CASE REPORT

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An Electrocution Death of an Infant Who Had Received an Electric Shock from an Uncovered Oval Shaped Lamp Switch in His Mouth while in a Hospital

REFERENCE: Yamazaki M, Bai H, Tun Z, Ogura Y, Wakasugi C. An electrocution death of an infant who had received an electric shock from an uncovered oval shaped lamp switch in his mouth while in a hospital. J Forensic Sci 1997;42(1):151–4.

ABSTRACT: A male infant aged one year and nine months was found dead on a bed after admission to hospital with suspected pneumonia. The patient apparently put an uncovered oval shaped lamp switch (pendant switch) into his mouth and died of electric shock after contacting the exposed wires of the switch (100 V, 60 Hz alternating current). There were extensive first- to fourth-degree burns on the inner surface of the both lips. Because the histological findings were consistent with electric burns and the burns showed vital reactions, electric shock was judged to be the cause of death. The pendant switch is normally a very convenient piece of bedside equipment for inpatients. However, when the patient is an infant who naturally puts all the objects into the mouth, such a switch should be placed out of reach, and it should be certain that the cap is not loose.

KEYWORDS: forensic science, forensic pathology, electrical burn, electric current, sudden death, electric shock, electrocution, death

Death from electric shock is relatively common among suicides (1–5) and persons engaged in electrical works (6–9), but rare in homicide cases (10) and household accidents (11). In our knowledge, there have been no reports on infants who died of electric shock in hospitals. We autopsied an infant who was considered to have died of electric shock after putting an uncovered pendant switch into his mouth while in hospital.

A male infant aged one year and nine months was brought to the outpatient clinic of a hospital in the morning with fever and treated conservatively. Late in the same night, he was brought again with the same symptom but still encouraged to follow the same treatment. On the 4th day, a high fever (>40°C) developed and he was hospitalized with suspected pneumonia. His course after admission was uneventful and the temperature became normal on the 6th day of the illness. He was scheduled to be discharged from hospital on the next day.

Early on the 7th day, he seemed to be sleeping normally when the nurse and his mother saw him between 6:30 to 7:30 a.m., respectively. However, at about 7:45 a.m., his mother found him prone on the bed and dead with an uncovered oval shaped lamp switch (a pendant switch: 41.5 mm long and 29.0 mm in maximum diameter) in his mouth (Fig. 1). Electrical current (alternating current of 100 V and 60 Hz) was flowing through the switch. We obtained consent for autopsy to clarify the cause of death and performed the examination about 8 h after death.

External Findings

The patient was 82 cm tall and weighed 10.9 kg with moderate build and nourishment. Postmortem rigidity was moderate in the joints of the neck, shoulders, hands and toes, but marked in other joints. There was moderate lividity on the dorsal surface of the whole body, which showed slight discoloration in response to

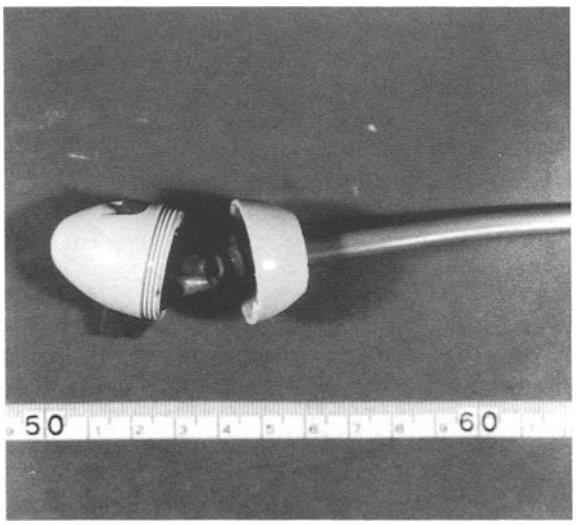

FIG. 1—*The pendant switch that was found in the mouth. The view of lateral side.*

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Received 1 April 1996; and in revised form 13 May 1996; accepted 15 May 1996.

finger pressure. The rectal temperature was 26.0°C, whereas the room temperature was 25.0°C. The palpebral conjunctiva showed pallor in both sides and petechiae were not observed. Both pupils were 4 mm in diameter and corneal opacity was moderate.

An area of mucosa measuring 2.8 cm by 1.3 cm was slightly carbonized (third- to fourth-degree burns) on the left side of the lower lip. Continuous with this lesion, the right side of the upper lip and the labial surface of the lower gingiva were slightly carbonized (third- to fourth-degree burns). On the lower lip, erythema and vesicles spread to the left from the site of carbonization (first- to second-degree burns). Similar changes were also noted at the left border of the upper lip. Erythemas were also noted on the labial surface of the gingiva near the upper and lower right lateral deciduous incisors (first-degree burns) (Fig. 2). Apart from these findings, there were no other abnormalities elsewhere and the anus was closed (a large amount of faeces was noted in the diaper at the time when the patient was found dead).

Internal Findings

Numerous petechiae were scattered below the pericardial membrane. The heart was 61 g in weight and slightly larger than the infant's fist. A few petechiae which looked like millet grains or smaller were scattered below the epicardium and postmortem rigidity was marked. The apex was formed by the left ventricle and profuse dark-red fluid blood was retained in the heart. There were no abnormalities in the endocardium, the valves or the myocardium, and the foramen ovale was closed. The coronary arteries were soft and free from atherosclerosis. The inner surface of the origin of the aorta was smooth and the circumferential length was 3.2 cm wide.

The left and right lungs respectively weighed 101 and 122 g. Considerable bulging and numerous rice-grain-sized petechiae were noted in both lungs. The blood volume was normal and edema was mild. The bronchi contained a small amount of yellowish-white clear mucus, and the hilar lymph nodes were not particularly enlarged.

The liver, spleen, pancreas, left and right kidneys, and left and right adrenals, respectively, weighed 592, 51, 17, 56, 53, 3.3, and 2.2 g. The blood volume was normal and no abnormalities were noted in these organs. The pelvic mucosa was pale with a few petechiae.

The palatine tonsils were not enlarged. The pharynx, larynx, and trachea were normal except for a small amount of adherent, foamy fluid, and a few mucosal petechiae. There were numerous petechiae on the undersurface of scalp, but the cranial bones were not fractured and the brain (weighing 1216 g) was unremarkable. No other abnormalities were noted elsewhere in the body.

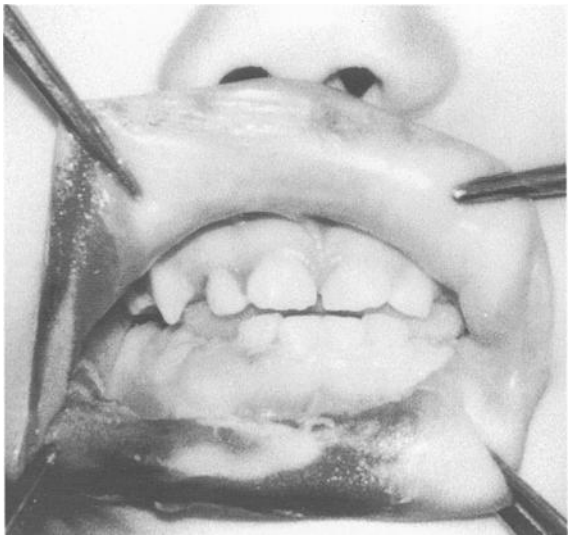

FIG. 2—*The electric burns observed on the lips which was turned inside out.*

Histopathological Findings

At autopsy, burnt areas with adjacent normal mucosa from lips and other tissues from various organs were collected. The specimens were fixed in 10% formalin and paraffin sections were prepared by standard methods. After staining with hematoxylin and eosin, the sections were examined by microscopy. Tissue specimens collected from the lips were also stained for copper (paradimethyl aminobenzyliden rhodanine (12) and rubeanic acid methods (13)) and iron (Berlin blue (14)). At the sites of the labial burns, the epidermis was largely detached from the basal layer. The residual epidermis was generally atrophic and flattened, although it was wrinkled and protruding at various sites. In addition, nuclear fusion and pyknosis were marked and the cells of the basal layer and their nuclei were elongated and aligned in a palisaded fashion. The collagen fibers of the dermis were swollen and eosinophilic. The nuclei of intradermal vascular endothelial cells were also flattened and were aligned radially (Figs. 3-a,b). Both copper and iron stains were negative. In the myocardium, vacuolation of part of the left ventricular papillary muscle was noted. The lungs were slightly congested and a small amount of secretion was retained in the bronchi. Peribronchial neutrophil infiltrates were seen, but there was no evidence of pneumonia. The other organs were unremarkable.

Discussion

The forensic problems in this case included: 1) determination of the cause of death (electric shock or suffocation), 2) determination of the influence of the pyogenic disease that had led to hospital admission, and 3) assignment of responsibility.

The pendant switch found in the infant's mouth was in the "off" position. However, its cap had been detached from the body and the terminals of the wires were exposed. Therefore, if the two terminals were connected electrically, current flow could occur. There was no doubt that current flow had occurred because the oral cavity and inner side of the lips were moist, and salivation would increase when the infant put something into his mouth. In general, dry skin is said to have a resistance of about 10^5 Ω (ohms) (15,16), and so only 10^{-3} A (amperes) of current would flow at 100 V (volts), as calculated by the equation I (electric current) = E (voltage) ÷ R (resistance). However, wet skin has a resistance of under 10^3 Ω (15,16). In this case, an electric current over 100-fold greater than that passing through dry skin, or over 0.1 A, probably passed through the infant's body. Such an electric current is likely to cause ventricular fibrillation (16–18,21,22) and thus may be lethal.

When the burns on the lips were examined histologically, typical findings of electric burns were noted. Briefly, epidermal nuclear fusion and pyknosis were prominent, while the basal cells and their nuclei were elongated and aligned in a palisaded fashion. In addition, the nuclei of the intradermal vascular epithelial cells were generally flattened and aligned radially (Fig. 3-b). This was an

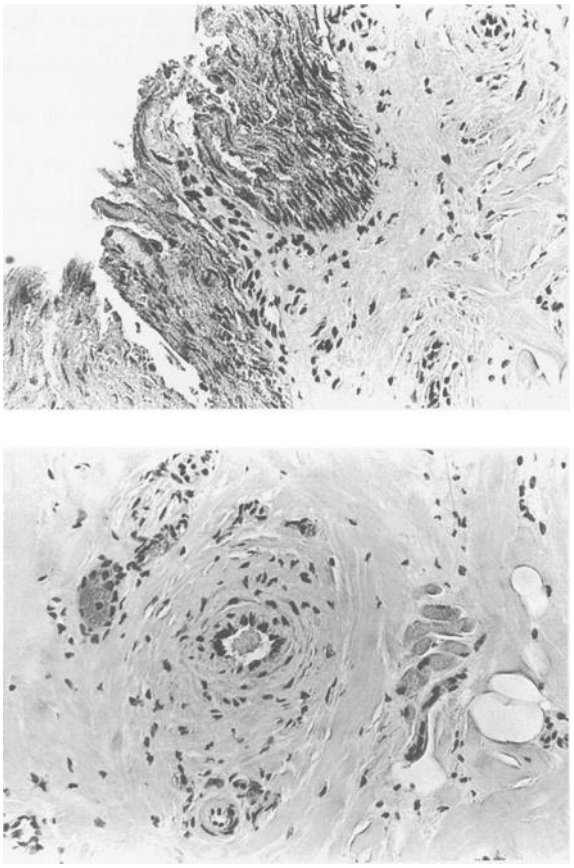

FIG. 3—*Histological findings of the injured skin in Fig. 2. (H-E staining, (a) ×250. It shows the destruction of the epidermis with the streaming effect of the epidermal nuclei and the dermal collagen stained more eosinophilic. (b) ×250. Other part of the section. It shows that endothelial nuclei are flattened and arranged in a radial manner.)*

interesting finding. It is conceivable that the electric current passed more easily through the intradermal capillary blood than through the dermal tissue because of its lower resistance. As a result, the nuclei of the endothelial cells would have been flattened and oriented in the direction of current flow, resulting in their radial alignment. Based on these histological findings, the labial burns were assumed to be caused by electric current. Furthermore, it was reasonable to conclude from the finding of the florid part in the lesion that electric current had passed through the body when the infant was alive.

The cord connected to the pendant switch was for household use. According to provision H of the JIS, it must contain not less than 99.96% copper and not more than 0.01% iron. When analyzed at the Forensic Science Laboratory of the Osaka Prefectural Police Headquarters, the screw of the pendant switch was found to contain 63–67% copper, 32–36% zinc, and not more than 0.05% iron. Although staining of the labial burns was negative for copper and iron, it is not rare for these reactions to be negative on histological examination of electric burns, so the possibility of current flow through the body could not be ruled out.

When an electric current passes through the body, heat is generated and burns may result depending on the site affected, duration of current flow and other factors, even when the voltage is as low as 100 V. In the present case, the duration of current flow was probably less than 15 min, and definite burns had occurred.

The pathway of current through the body can be crucial in determining the injuries caused by electric shock. The mortality rate is likely to be high when vital organs such as heart and brain are present in the pathway of the current. Even when electric burns are present at the entry site, there may be no signs at the exit, depending on the involved skin area, moisture content, and duration of current flow (19,20). In this infant, there were no injuries indicating the passage of current through tissues other than the lips. However, because the accident occurred while he was lying on a hospital bed and there were no definite site through which electricity could easily escape, the possibility that he died of this type of electric shock characterized by the absence of exit burns is rare.

There is no doubt that current flowed between the two terminals of the pendant switch when these were brought into contact with the mucosa and/or saliva within the mouth of the infant. However, both terminals were very close to each other and it was unclear whether or not death was caused by such current flow.

The cause of death in this case may have been that electric current applied to the lips traveled along the laryngopharyngeal mucosa and reached the heart via the esophagus, trachea, and other organs. In other words, the electric current traversed much of the body as well as the lips, resulting in the involvement of vital organs, such as the heart. Myocardial vacuolation is a common finding of electric shock after death and suggests the influence of current on the heart. When the victim is an infant, the pathway of the current is shorter than in adults. In addition, the water content of the body is higher in infants than in adults, and therefore electrical resistance is decreased, so current flow may be increased. The relative sensitivity to electric shock is child > woman > man, while the relative threshold for ventricular fibrillation is man > woman > child (17). The duration of current flow was probably prolonged because the infant could not open his mouth to vomit out the pendant switch, because the electricity was strong enough to prevent voluntary movement. We have previously experienced a case of death from electric shock which occurred when the victim tried to tear off the plastic insulator of an electric cord through which live current (100 V, 60 Hz alternating current) was flowing with the teeth during repair of an electrical apparatus. The present case was similar and we judged that death from electric shock was caused by conduction between the two terminals of the switch placed very close to each other on the lips.

The pendant switch was not so small in size relative to the mouth of this infant. However, even assuming that this switch was completely contained in the mouth, it was difficult to conclude that the cause of death was due to inhibition of inspiration or expiration. Therefore, death was not considered to be ascribable to suffocation due to airway obstruction by the switch.

The pyogenic disease that was the cause of hospital admission could not be defined at autopsy. Histological examination of the lungs disclosed slight peribronchial neutrophil infiltration, a finding suggestive of previous infection. Thus, the pyogenic disease was considered to have no influence on the death of this infant. Accordingly, it was considered medically appropriate that discharge from hospital had been scheduled on the day this tragic accident occurred, because he had probably recovered sufficiently.

If the reports on the detection of this accident were accurate, the infant was sleeping until only 15 min before he was found dead. Therefore, he awoke, removed the cap of the pendant switch, and put it into his mouth in a very short period. Accordingly, it seems difficult to hold the nurse or his mother to blame for neglecting the infant. However, this accident emphasizes that it is very important to assure that the screw of the cap of a pendant switch

is not loose and unable to remove it easily, or to place it out of reach when the patient is an infant. Moreover, similar attention must be paid if the patient has dementia, or has other conditions that prevent normal switch operation and ever disencourage to use of the switch as a toy.

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