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CASE REPORT

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Multi-organ injuries due to a lightning strike: a case report highlighting the importance of a multi-disciplinary approach

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ABSTRACT

The interdisciplinary management of patients with multiple organ injuries after lightning strike is of paramount importance. Cutaneous burns can be associated to other organ injuries requiring emergency and life-support treatment. We report the case of a lightning strike victim who presented with burns as well as cardiologic and neurologic complications.

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Lightning; burns; cardiopathy

Introduction

Injuries due to a lightning strike are rare presentations in emergency departments. Nonetheless, they represent the most common environmental cause of sudden cardiac death [1]. Lightning strikes can be associated with multi-organ injuries leading to putative cutaneous, cardiological, renal and neuropsychological complications [1,2]. However, due to the sporadic nature of lightning injuries, the body of literature and especially the management strategies on the subject are scarce. We report the clinical case and management of a lightning strike victim who presented with burns as well as cardiological and neurological complications.

Materials and methods

A 75-year-old female in good general health was struck by lightning as she was standing 3 metres away from a tree. On-site evaluation showed the patient in prone position; her clothes and shoes were partially burned, still-smoking, and were removed immediately. She was hemodynamically stable (BP 138/87 mmHg, HR 87 beats per minute) and conscious. However, she presented transient amnesia for the event. Burn injuries going from the left ear to the left toe were visible. The patient was transferred to the emergency department for further evaluation, where thorough clinical examination by a plastic surgeon confirmed linear first and superficial second degree burns with some blisters on a line going from the left ear to the left toe, corresponding to about 6% of the total body surface area (Figures 1, 2 and 3). Total body CT revealed no profound injuries with the exception of an old fracture of the second thoracic vertebra. The ECG depicted a right bundle branch block, with deep and symmetrical T-wave inversion in precordial and lateral leads and a prolonged QT interval (480 ms) (Figure 4). These ECG changes were associated with an elevation of troponine T levels (peak: 403 ng/l). Other laboratory investigations yielded normal blood count and no electrolyte abnormalities with the exception of a minimally elevated serum creatinine value of 89 μmol/l. A transthoracic echocardiography revealed a reduced ejection fraction of the left ventricle at 40% with apical akinesia and preservation of the contractility of the basal segment. Further cardiological evaluation by cardiac MRI demonstrated apical hypokinesia with discrete left ventricular dysfunction without signs for myocarditis or myocardial infarction. Overall, the cardiological status was compatible with a stress-induced cardiomyopathy of Tako-Tsubo [3]. Supportive measures were

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Figure 1. Superficial second degree burn on the patient's back, both buttocks and left calf with painful redness and blisters.

Figure 2. Superficial second degree burn on the patient's left ear lobe.

employed with the introduction of angiotensin-converting enzyme (ACE) inhibitors and diuretics. The cardio-pulmonary function was monitored at the intermediate care unit for four days. Hemodynamic parameters remained stable and renal function normalised within 24 h from admission. ECG at the four weeks follow-up showed no persistent abnormalities.

Figure 3. Longitudinal first degree burn on the medial surface of the left foot and second degree superficial burn on the left hallux with a painful blister.

In addition, the patient presented dysesthesia in the right L5 dermatome, diffuse allodynia on both legs and walking difficulties due to a sensation of numbness. Lumbar MRI confirmed the old fracture of the second thoracic vertebra and no signs of ligamentous instability. The patient underwent physiotherapy treatment during her hospitalisation. The neurological symptoms in both legs diminished; however, the patient presented persistent radiculopathy in the L5 dermatome of the right leg and lumbar pain at the six weeks neurosurgical follow-up.

The burn injuries were treated conservatively with daily showers and dressing changes with application of paraffin gauze dressing and topical hyaluronate. The wounds were completely healed by two weeks. At the six months' follow-up, the patient had no residual scars on the burned skin.

Discussion

Lightning injuries are rare but can be associated with high mortality and persistent long-term morbidity. Six different energy transmission mechanisms from lightning strikes have been described: (1) ground strike, (2) contact voltage, (3) side flash, (4) wire-mediated lightning, (5) direct strike and (6) weak upward streamer [4]. The most dangerous mechanism is a direct strike by the lightning, which usually causes lethal injuries. A flashover phenomenon happens when the lightning current does not break the skin resistance but passes directly over the skin dissipating into the ground. Our patient was probably struck indirectly by a side flash from the nearby tree.

Lightning strike patients may present injuries to multiple organ systems. However, because the human

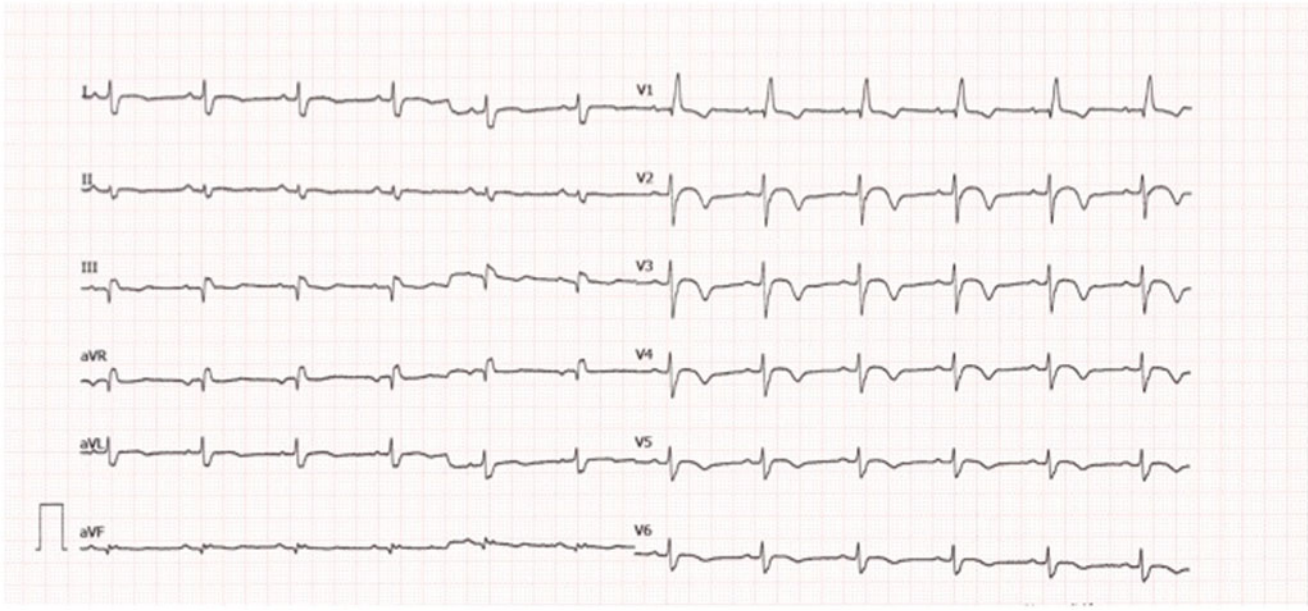

Figure 4. Electrocardiogram showing a right bundle branch block, with deep and symmetrical T-wave inversion in precordial and lateral leads and a prolonged QT interval.

skin has relatively high resistance to the passage of current, death does not usually result from injury to inner organs. In contrast, nervous and vascular tissues have the poorest resistance in the human body, which explains the frequent occurrence of neurological and cardiological complications [4].

The full range of possible complications after lightning strikes highlights the importance of an interdisciplinary approach in the management of affected patients. The most frequent and important injuries are as follows:

1. Burns from a lightning strike are mostly superficial second degree burns and victims rarely suffer from extensive tissue destruction or large cutaneous burns [5]. Patients should be managed as any other burn victim, with early assessment of the indication for early excision and grafting versus conservative treatment. Fasciotomy is required if there is a clinical suspicion of a compartment syndrome. One described pathognomonic skin alteration seen in lightning injuries are the Lichtenberg figures, where a physical phenomenon created by positive discharge over the skin provokes a transient reddish and ferning pattern on the skin [6–8]. Our patient presented first and superficial second degree burns. She had no evidence for the presence of Lichtenberg figures.
2. Cardiological manifestations may include direct necrosis to the myocardium and rhythm disturbances. Cardiac arrest and ventricular fibrillation are the most serious cardiac complications and are usually fatal unless immediate resuscitative efforts are undertaken. To the best of our knowledge, this is one of the first reported cases of a Tako-Tsubo cardiomyopathy following a lightning strike. Tako-Tsubo cardiomyopathy, also known as stress-related cardiomyopathy, transient left ventricular apical ballooning syndrome or ampulla cardiomyopathy, is a transient wall motion abnormality of the left-ventricular apex caused by emotional or physical stress [3]. The criteria for diagnosis are an acute onset and a stressful induction. ECG findings include a mimicking acute coronary syndrome, elevation of cardiac enzymes, absence of coronary lesion, balloon-like dilatation of the left ventricle and recovery of cardiac function within days to weeks [9]. Tako-Tsubo cardiomyopathy is treated supportively in the acute phase. For hemodynamically unstable patients, an intra-aortic balloon pump is required in addition to cardiopulmonary circulatory support. Hemodynamically stable patients are treated with diuretics, ACE inhibitors and beta-blockers. Patients with a Tako-Tsubo cardiomyopathy usually have a good prognosis with complete recovery in 96% of all cases [3]. The differential diagnosis includes direct electrical injury, direct cardiac trauma, hypoxic injury and/or bystander myocarditis. The cardiological complication of our patient may be interpreted as a somatic manifestation of a post-traumatic stress disorder. Our patient was monitored at the intermediate care unit and given supportive therapy. ECG at the

four weeks follow-up showed no persisting abnormalities.

3. Neurological manifestations following a lightning strike vary from transient benign symptoms to permanent disability. Clinical findings may include a transient loss of consciousness, a transient amnesia, paresis or paresthaesia. Electric fields may damage the structural integrity of nerve membranes and muscle tissues [10]. Keraunoparalysis, which is a temporary paralysis of the limbs, is pathognomonic of lightning injuries [11]. Sensation and muscle strength usually normalise within a few hours. In addition, severe short-term memory impairment is frequent. Conversely, spinal cord injuries are uncommon following lightning strikes. Our patient's neurological manifestations included dysesthesia and diffuse allodynia in both legs and walking difficulties. Despite some clinical improvement, the patient presented persistent symptoms in the L5 dermatome of the right leg and lumbar pain at the 6 weeks follow-up.
4. Renal failure due to muscle necrosis and consecutive myoglobinuria is a possible finding in lightning strike victims [12]. Thus, the renal function has to be closely monitored at presentation and during hospitalisation, and volume substitution has to be consequent. Our patient demonstrated a minimally elevated serum creatinine value, which normalised with hydration within 24 h of admission.
5. Lastly, acute and long-term psychological impairment should not be underestimated. The neuropsychological and cognitive deficits resemble those of a traumatic brain injury and a post-traumatic stress disorder. Clinical features include fatigue, lack of energy, poor concentration, irritability and emotional instability [12]. These symptoms can follow a progressive course and interfere with employment and family life. Patients may demonstrate improvement over time. Here, the importance of concerned physicians and a solid support network are to be emphasised [13]. Our patient was psychologically traumatised by the event; however, she refused psychiatric evaluation.
6. Blunt trauma should be a major concern in lightning strike victims. Patients may be injured from the explosive force of lightning or from a fall and can present missile injuries caused by pieces of wood or concrete due to explosive barotrauma, when air crossing lightning is rapidly heated and expands at supersonic speed [14,15]. Thus, secondary trauma should always be considered.

Conclusions

Our case underlines the fact that lightning strike victims are to be considered high-energy trauma patients and the entire panel of possible injuries should be evaluated. Multiple manifestations to the skin, neurological, cardiological, musculoskeletal and the renal system may occur. A multi-disciplinary management is of paramount importance, and the psychological impact of a lightning strike needs to be assessed early.

Disclosure statement

The authors declare no conflicts of interest.

References

1. Whitcomb D, Martinez JA, Daberkow D. Lightning injuries. South Med J. 2002;95:1331–1334.
2. Offiah C, Heran M, Graeb D. Lightning strike: a rare cause of bilateral ossicular disruption. AJNR Am J Neuroradiol. 2007;28:974–975.
3. Komamura K, Fukui M, Iwasaku T, et al. Takotsubo cardiomyopathy: pathophysiology, diagnosis and treatment. World J Cardiol. 2014;6:602–609.
4. Gruhn KM, Knossalla F, Schwenkreis P, et al. Neurological diseases after lightning strike: lightning strikes twice. Nervenarzt. 2016;87:623–628.
5. Maghsoudi H, Adyani Y, Ahmadian N. Electrical and lightning injuries. J Burn Care Res. 2007;28:255–261.
6. Mahajan AL, Rajan R, Regan P. Lichtenberg figures: cutaneous manifestation of phone electrocution from lightning. J Plast Reconstr Aesthet Surg. 2008;61:111–113.
7. Domart Y, Garet E. Images in clinical medicine. Lichtenberg figures due to a lightning strike. N Engl J Med. 2000;343:1536.
8. Resnik B, Wetli C. Lichtenberg figures. Am J Forensic Med Pathol. 1996;17:99–102.
9. Scantlebury DC, Prasad A. Diagnosis of Takostubo cardiomyopathy. Circ J. 2014;78:2129–2139.
10. Lee RC, Zhang D, Hanning J. Biophysical injury mechanisms in electrical shock trauma. Annu Rev Biomed Eng. 2002;2:477–509.
11. Paterson JH, Turner A. Lightning and the central nervous system. JR Army Med Corps. 1944;82:73–75.
12. Cherington M. Neurologic manifestations of lightning strikes. Neurology. 2003;60:182–185.
13. Primeau M, Engelstatter GH, Bares KK. Behavioral consequences of lightning and electrical injury. Semin Neurol. 1995;15:279–285.
14. Cooper MA, Andrews CJ, Holle RL. Lightning injuries in wilderness medicine. Saint Louis (MI): Mosby; 2007.
15. Blumenthal R. Secondary missile injury from lightning strike. Am J Forensic Med Pathol. 2012;33:83–85.