

Multi-organ System Involvement and Multidisciplinary Evaluation After Lightning Strike: A Case Series

Yıldırım Çarpması Sonrası Çoklu Organ Sistem Tutulumu ve Multidisipliner Değerlendirme: Bir Vaka Serisi

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ABSTRACT Lightning strike is one of the causes of injury and death caused by environmental or natural events. Deaths can be seen after lightning strikes, also many different organ systems can be temporarily or permanently affected. Lightning strike can cause damage to many organ systems such as musculoskeletal system, cardiovascular system, neurological system, dermatological system, visual and hearing. The patients must be evaluated for multi-organ system involvement after lightning strike and the treatment must be structured with a multidisciplinary approach. An appropriate rehabilitation plan should be made according to the clinical conditions of the patients. Here, we present a case series of 4 patients with different organ or system involvement after lightning strikes who were followed up with a multidisciplinary approach and rehabilitation programme.

Keywords: Lightning strike; rehabilitation; multidisciplinary evaluation

ÖZET Yıldırım çarpması, çevresel veya doğal olayların neden olduğu yaralanma ve ölüm nedenlerinden biridir. Yıldırım çarpması sonrasında ölümler görülebildiği gibi birçok farklı organ veya sistemin geçici veya kalıcı olarak etkilendiği yaralanmalar da görülebilir. Yıldırım çarpması kas-iskelet sistemi, kardiyovasküler sistem, nörolojik sistem, dermatolojik sistem, görme ve işitme sistemleri gibi birçok organ sisteminde hasara neden olabilir. Yıldırım çarpması sonrası başvuran hastalar çoklu organ sistemi tutulumu açısından ayrıntılı değerlendirilmeli, tedavileri ve takipleri multidisipliner bir yaklaşımla planlanmalıdır. Hastaların klinik durumlarına yönelik uygun rehabilitasyon planı yapılmalıdır. Biz de burada yıldırım çarpması sonucu farklı organ veya sistem etkileni olan ve multidisipliner bir yaklaşımla takip edilen ve rehabilitasyon programı yapılan 4 hastanın olgu serisini sunmayı amaçladık.

Anahtar Kelimeler: Yıldırım çarpması; rehabilitasyon; multidisipliner değerlendirme

Lightning occurs more than 8 million times a day/100 times each second in the world. The mortality rate due to lightning is about 0.2-1.7 deaths/million people. Men are five times more likely to be injured by lightning than women.¹ There are regional, seasonal, and temporal variations in lightning strikes around the world. Lightning is more frequent in tropical and subtropical zones.² In Türkiye, the mortality rate due to lightning is reported to be 0.49 deaths/mil-

lion in 2012 and 2013, and 0.84 deaths/million in 2014 (January-June). Lightning injuries were most frequent in spring. It is more common in outdoor activities.³

We report case series with a total of four cases of lightning injuries with clinical findings. All of the patients were accepted to a tertiary rehabilitation center 7 days after injury and were evaluated for musculoskeletal, cardiac, neurologic, auditory system, and ocular injuries due to lightning strike, and each of the

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cases was individually described as case series with their findings in this report.

CASE REPORTS

CASE 1

A 26-year-old man presented with left upper extremity weakness. He had speech disorder, temporary visual impairment, and tinnitus after the event. There were scleral hyperemia and redness in the left eye (Figure 1a). There were skin lesions that resolved within a few weeks (Figure 1b). The patient's vital findings were stable. Electrocardiogram was normal. Blood tests were normal and no pathology was detected in chest X-ray. In the physical examination, muscle strength of right upper extremity, and bilateral lower extremities were 5/5. Muscle strength around the left shoulder was 0/5, 2/5 in the elbow, 3/5 in wrist, and 3/5 in the fingers. His right upper extremity was hypoesthetic on sensory examination. Deep tendon reflexes (DTR) were normal in four extremities. There was tension in the left sternocleidomastoid muscle. Superficial tissue ultrasound was performed for the tension in the sternocleidomastoid muscle. Parenchyma of both sternocleidomastoid muscles were normal. The thickness of the sternocleidomastoid muscle at its thickest

level was 9.3 mm on the right and 8.2 mm on the left. The thorax computerized tomography (CT), abdomen CT, cranial CT, and cervical CT results were evaluated as normal. He was consulted to the neurology department due to muscle weakness and speech disorders. Electromyography (EMG) was performed with the suggestion of neurology department. It was normal. In ocular examination, all the ocular findings were normal. A follow-up examination was recommended 6 months later. He was also examined by the otolaryngology and cardiology departments. Examinations were evaluated as normal. The patient was evaluated as an acute stress reaction by the psychiatry department. Quetiapine 50 mg/day and sertraline 25 mg/day were started. The patient was included in group psychotherapy. Rehabilitation program was applied to the patient for muscle weakness. A rehabilitation programme consisting of range of motion exercises, progressive resistance exercises, stretching exercises, and hand rehabilitation was applied to the patient. At the follow-up examination after the rehabilitation programme, muscle strength of the right upper extremity and bilateral lower extremities was 5/5. Muscle strength around the left shoulder was 1/5, 2/5 in the elbow, 4/5 in the wrist, and 4/5 in the fingers. Control EMG was planned after 21 days of injury.

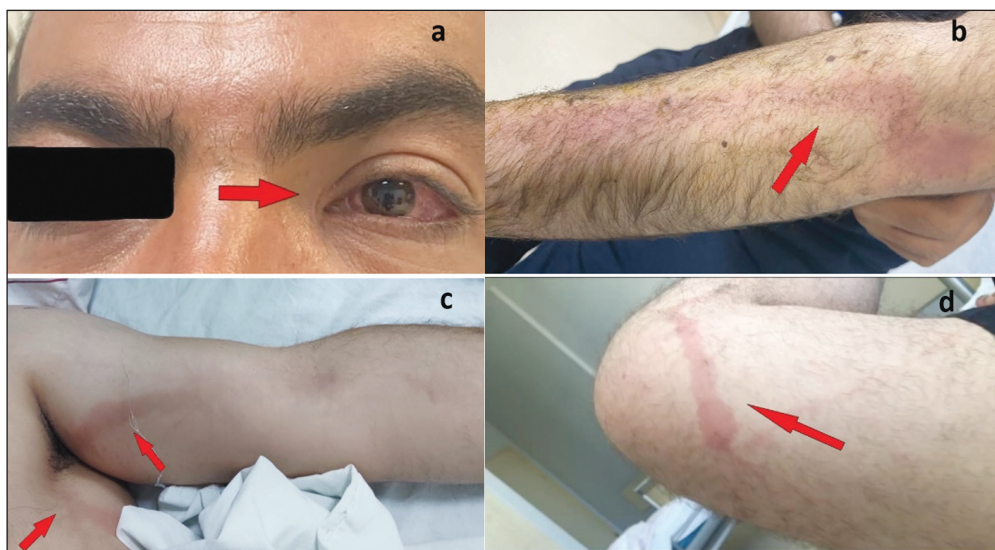


FIGURE 1: a) Scleral hyperemia and redness in the left eye of Case 1; b) Linear skin lesion on posterior left forearm of Case 1; c) Linear skin lesion on the trunk and anterior left arm of Case 2; d) Linear skin lesion on anterior left thigh of Case 3.

CASE 2

A 23-year-old man presented with weakness in the right upper and lower extremities. The patient lost consciousness after a lightning strike. The patient had short-term vision loss. There were skin lesions that resolved within a few weeks (Figure 1c). The patient's vital findings were stable. Electrocardiogram was normal. Blood tests were normal and no pathology was detected in chest X-ray. In the physical examination, muscle strength of the right upper and lower extremities were 0/5. There was minimal active movement in the right thumb. His right upper and lower extremities were hypoesthetic on sensory examination. DTR were hypoactive at the right side. There was tension in the right sternocleidomastoid muscle. Superficial tissue ultrasound was performed for the tension in the sternocleidomastoid muscle. Parenchyma of both sternocleidomastoid muscles were normal. The thickness of the sternocleidomastoid muscle at its thickest level was 13 mm on the right and 15 mm on the left. The thorax CT, abdomen CT, cranial CT, cervical CT, and carotid Doppler ultrasound findings were normal. EMG and cervical and cranial magnetic resonance imaging (MRI) results were normal. The control EMG performed 1 month after the first EMG was also normal. The patient was evaluated by the ophthalmology, otolaryngology, cardiology departments, and the results were normal. The patient was evaluated as an acute stress reaction by the psychiatry department. Quetiapine 25 mg/day was started. The patient was included in group psychotherapy. Appropriate rehabilitation program was applied to the patient. The patient received a rehabilitation programme including progressive resistance exercises, range of motion exercises, stretching exercises, posture exercises, balance/coordination exercises, gait training, and therapeutic electrical stimulation to the required areas. In the control physical examination after rehabilitation, left upper and lower extremity muscle strength was 5/5. Muscle strength around the right shoulder was 2/5, 2/5 in the elbow, 2/5 in the wrist, 3/5 in the fingers, 2/5 in the hip, and 2/5 in the knee. There was no active movement around the right ankle.

CASE 3

A 22-year-old man presented with weakness in bilateral lower extremities. The patient lost consciousness for 1 hour after the lightning strike. He had no movement in the bilateral lower extremities for two days after the event. Afterwards, muscle strength increased gradually, especially in the right lower extremity. There were skin lesions that resolved within a few weeks (Figure 1d). The patient's vital findings were stable. Electrocardiogram was normal. In the physical examination, muscle strength of the lower-left extremity was 4/5. Strength of other extremities were normal. His left lower extremity was hypoesthetic on sensory examination. DTR were normal. In blood tests, the following values were found: aspartate aminotransferase (AST): 54 and gamma-glutamyl transferase (GGT): 74. The patient was evaluated by the internal medicine, and liver preservation diet, abdominal ultrasound, and follow-up were recommended. Abdominal ultrasound result was normal. There was no significant change in AST and GGT values during follow-up. He was evaluated by the neurology department because of bilateral lower extremity weakness. EMG was normal. Cardiology evaluation was normal. The patient was evaluated as an acute stress reaction by the psychiatry department. Quetiapine 25 mg was started. The patient was included in group psychotherapy. The patient's rehabilitation programme consisted of progressive resistance exercises, range of motion exercises, stretching exercises, balance/coordination exercises, gait training, EMG-biofeedback to the left ankle, mechanical exercise training, and vocational rehabilitation. In the control examination, bilateral upper and right lower extremity muscle strength was 5/5. Muscle strength around the left hip and knee was 5/5, 4/5 in ankle.

CASE 4

A 22-year-old man who suffered from weakness in upper-left and lower-right extremities admitted. He never lost consciousness. The patient's vital findings were stable. Electrocardiogram was evaluated as normal. No pathology was detected in the anterior-posterior chest X-ray. No significant abnormality was detected in blood tests. In the physical examination,

muscle strength of the right lower and left upper extremities was 4/5. DTR were normal. Six days after the event, he had pain in the right testis. Orchitis was detected on ultrasound. Intravenous antibiotic therapy was started. After the treatment, the patient's complaints regressed. His thorax CT, abdomen CT, cranial CT, and cervical CT results were evaluated as normal. The patient was evaluated by the neurology department. EMG was recommended. EMG was performed approximately 3 weeks after the event. The control EMG performed 1 month after was also normal. No pathology was detected evaluated by the cardiology department. The patient was diagnosed with post-traumatic stress disorder by the psychiatry department. Quetiapine 100 mg/day and venlafaxine 75 mg/day were started. The patient was included in group psychotherapy. The patient underwent a rehabilitation programme to increase muscle strength. A rehabilitation programme consisting of range of motion exercises, progressive resistance exercises, stretching exercises, gait training, and balance/coordination exercises was applied to the patient. Physical examination performed after rehabilitation revealed bilateral upper extremity and left lower extremity muscle strength as 5/5 and right lower extremity muscle strength as 4/5.

Written informed consent was obtained from the patients regarding the publication of their data and images.

DISCUSSION

Lightning strikes cause deaths and injuries in multiple systems and organs. Lightning injuries occur in the form direct strike, flash discharge (splash) and contact, ground current (step voltage), and blunt trauma. Direct strikes are likely to cause the most serious clinical presentation.⁴ Our cases are military personnel and they are at high risk due to working conditions.¹

Many organs and systems may be injured after a lightning strike. One of the most frequently injured systems is the musculoskeletal system. Lightning can cause rhabdomyolysis or myoglobinuria with elevated creatine kinase levels. Acute renal failure due to rhabdomyolysis after lightning strike is very rare.^{2,4} There were no signs of rhabdomyolysis in our cases. Weekly

blood tests were done. Follow-up of the patients was normal, creatine kinase levels were not elevated.

Different skin injuries can be seen after lightning strike. Lightning strikes can cause four different types of skin injury: linear, punctate, Lichtenberg figures, and thermal injury. Linear burns can occur in areas with high sweat concentrations. It is formed by the evaporation of the water on the skin surface. Punctate burns are small and sometimes they may have full-thickness. The fern-like, Lichtenberg figure has been described as pathognomonic for lightning. They resolve within a few hours without the need for any treatment. Thermal burns can also occur.^{1,5} The skin lesions in Case 1, Case 2, and Case 3 are linear lesions. The skin lesions resolved within a few weeks after formation.

There are many different cardiovascular problems after a lightning strike. There may be mild ECG changes or very serious conditions such as cardiac arrest. Lightning strike can cause sinus tachycardia, transient ST-segment elevation or depression, QT prolongation, premature ventricular contractions, atrial fibrillation, or bundle-branch block, and ventricular arrhythmias.^{6,7} No cardiovascular pathology was observed in our cases.

Different eye injuries can occur due to lightning strikes. Pathologies such as anterior segment-related keratitis, cataract, uveitis, and posterior segment-related retinal detachments and papillitis can be seen.⁸ The most common eye pathology after lightning strike is lightning cataract.¹ In Case 1, redness and scleral edema in the left eye occurred in the early period. He was evaluated by the ophthalmology, no pathology was detected, and follow-up was recommended.

Although tympanic membrane rupture is the most common ear-related injury after lightning strike, more serious injuries such as sensorineural or vestibular injury may also occur.⁹ Case 1 was evaluated by the otolaryngology department because of the tinnitus. No pathology was detected.

After a lightning strike, 85% of patients present with neurological damage.¹⁰ There are many different neurological injuries due to lightning. Neurological complications of lightning strikes can be immediate transient, immediate permanent, delayed or trauma

from fall. Headache, loss of consciousness, numbness and weakness are transient symptoms.¹¹ Case 2 and Case 3 had a brief loss of consciousness. Keraunoparalysis is a temporary pathology that often affects the lower extremities and is accompanied by loss of sensation. It is specific to lightning strike. It is assumed that keraunoparalysis is the result of intense catecholamine release.¹¹ Keraunoparalysis may resemble spinal cord injury or compartment syndrome.¹⁰

After the rehabilitation programmes applied to the patients, there were improvements in the muscle strength of the left shoulder girdle and hand-wrist girdle in Case 1. Case 2 had no active movement in the right lower and upper extremities when admitted to our hospital, but after the rehabilitation programme, muscle strength in the right lower and upper extremities improved. In Case 3, there was no movement in the bilateral lower extremities after the lightning strike, but the muscle strength of the lower extremities recovered rapidly over time. Therefore, previously mentioned keraunoparalysis might be considered in Case 3. Neurological symptoms disappear rapidly in the follow-up of the patients.¹² In Case 4, it was determined that there was an improvement in the muscle strength of the right upper extremity.

Post-hypoxic encephalopathy, cerebral infarction, intracranial hemorrhages, myelopathy, rarely peripheral nerve lesions, autonomic nervous system

disorders, and behavioral and neuropsychological problems are permanent neurological complications.¹³ Motor system disease, including amyotrophic lateral sclerosis, Parkinsonism, and focal dystonia are focal delayed complications of lightning.¹³ Diagnostic imaging should be performed if neurological deficits persist. Immediate transient and immediate permanent neuropathological findings associated with central nervous system injuries can be seen on CT or MRI. Long-term disability is seen in 70-75% of all lightning strike patients.¹⁰ Spinal cord injury and peripheral nerve injury, which are immediate permanent injuries after lightning strikes, are not very common.¹⁰ To the best knowledge of the authors, there is quite insufficient data in the literature regarding peripheral nerve damage and EMG used in the follow-up after lightning strikes. Therefore, further studies on this subject are needed. We continue to follow up cases for permanent or delayed type neurological complications.

Our case series show how lightning strike injury can present with a variety of symptoms. Musculoskeletal system, skin, cardiovascular system, eye, ear and nervous system are frequently affected. Therefore, multidisciplinary evaluation is necessary. Early and late follow-ups of patients should be done and most appropriate treatments of each patient should be planned.

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