Case Report

Electrocution death and pathological findings with the metallization in wild elephant: case report

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Abstract

An about 20-year-old, male wild elephant was found dead on the road and electrocution was suspected to be the cause. Electrocution of wild elephants was rarely documented. On necropsy examination, an electrical mark may be the only external appearance with no appearance of specific gross lesions on the internal organs. The pathologist will use evidence from the scene with histopathological investigation to make the diagnosis of the cause of death. The necropsy determined electrical marks on the trunk and legs of the elephant, while hemorrhage and congestion were found in the lungs, heart and omentum. Microscopically, skin showed epidermal separation with streaming cytonuclear elongation. The metallization of iron and copper were presented on the electric skin burn. The myocardium was fragmented and presented as square nuclei. These findings were typical morphologic changes that supported the differential diagnosis of skin lesions and internal organ damage caused by electrocution. This is the first description of a post-mortem with distinctive histopathologic investigation in electrocution of wild elephant.

Keywords: wild elephant, electrocution death, pathology, metallization

ลักษณะทางพยาธิวิทยาและการสะสมของโลหะบนผิวหนังในช้างป่าที่เสียชีวิตจากการถูกไฟฟ้าช็อต : รายงานสัตว์ป่วย

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บทคัดย่อ

ช้างป่า เพศผู้ อายุประมาณ 20 ปี ถูกพบนอนเสียชีวิตอยู่บนถนนในเขตรักษาพันธุ์สัตว์ป่า ในเบื้องต้นเจ้าหน้าที่สันนิษฐานว่าช้างดังกล่าวเสียชีวิตจากการถูกไฟฟ้าช็อต การตรวจชันสูตรการเสียชีวิตจากการถูกไฟฟ้าช็อตถือเป็นเรื่องที่ยากมากสำหรับพยาธิสัตวแพทย์ เนื่องจากรอยโรคที่เกิดจากการถูกไฟฟ้าช็อตไม่มีความจำเพาะ และรอยโรคที่ตรวจพบภายนอกอาจเป็นรอยโรคเดียวที่เกิดขึ้นโดยไม่พบวิการอื่นๆในอวัยวะภายในเลย ดังนั้นในการวินิจฉัยการเสียชีวิตจากการถูกไฟฟ้าช็อต จึงต้องอาศัยข้อมูลที่ได้จากที่เกิดเหตุร่วมกับผลทางจุลพยาธิวิทยาในการสรุปสาเหตุของการเสียชีวิต ในกรณีของช้างเชือกนี้พบว่าจากการตรวจสภาพร่างกายภายนอกปรากฎวิการลักษณะคล้ายรอยไหม้ที่เกิดจากไฟฟ้าช็อตที่งวงและเท้า และจากการชันสูตรซากพบวิการที่เป็นหย่อมเลือดออกและเลือดคั่งที่ ปอด หัวใจและเยื่อแขวนลำไส้ในช่องท้อง การตรวจทางจุลพยาธิวิทยาพบว่าผิวหนังบริเวณที่เกิดรอยไหม้มีการแยกชั้นออกจากกันของชั้นหนังกำพร้า นอกจากนี้ยังพบว่าเซลล์และนิวเคลียสในชั้นหนังกำพร้ามีลักษณะยืดยาวออกและยังตรวจพบการสะสมของเหล็กและทองแดงบนผิวหนังจากการใช้เทคนิคทางฮีสโตเคมี เซลล์กล้ามเนื้อหัวใจมีลักษณะหักเป็นท่อนและพบลักษณะนิวเคลียสมีรูปร่างเป็นสี่เหลี่ยม ลักษณะรอยโรคทางพยาธิวิทยาตาเปล่าและจุลพยาธิวิทยาที่ตรวจพบในช้างเชือกนี้เป็นลักษณะเด่นของวิการที่เกิดจากการถูกไฟฟ้าช็อต รายงานนี้ถือเป็นรายงานกรณีสัตว์เสียชีวิตรายงานแรกที่อธิบายถึงการชันสูตรช้างที่มีผลการตรวจทางพยาธิวิทยาตาเปล่า จุลพยาธิวิทยาและฮีสโตเคมี ที่เป็นลักษณะเด่นของรอยโรคอันเป็นสาเหตุของการเสียชีวิตจากการถูกไฟฟ้าช็อต

คำสำคัญ : ช้างป่า ไฟฟ้าช็อต พยาธิวิทยา การสะสมของโลหะบนผิวหนัง

Electricity can cause damage by the passage of current through the body. The severity of the injury depends on the current, voltage, pathway, tissue resistance and contact time (Saukko and Knight, 2015). Clinical presentation and severity of electrical injuries vary from a transient irritating sensation to massive injury and instantaneous death depending on contact with low or high-voltages. Electrocution from low-voltage (<1000Volts) frequently occurs through accidental contact with electrical circuits, with death most likely caused by ventricular fibrillation. Death from high-voltage electrocution (>1000Volts) is usually due to electrothermal injury and paralysis of the respiratory centres (DiMaio and DiMaio, 2001). The necropsy assessment of a possible electrocution is complicated, and it is often very difficult for the pathologist to determine the exact cause of death. Electric burns or marks left on the body by the passage of an electric current do not always exist, and non-specific lesions can only be recognized in internal organs. The pathologist needs to determine the position of the victim in relation to the contact source of the electricity. Information should be collected from witnesses regarding the sequential events of the accident, on the spot evidence, and necropsy findings while a microscopic examination will provide clues as to exactly what happened.

Case history

An about 20-year-old, male wild Asian elephant *(Elecphus maximus)* with short tusks was found dead on the road to the Weather Radar Station in Salakpra Wildlife Sanctuary, Kanchanaburi Province, Thailand. The straight burn marks on the skin and trunk of the elephant was noticed by the witness. Electric shock was the suspected that might be accidentally occurred during eaten the bamboo nearby, The three-phase low-voltage electricity line was contacted with the bamboo branch. The elephant collapsed and died. The veterinarian from Pasupalan Livestock and Wildlife Hospital was called to investigate the cause of death. The elephant was lying on its right-hand side under the electricity pole and the piece of electrical line was found close to the body of the elephant.

Pathologic finding

During the necropsy, an external examination identified three marks on the trunk and legs of the elephant. The trunk presented gross lesions which electrical mark appeared as linear skin lacerations of 3 cm (Fig. 1). On the sole of the left foreleg there was an electric burn as black discoloration of 2 cm x 1.5 cm (Fig. 2). The lower part of the left hind leg exhibited an electric skin burn with abrasion and laceration of 8 cm x 7.5 cm. The nasal opening of the trunk showed bleeding of serosanguinous fluid that had drained onto the ground. The remaining of the body surface was grossly normal.

An internal examination revealed red discoloration on the lung with localized areas of hemorrhage presented on the omentum and epicardial surface of the left ventricle. Other internal organs showed no remarkable morphologic change. Samples of heart, spleen, liver, kidney, lung, and lacerated skin were fixed in 10% neutral buffered formalin, paraffin embedded, and stained with H&E for histopathological investigation. Additionally, the suspected electrical skin burns of the trunk were collected for histochemical analysis to determine the metallization using Pearl's Prussian blue and

Rhodamine staining for iron and copper, respectively.

Microscopically, the lung area showed congestion of the alveolar walls with slight hemorrhage in the alveolar spaces. The myocardial fibers exhibited waviness and separation. Some cardiac myocytes appeared necrotic and fragmented. Myocardial hypercontraction was evident, with square or round shaped nuclei observed in scattered areas (Fig.3). Small intracardial blood vessels were destroyed and interstitial hemorrhage was also presented. The skeletal muscle cells under the electric marks presented severe diffuse necrosis. The myocytes were fragmented and vacuolated with a hypereosinophilic appearance (Fig.4). The skin lesions revealed intraepidermal separation (Fig.5) and the epidermal cells and nuclei were elongated and demonstrated streaming (Fig.6). The collagen fibers in the dermis were swollen and homogenized with hypereosinophilic staining. In addition, vascular contain hemolyzed blood was observed in the superficial dermis in the vicinity of the electrical burn. Histochemically, results showed positive staining for iron and copper on the margin of the electrical skin marks (Fig.7-8). Other internal organs showed intact gross morphology and histopathology only observed hemorrhage and congestion.

Discussion

Electrocution-induced death in wild elephant was rarely documented in Thailand and worldwide. In humans, death occurs mostly at low-voltage in the range of 110 to 220 Volts (Dokov and Dokova, 2011). For animals, low-voltage current has been reported to cause fatalities in horses and cattle (Bae YC et al., 2008; Adrian et al., 2016). Animal deaths from high-voltage are uncommon but have frequently been reported for birds because of their habitats and behaviors (Kagan, 2016; Schulze, 2016). In Thailand, the domestic electricity supply is set at 220V alternating current (AC) with 50 Hz, and low-voltage transmission lines in urban areas carry 400V. This elephant was found dead from low-voltage electricity. The suspicion is that its trunk made contact with the 400V electric cable while foraging for food. Electrocution was recorded as the cause of death.

Electricity requires a complete circuit for continuous flow. When an electric wire is accidentally touched, current will pass through the body from the contact point to the ground. An electrical burn may appear at the entry and exit points of the discharge. This elephant presented an electric mark on its trunk with the sole of the left foreleg. The linear burn on trunk was suspected as the point of entry because the shape and size of this lesion were consistent with contact with an electric cable. Electric current passes by the shortest route between entry and exit to the earth (Tsokos, 2007). Accordingly, the exit ground point was suspected to be a black discoloration of skin burn on the sole of the left foreleg as the nearest electrical mark from the trunk. In addition, microscopic examination of the skin burn revealed intraepidermal separation and nuclear streaming. These were caused by thermal heat and the electromagnetic effects of electricity (Takamiya et al., 2001; Saukko and Knight, 2015) as typical microscopic evidence presented in many experiments concerning electrocution (Sukheeja et al., 2013; Viswakanth and Shruthi, 2015).

Electrical conductors are generally not made from a single metal. Copper, iron, aluminium, zinc or nickel can be combined to decrease the cost of using pure material. When electric current transfers from a metal conductor into the body, a form of electrolysis occurs and metallic

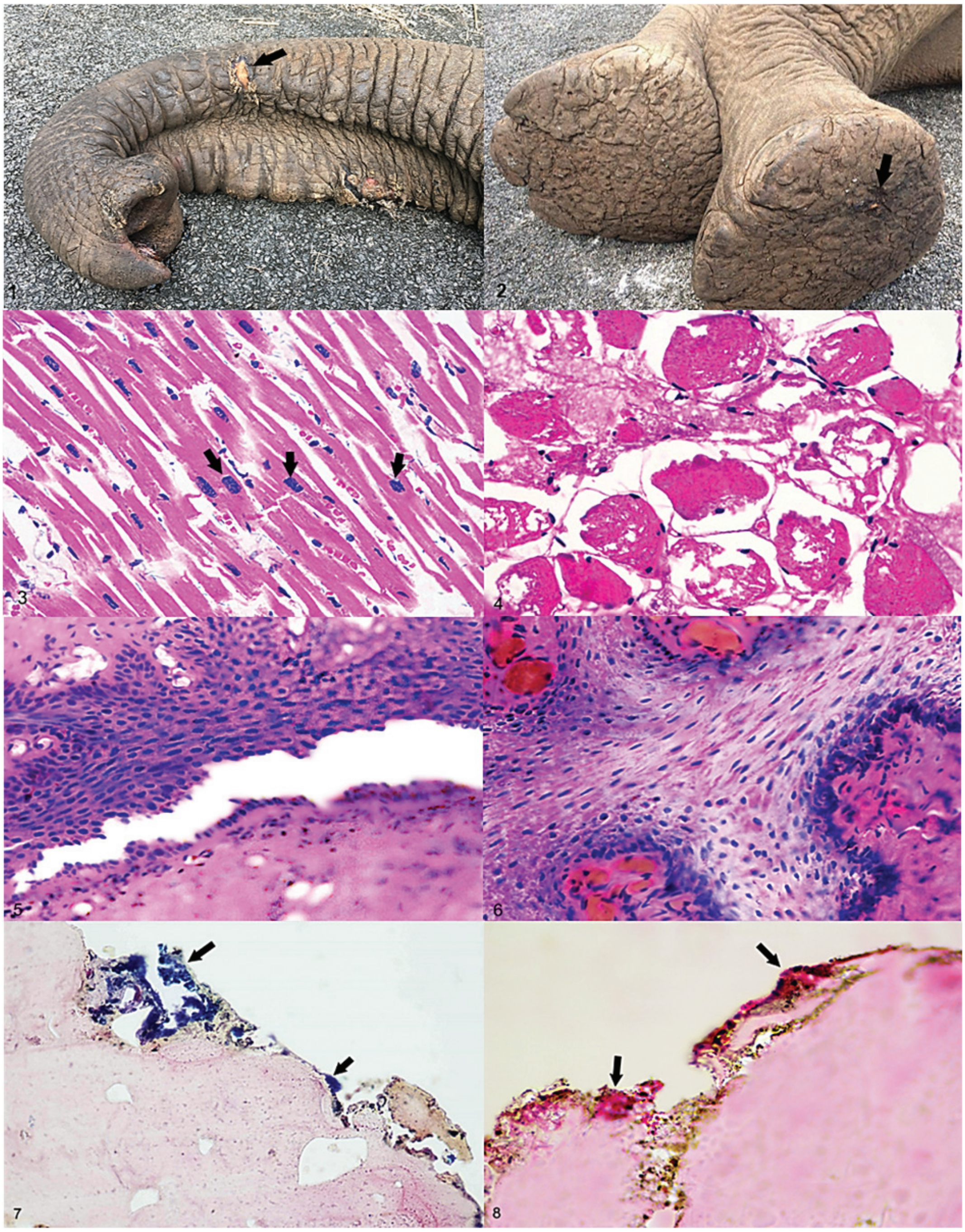

Figure 1. Electric mark, skin of the trunk, elephant. Linear skin lacerations (arrow) representing point of entry.

Figure 2. Electric mark, skin of the sole of left foreleg, elephant. Electrical burn (arrow) of sole representing exit site.

Figure 3. Electrocution, cardiac muscle, elephant. The myocardium was fragmented and presented as square nuclei (arrows).

Figure 4. Electrocution, skeletal muscle, elephant. The myocytes were vacuolated, torn and necrosis with hypereosinophilic appearance.

Figure 5. Electric mark, skin, elephant. Intraepidermal separation.

Figure 6. Electric mark, skin, elephant. The epidermal cells and nuclei were elongated and demonstrated streaming.

Figure 7. Electric mark, Metallization, skin, elephant. Iron deposit at the electric skin mark show positive blue color strained (arrows) with Pearl Prussian Blue.

Figure 8. Electric mark, Metallization, skin, elephant. The accumulation of copper were demonstrated in red color (arrows) on electric skin burn with Rhodamine stain.

ions are released on contact with the skin (Bellini et al., 2016; Schulze, 2016).These cannot be seen by the naked eye but are detectable by chemical, histochemical and spectrographic techniques. In this case, electrical skin marks were collected and histochemically analyzed to determine the metallization. To detect the presence of iron, Perlsí Prussian Blue staining method was used. The Rhodamine method was applied to indicate the occurrence of copper. Results showed positive staining for iron and copper on the margin of the electrical skin marks. Moreover, iron was observed in both the intraepidermal and superficial dermis. The presence of iron and copper on the skin provided evidence that these lesions were caused by an electric current. In addition, the ranger also found a piece of electric cable close to the body. Thus, the hypothesis was that after death, the elephant fell down and the wire fortuitously dropped to touch the lower part of left hind leg then caused dark skin burn with abrasion and laceration.

Skeletal muscles and the myocardium have high sensitivity to electrical injuries because they contain high concentrations of electrolytes so electric current can cause severe damage in these structures. In this case, the myocytes showed normal gross lesions but microscopic examination revealed severe diffuse fragmentation, vacuolation, hyaline degeneration and necrosis.

Macroscopically, the heart showed hemorrhagic areas on the epicardium; however, histopathological investigation demonstrated separation, fragmentation and square expression of the myocardial nuclei with hemorrhaging. These lesions were consistent with cardiac lesions found in previous studies (Badawy, 2015; Viswakanth and Shruthi, 2015). Necrosis of the skeletal and myocardial fibers was not associated with inflammatory features, suggesting that sudden death occurred with no time to develop the inflammatory process.

In fatal electrocutions, gross findings in the internal organs may be absent. The internal tissues are largely aqueous and contain conductive electrolytes, thus, the current pathway is usually too diffuse to cause thermal injury (Saukko and Knight, 2015). In this case, other internal organs showed only congestion and hemorrhaging under microscopic examination.

Necropsy evidence showed electric marks on the trunk and the sole of the left foreleg. Moreover, the heart demonstrated the typical lesions associated with electrical injuries. Therefore, the electric pathway began at the contact point on the trunk, passed through the head and heart and then down to exit at the sole of the left foreleg. An electric current that travels through the head may also affect the brain. The fatal process in this case was a direct effect on the brainstem and the cardiac and respiratory centers were paralysed. Additionally, the current travelled to the heart and caused cardiac injuries and fibrillation (Tsokos, 2007; Dokov and Dokova, 2011; Saukko and Knight, 2015). We concluded that the electricity severely damaged the respiratory centre in the brain, accompanied by myocardial damage which resulted in instantaneous death.

Although, the pathologic finding in necropsy and microscopic are not a specific lesion for electric injury, but there are the most frequently notified lesions in electrocution. The significant clues to determine the diagnosis are described as follows: 1. The evidence on the spot showed that the elephant died under an electric power pole, and a broken electric wire was found beside its body, 2. An external examination found electricity entry and exit points on the trunk and the sole of the left foreleg. The electrical marks on the trunk matched with the shape of the electric cable, 3. Microscopic findings presented typical lesions consistent with electrocution as epidermal nuclear streaming, intraepidermal detachment, myocardial fragmentation and necrosis, and square nuclei shapes of the cardiac myocytes, and 4. Histochemical analysis demonstrated iron and copper metallization on the contact skin point.

Taken together, we finalize the diagnosis to accidental death from electrocution. Elephant deaths due to electrocution are rare; however, the relevant authorities should pay attention and protect other animals and humans who may be exposed to electricity by inadvertently touching electric lines in the same dangerous environment.

Acknowledgement

The authors would like to thank the official of Salakpra Wildlife Sanctuary, Kanchanaburi, Thailand and The Faculty of veterinary science, Mahidol University for the support.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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