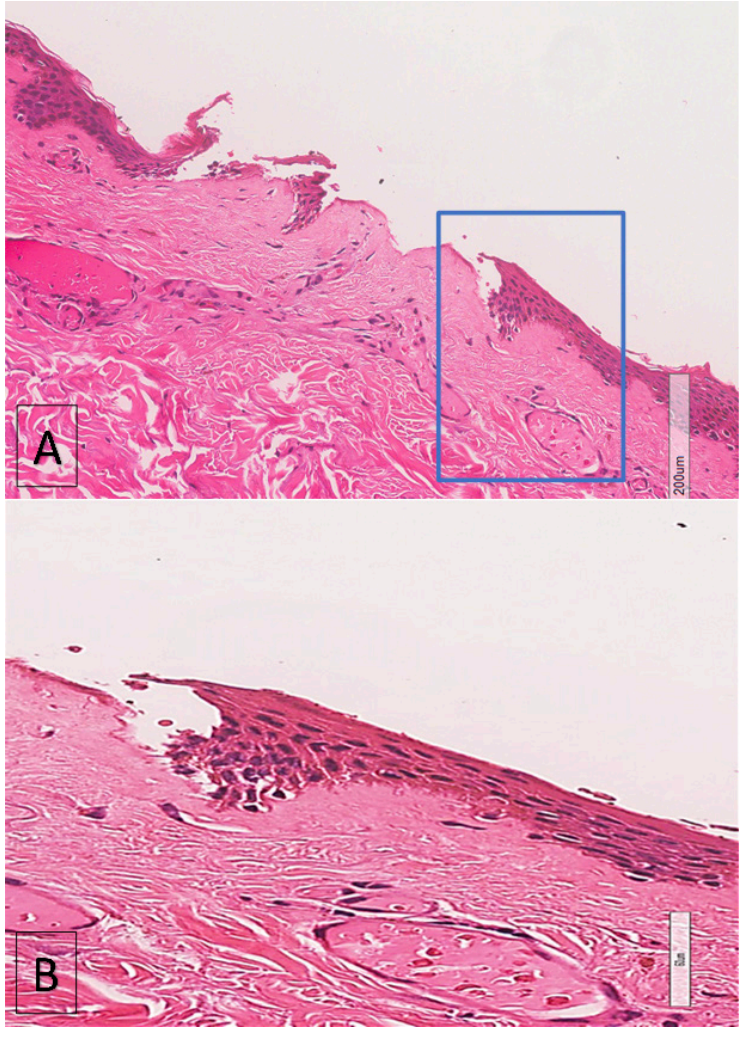

FIG. 4: Haematoxylin & Eosin (H&E)-stained section of the Y-shaped electrical burn mark over the right side of the neck revealed intraepidermal detachment with streaming and elongated pattern of the nuclei and coagulative necrosis (blue box). (A: ×200; B: ×400)

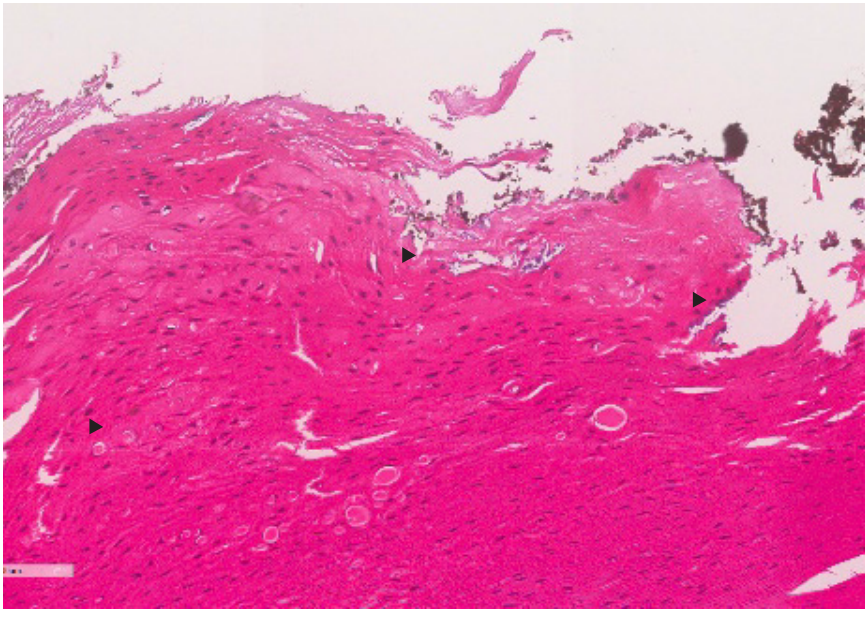

FIG. 5: H&E-stained section of the left heel revealed intraepidermal detachment (asterisk) with streaming and elongated pattern of the nuclei (head arrows) and coagulative necrosis of the collapsed blisters (×200).

DISCUSSION

Electrocution-related death is a common case encountered by a Forensic Pathologist. Annually approximately 1000 deaths in the United States can be attributed to electrical injuries, with about 400 of these cases specifically linked to high-voltage electrical injuries.[3] Among adults, these injuries are most prevalent in occupational settings, making them the fourth-leading cause of workplace-related traumatic death.[3] Data from the Occupational Safety and Health Administration (OSHA) and the Bureau of Labor Statistics reveal a total of 1201 workplace

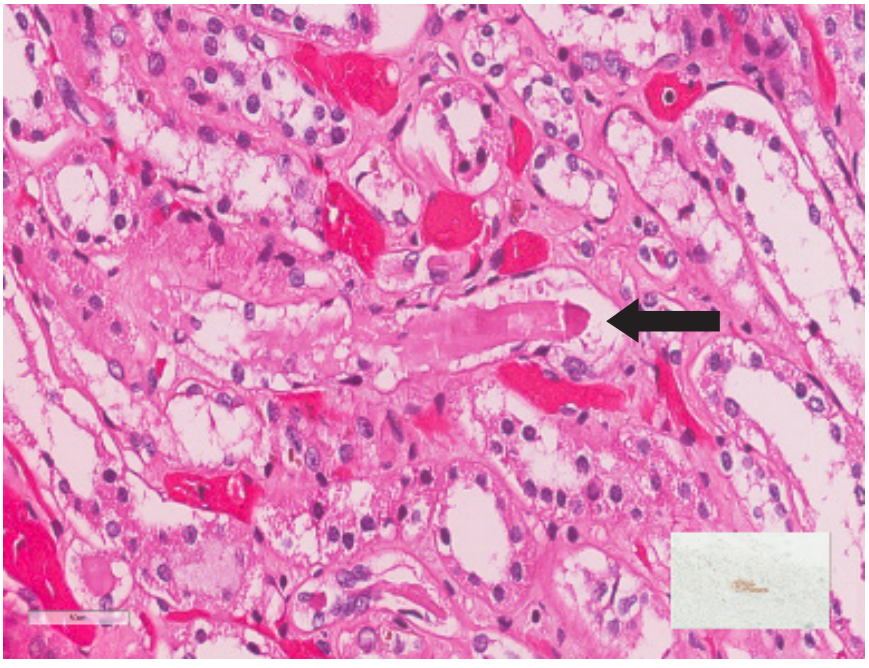

FIG. 6: H&E-stained section of kidney showing casts of muscle fibres in kidney tubule (black arrow) (×400).

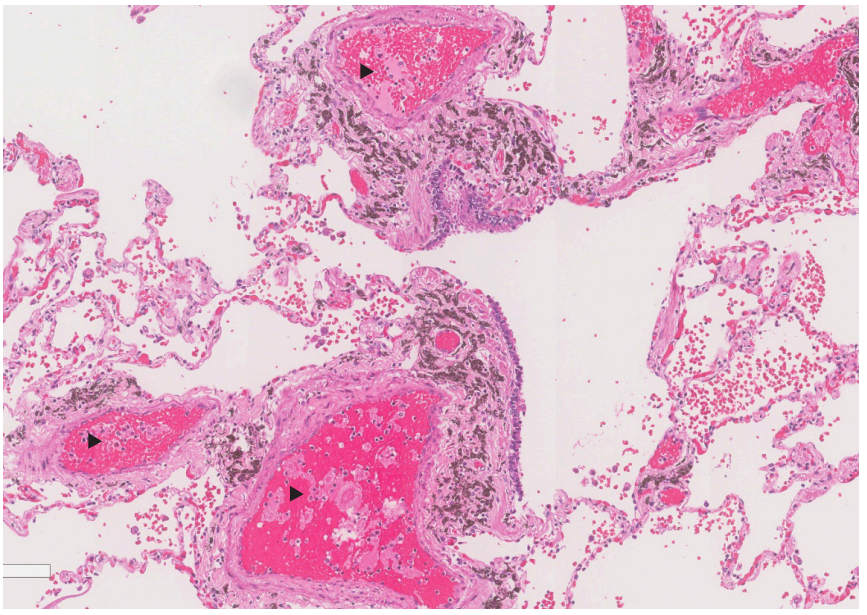

FIG. 7: H&E-stained section of the lungs showing microthrombi (head arrows) (×200).

fatalities involving electricity and 1653 electrical fatalities reported during the period from 2011 to 2021.[14] Interestingly, 69% of all electrically related fatalities during this time occurred in occupations not directly related to working with electricity.[14]

As a Forensic Pathologist, it is challenging to arrive at the diagnosis of electrocution, especially in cases where electric marking is not visible or unclear. Moreover, it could be arduous if the electrical mark is inflicted amidst the perimortem. On top of diagnosing, establishing the manner of death is of the utmost importance in order to classify the electrocution fatality.

Electrocution-related deaths can occur as a result of homicide, suicide, or accidental circumstances. The majority of cases are accidental. However, there was a remarkable increase in the number of suicidal electrocutions in the 1980-1990s, especially in baths where individuals will build elaborate devices to electrocute themselves.[4] On the other hand, homicidal cases were occasionally reported and the most common method is to drop a plugged-in device into a bathtub.

In our case which we reported above, the deceased was operating a water pump on a wet metal floor in his workplace. The Y-shaped burn mark found on the neck of the deceased was consistent with a metal object found by the investigating officer at the scene. It was a challenging case to begin with without proper history given. The process of getting to the final diagnosis was anchored with significant histological findings of rhabdomyolysis and vascular thrombosis on top of the external electrical marks, after ruling out the other possible causes through thorough investigations.

The electrical mark still represents a fundamental indicator above all in the medico-legal field, but the identification of pathognomonic elements and signs not limited to the skin alone could be a valid help in the future, especially in unclear cases.[1] Skin lesions caused by electrocution show histological patterns such as intraepidermal separation or intraepidermal-subepidermal separation, epidermal nuclear elongations and coagulative necrosis.[7] The increased heat from the electricity determines tissue fluid evaporation and separation of epidermal cells or subepidermal cells according to the various voltages. At the same time, the electromagnetic effects of electricity cause pyknotic and elongated nuclei which were arranged in the direction of electric burns. However, these patterns cannot be considered pathognomonic because they also occur in thermal burns,[3] blisters due to barbiturate poisoning, blunt dermal trauma, and sometimes even in freezing injuries.[2,8] In our case, we observed intradermal separation, epidermal nuclear elongation and coagulative necrosis which later guided us in arriving at our final diagnosis.

Furthermore, electrocution can cause myonecrosis and myoglobinuria which can further lead to tissue oedema and rhabdomyolysis.[6] Rhabdomyolysis is a common sequela of electrical burns and may result in severe and permanent metabolic and renal impairment.[9] Histologically, it is characterised by fragmentation of muscle fibres with associated necrosis and erythrocytes and, ultimately by acute kidney injury due to accumulation of myoglobinuria mainly in survivors.[10,11] More often, the presence of myoglobin, which some have found in the kidney, represents an indirect and peripheral sign of electrocution.[1] In addition, some studies highlighted the presence of rhabdomyolysis, suggesting it as a useful indicator to identify electrocution especially for cases without a detectable electrical burn mark on the skin or an unclear history.[9]

Rhabdomyolysis can arise from numerous factors, including trauma, burns, electric shocks, infections, muscular dystrophies, autoimmune diseases, heavy metal poisoning, drug toxicity, exertion, or epilepsy.[9] It may not be a specific finding per say, though seeing it collectively is what matters in our case.

We discovered fibrinous microthrombi in the deceased's small-sized pulmonary arterioles. These findings offer supportive evidence, rather than being definitive, of the potential influence of electrical injury. According to Ulrich *et al*. (2004), an imbalance between the clotting system and fibrinolysis is observed in cases of electrical injury.[12]

Furthermore, Ulrich *et al*. (2004) reported a case where vascular thrombosis developed three days after exposure to high-voltage electrical injury.[12] It is noteworthy that patients who have experienced high-voltage electrical injury may exhibit tissue necrosis and vascular thrombosis, regardless of the entry and exit sites of the electrical flow.[12] In addition to the aforementioned clotting abnormalities, the susceptibility of blood vessels to electrical damage is attributed to their excellent electrical conductivity, primarily due to their high water and electrolyte content, as emphasized by Mansueto *et al*.[1] Additionally, Park *et al*. (2012) found a significant impairment in the endothelial and smooth muscle functions of the brachial artery following high-voltage electrical injury.[13] The combination of hypercoagulability and endothelial injury, which constitute two-thirds of the components of Virchow's triad, contributes to the formation of vascular thrombosis and has been associated with electrical injury.[5]

Based on the studies carried by Mansueto *et al*. (2021), 960 articles were totally reviewed. However, only 16 papers satisfied the inclusion criteria reporting the histological findings of organ lesions apart from the skin were considered[1]. It is unquestionably that electrocution stigmas of organ damage are among the under-discussed topic. Therefore, more case studies or reports are required to emphasise the importance of organ damage related to electrocution fatality.

CONCLUSION

In conclusion, the presence of external electrical burn marks and significant histopathological changes in internal organs provide compelling evidence supporting the hypothesis that the deceased died from electrocution, ruling out any other major fatal injuries. However, it is crucial to conduct a thorough examination of the crime scene to accurately classify the cause of death as electrocution.

Despite the fact that the majority of the deaths are accidental in nature, future safety precautions are necessary. Public awareness and the implementation of good safety measures can reduce the mortality rate from fatal electrocution.

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