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Death due to electrocution during shower: one case report and brief review of the literature

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Abstract: Along with electric power becoming an essential part of industry and social environment, death due to electrical injury emerged as a considerable public health problem. And yet, it is still an uncommon cause of death. We report an electrocution case due to the improper use of an electric water heater to expose in order to show the potential hazards of electric water heaters as it is that are quite commonly used nowadays. This case report with respect to includes data from the scene investigation, and autopsy and findings, including microscopic toxicology analysis. We suggested preventive measures against electric injury to be carried out to the public. Finally, selected aspects of electric injury were reviewed with literature.
Key Words: electrocution; accidents; forensic pathology; electric water heater.

According to studies, electric death often occurs in summer have a male predominance [1-3], and are associated with increased humidity, sweaty or massive exposure of skin. In regard to the manner of death, suicidal or homicidal electrocution is rarely encountered in forensic work only a few cases being reported [4, 5]. Carelessness or ignorance is the main reason contributing to accidental electrocution, which makes up the vast majority of electric fatalities [6-8].

The incident happened during use of electric water heater, which is of frequent utility in China nowadays. This kind of death is sometimes encountered in our practical work but barely reported, and ignorance of the potential risks of these appliances is considered to be incriminated for these fatalities. We analyzed the hazards of this commonly used electric device under improper usage, intending to draw the attention of the public to in order reduce such kind of death.

CASE REPORT

A-34-year-old woman was found naked, laying on the bathroom floor one day after her shower, being found by the stuff of her rental housing. Doctors arrived and announced her dead. During the scene investigation, the police failed to detect proofs of struggle but found a potentially risky layout of shower devices: Electric water heater (220 volt) and its plug were placed in the bathroom, near the shower head; metal plumbing and shower head were uncoated with insulative material (Fig 1. A, B) and the electrical shower device was not earthed. Under highly humid environment during shower, the

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metal jacketing of the electric water heater became easy to get electrified and the current circuit was available from the electrified jacketing of water heater to the metal plumbing, shower head and then the victim standing on the ground.

During the external examination were identified four suspected electric marks on the dorsum of right hand, whose sizes were 1.9cm×1.4cm, 0.5cm×1.0cm, 1.0cm×0.4cm, 0.8cm×0.4cm, respectively. These lesions were all round or oval with pale and raised borders, taking on typical electric mark appearances. Localized exfoliation was identified on the 1.9cm×1.4cm lesion (Fig 1. C). Other fatal injuries were undetected on the body surface.

These four suspected electric-mark-like lesions were taken for histological study. We observed localized exfoliation as well as detachment and comb of epidermis, which we called "gaseous cavitation" (Fig 2. A, B). Epithelial cells and cutaneous appendage cells were hyperchromatic, elongated and compressed, showing "stream of nuclei" (Fig 2. C, D). In addition, collagen of dermis was swelling and homogenized, with increased eosinophilic staining.

Autopsy and microscopic study of viscera found only blood congestion of multiple internal organs instead of and no specific lesions. Toxicological analysis of specimens obtained from the blood, urine and stomach contents excluded the possibility of poisoning.

Taken together, the cause of death was determined to be accidental electrocution.

BRIEF LITERATURE REVIEW AND DISCUSSION

Heat, magnetism and chemistry are the three categories of electrical effects. The thermal energy converted from electricity has a particular significance in forensic science as it may cause visible lesions of tissue like including the electric mark on skin. Symptoms vary to a large extent depending on the levels of electricity exposure [9]. Mild symptoms after electrical contact may include local numbness, painful and sharp contraction of muscle; more severe electric discharges may cause dizziness, palpitation, muscle cramp, die Blausucht and malaise. Shock, coma, ventricular fibrillation or cardiopulmonary arrest are the most severe symptoms that are associated with electric fatalities. Multiple factors are contributory to the form and severity of electric injury, including tissue resistance, duration of contact as well as the type, magnitude and pathway of current [10]. High voltage and low voltage currents are both accountable for electrocution but low voltage fatalities are causing most home and industrial incidents. Higher voltage selectively damages the nervous system, either central or peripheral, causing respiratory arrest; most victims are therefore recoverable under prompt rescue. However, the heat associated with the high energy transfer (Joules) produced by high voltage always causes devastating burns [11,12] and victims mainly die from terrible burn injuries directly or secondary, from infection or electrolyte disturbance. In lower voltage incidents, the dominating mechanism of death is cardiac conduction system disruption, directly

Figure 1. Main findings in the scene investigation and external examination of the victim.
A and **B**. The accident scene. 1: Plug 2: Electric water heater 3: Plumbing 4: Metal shower head connected to the plumbing; **C**. Four electric marks on the skin of right hand.

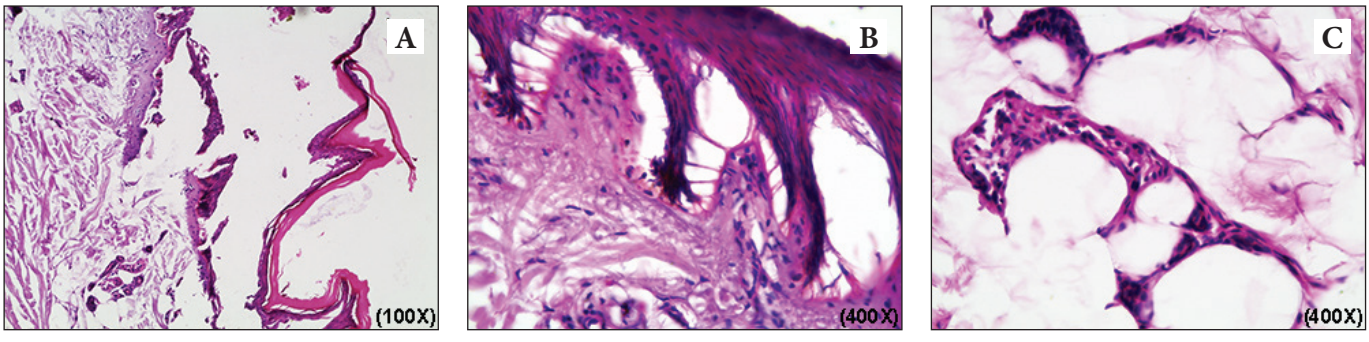

Figure 2. Important pathological detections of the electric marks on the right hand.
A. Detachment of epidermis; B. Gaseous cavitation and polarized epithelial cells; C. Cutaneous appendage cells showing streaming of nuclei.

leading to asystole or fatal ventricular fibrillation [13]. Usually, deaths occur instantly. 110-380 V is the most frequent voltage causing electrocution, which is also the most commonly used range of voltage found in homes and industries [9]. Still, it has been reported that voltage as low as 47 V was able to cause electric death [14].

Current frequency between 25 and 300 Hz is extremely dangerous to our body; however, the most commonly used frequency in China is 50 to 60 Hz. Under the same voltage, alternating current is three times dangerous than direct current as the alternating current tends to cause tetanic contraction of muscle, leading to involuntary continuous spasms, which lead to the inability to cast off the current source, prolonging the exposure time and increasing the current intensity and severity of electric damage to the body (let-go effect of current). Older theories postulated that electrical current was distributed through the nerve pathways or major vessels of the body; recently however was proposed that the electrical current is transmitted through a structureless gel in the body.

When the electrical circuit includes the brain, heart or lung it is high-hazard and usually causes death. It has been demonstrated that fatalities were higher in hand-to-hand passage than hand-to-foot passage. Pathways through upper-to-upper extremities usually damage the cervical (C) spinal cord from C4 to C8, which is lethal to the human body. B. Bailey *et al.* held however, the opposite view, as they found more victims that died from upper-to-lower extremities current flow compared with the upper-to-upper pathways [15].

The degree of electro-thermal injury is inversely proportional to the resistance offered by tissue. In general, the tissue offers more resistance when it possesses less water content. For example skin, bone, cartilage and hair are more resistant to the electricity than heart, brain or blood. Thus, examination by autopsy ordinarily reveals electrical burn mark on the skin rather than the internal organs. Thicker epidermal areas like those found on the back, haunch, palm and sole have a greater resistance while thin epidermal areas have a decreased resistance. Intact skin offers greater protection; after an electric injury, the resistance of charred skin drops to nearly zero, significantly reducing the protective effect of skin [16]. The contact with water, or perspiration significantly decreases skin resistance; this partly explains why electrocution is more frequent in the summer. In the latter event, a lower current may cause respiratory arrest or ventricular fibrillation. Also, the reduced resistance decreases the heat generated by the energy transfer, which sometimes causes the lack of formation of electric marks.

In terms of histological investigation, differential diagnosis of electric injury mainly includes thermal injury and abrasion. Electrical injuries are usually accompanied by additional traumas due to falls after electrocution. Although burns also exist in electric injury due to the heat produced by electricity and tissue resistance, electrical damage causes much more damage compared to thermal injury. Intra-epidermal separation and sub-epidermal separation are common in electrical lesions, but they can also be detected in abrasion. Tissue fluid evaporation caused by heat results in the separation of epidermal cells; therefore thermal damage may show intra-epidermal or sub-epidermal separation as well [17].

Collagen homogenization caused by collagen fibril swelling and denaturation [18,19] is another pathological change frequently observed in electrical injuries, which can also be detected in flame burns. If the thermal damage is more severe, coagulation necrosis may occur [20]. As for nuclear elongation, which was considered highly specific for electrocution, is now debatable since blunt injury, thermal damage as well as some other injuries like drying, freezing, cauterization and barbiturate poisoning may cause similar morphological changes [21].

Although less commonly used, special techniques have been applied into the diagnosis of electric marks. Schaeffner method and Timm method are often used in the chemical analysis for the detection of metal residues on skin. A positive reaction is identifiable based on the color determined by the reaction between the metal and chemical reagents. With high maneuverability and feasibility, chemical analysis is a more common option among special tests. Energy dispersive X-ray fluorescence spectrometry (EDXRF) is capable to analyse the spectrum of the whole elements and therefore describe the composition of electrified objects. Activation analysis is a qualitative and quantitative technique whose principle is to transform stable isotopes into radioactive isotopes by nuclear reaction and then measure the emission energy of radioactive isotope. This is an advanced testing method that entails complex condition and equipment; therefore its popularization of applications is limited.

In our reported case, following points were in support of the identification of electrocution:

1. There was potential electrocution risk of the electric water heater involved in this incident, current circuit was available between the victim and the electric shower device; no evidence of struggle was detected at the incident scene.

2. External examination revealed no lethal injuries except several electric marks.

3. Internal examination demonstrated just blood congestion of viscera instead of specific pathologic alteration.

4. Histological investigation demonstrated the skin lesions to be typical electric marks.

5. Through toxicological analysis, we excluded the possibility of poisoning.

In electric marks case, the diagnosis of typical electric marks was a critical point for identification of an

electric death. In regard to the cause of the incident, using electric equipment in high humidity environment is believed to be responsible. Electric water heater is widely used; there is a risk of when placed in the bathroom; because of that a grounding wire is prerequisite. During bathing, large amounts of water vapour made the jacketing of the water heater electrically charged [22]. In addition, the naked metal plumbing and shower head which the victim directly contacted served as excellent media for the conduction of electricity from the water heater. Due to the inability of the public to clearly understand the potential hazards of the installation pattern of electric water heater, quite a few electric water heaters are settled in the bathroom as a convenience. In view of the electrocution risk involved, we propose that the electric water heater and its plug to be settled in a dry environment and the shower head which we directly handle to be covered with insulating material.

Identification of electrocution requires high suspicion and intensive investigation of the incident. The equipment involved should be carefully photographed and have electric test. Electric injuries are often preventable with simple safeguards, protective measures entails proper design as well as comprehensive installation and maintenance of electrical appliances. Moreover, programs of public education and propaganda of protection against electric injury are also imperative to avoid such fatalities.

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Conflict of interest. The authors declare that they have no conflict of interest.

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