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Acute Ischemic Stroke Associated with Low-voltage Electrical Injury: A Case Report

Düşük Voltaj Elektrik Akımına Bağlı Akut İskemik İnme: Olgu Sunumu

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Summary

Electrical injuries are common physical injuries in daily life. Vascular injury and thrombosis are frequently found in cases of high-voltage electric injury because of the low resistance of vascular tissue, but are rarely reported in low-voltage electric injuries. Acute stroke is not a common complication of electrical injury, and only a few cases of acute stroke have been reported for low-voltage injures. Electric shock injury with low-voltage alternating currents and prolonged contact periods may possibly cause ischemic stroke. We present a case of a man who had a low-voltage electrical injury, by an ischemic stroke.

Keywords: Ischemic stroke, low-voltage electrical injury, neurologic complication

Öz

Elektrik yaralanması günlük yaşamda sık görülen bir fiziksel yaralanmadır. Vasküler dokuların düşük direncinden dolayı, vasküler yaralanma ve tromboz genellikle yüksek voltaj elektrik yaralanmasındaki olgularda bulunur, ama düşük voltaj elektrik yaralanmasında nadiren bildirilmiştir. Akut inme elektrik yaralanmasının yaygın bir komplikasyonu değildir ve düşük voltajlı elektrik akımına bağlı az sayıda olgu bildirilmiştir. İskemik inmenin muhtemel mekanizması düşük voltaj elektrik yaralanmasının devamlı ve uzayan teması olabilir. Burada düşük voltaj elektrik yaralanmasını takiben gelişen iskemik inme olgusu sunuldu.

Anahtar Kelimeler: İskemik inme, düşük voltaj elektrik akımı, nörolojik komplikasyon

Introduction

Electrical injuries affect several tissues and organ systems including the heart, skin, muscles, kidneys, and vascular and nervous systems. The severity of electrical injury is related with the intensity of current, duration of contact, route followed in body, and tissue resistance (1).

In the Trial of Org 10172 in Acute Stroke Treatment classification, ischemic stroke following exposure to electric current constitutes a small part of ischemic stroke due to other causes (2).

Central nervous system complications that might arise after exposure to electric current include myelopathy, encephalopathy, intracranial hemorrhage, ischemia, edema, hydrocephalus, and venous thrombosis (3). Other neurologic complications that might occur, particularly after high-voltage electrical injuries, include spinal cord lesions, peripheral nerve injuries and motor neuron diseases, as well as brain injury (4).

Six ischemic stroke cases secondary to exposure to high-voltage current and two ischemic stroke cases secondary to exposure to low-voltage electrical current have been reported in the recent literature, published in the last two decades (5). In this manuscript, we report a very rare case of ischemic stroke secondary to low-current electrical injury and discuss it in the light of related literature.

Case Report

A man aged 79 years who was previously healthy was found unconscious at his home and taken to the emergency room. In

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the neurologic examination the patient had stupor, right central facial paralysis, and right hemiplegia. Deep tendon reflexes were brisk and the plantar response was extensor on the right. First and second-degree burns constituting 8-9% of the body surface were noted on the right mandibular corpus (Figure 1a), dorsal surface of the right hand, lateral right thigh, and anterior right leg (Figure 1b). The patients's medical history was obtained from his family, which revealed that he worked as a television mechanic; an electrical cable was found cut with a knife where he was found at home. Atrial fibrillation was seen in electrocardiography. Non-contrast brain tomography revealed dense middle cerebral artery signs on the left and left total middle cerebral artery infarction. Additionally, chronic infarctions were noted in the right frontal cortical, right inferior temporal, and right cerebellar areas, but the patient had no history of previous stroke (Figure 2a, 2b). Laboratory results were compatible with rhabdomyolysis (white cell count 22 700 uL, creatinine 2.7 mg/dL, potassium 6.21 mqE/L, aspartate aminotransferase 186 U/L, alanine aminotransferase 73 U/L, creatine phosphokinase 13495 U/L, creatine kinase-myocardial band >300 ng/mL, troponin-C 21 ng/mL, and myoglobin in urine). The patient deteriorated after 12 hours of hospitalization and respiratory failure developed. Mechanical ventilation was initiated and daily dialysis was scheduled due to rhabdomyolysis. The patient died on day 5 of hospitalization of multi-organ failure. Advanced studies including angiography and echocardiography aimed at determining the stroke etiology could not be performed because the patient was on mechanical ventilation, had unstable hemodynamic parameters, and renal failure.

Figure 1a. Second degree burn at right mandibular corpus

Figure 1b. Second degree burn at anterior surface of right leg

Discussion

Three mechanisms have been described with regards to how electric injuries affect the central nervous system; thermal injury, electroporation, and vascular injury. Low resistance and wide surface area of neurons facilitate electroporation injury. Electric current at high voltages causes permanent structural changes in membrane proteins. Hence, both permeability and conductivity of neurons change, which result in cell death. The flow of current from low resistance to high resistance areas creates heat loss that damages intima and media layers of blood vessels, and causes thrombosis and vasospasm (5,6). Stroke secondary to electric injury might potentially be associated with aneurysmal dilatation and coagulation necrosis on vessel wall, rupture of intramural thrombus, intense and prolonged vasospasm, elevated blood pressure, intramural dissection, and transient circulatory arrest (5,6). Potential causes of extremity weakness following electrical injuries primarily include vascular injuries due to vasospasm, dissection, and rupture of aneurysm, followed by rhabdomyolysis, electrolyte imbalance, dehydration, hypoxic encephalopathy, cerebral hypoperfusion, and thermal injury (5).

Animal studies have shown narrowing of pial artery and arterioles following electro-convulsive therapy (7). Lee et al. (7) demonstrated that the non-thermal effect of electroporation (administration of electric current to tissues at very high intensity) damages tissues and cellular membranes. In other words, electrical current damages the body via both thermal and non-thermal effects.

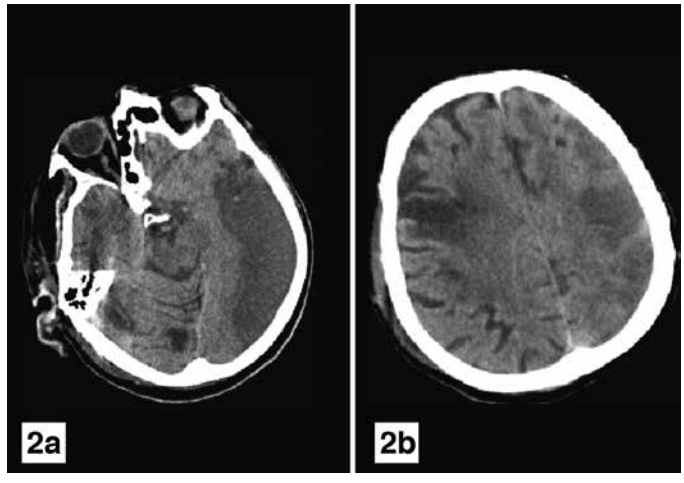

Figure 2a, 2b. Total middle cerebral artery infarction, and chronic infarction areas in right frontal cortex, right inferior temporal lobe, and right cerebellar lobe in non-contrast enhanced brain tomography

Thrombosis and vascular injury are more common in high-current electrical injuries, and rare in low-current injuries, because vascular structures are resistant to low-current injuries (6). Prolonged exposure to an electrical current might increase the temperature of cerebrospinal fluid and intensify injuries (8). Milton et al. (9) reported white matter changes in cranial magnetic resonance imaging of a patient who was struck by lightening. There are only case reports of ischemic stroke secondary to lightening strike in the literature (10,11,12,13). In their series, Janus and Barrash (14) reported abnormalities in brain computerized tomography (CT) in 2 out of 10 patients with neurologic complications due to lightening strike. Intracranial hemorrhage, subdural and epidural hematoma due to high current, and peripheral nerve injury due to low current have been reported as individual cases in the literature (1,15,16). The term low current electric injury describes values lower than 1000 V. One study that examined the long-term effects of low current electric injury found that neurologic complications were the most common (81.6%) and included, in order of frequency, numbness, loss of strength, memory loss, paresthesia, and chronic pain. However, there were no cases of ischemic stroke in the series (8). Huan-Jui et al. (5) demonstrated segmental narrowing of the right internal and middle cerebral artery with magnetic resonance angiography in cases of ischemic stroke secondary to low-voltage electric current. Chen et al. (6) reported a patient with brain stem infarction due to low electric current exposure. Another cause of infarction in joint territories of arteries following electric injuries is hemodynamic changes that occur after cardiac arrest (17). Cardiac dysrhythmias might also occur following electric injuries, although atrial fibrillation is less frequent (18). Our patient had no previously known chronic diseases. The atrial fibrillation determined at hospital admission was deemed chronic when the chronic infarction areas in the brain CT were also considered. The acute ischemic infarction was considered secondary to electrical injury due to the temporal association; however, the exact etiology could not be established because imaging of the vascular tree could not be performed.

Conclusion

Ischemic stroke secondary to low-voltage electric current is a rare disorder, in which patients have potentially had prolonged exposure to an electrical current. The pathophysiologic process might be enlightened with imaging studies performed in patients with stable vital parameters.

Ethics

Informed Consent: Consent form was filled out by a participant. Peer-review: Internal peer-reviewed.

Authorship Contributions

Medical Practices: Hakan Doğru, Kemal Balcı, Levent Güngör, Concept: Hakan Doğru, Çetin Kürşad Akpınar, Design: Hakan Doğru, Çetin Kürşad Akpınar, Data Collection or Processing: Hakan Doğru, Çetin Kürşad Akpınar, Analysis or Interpretation: Hakan Doğru, Çetin Kürşad Akpınar, Literature Search: Hakan Doğru, Çetin Kürşad Akpınar, Writing: Hakan Doğru, Çetin Kürşad Akpınar, Kemal Balcı, Levent Güngör.

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