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Case Report

A bolt from the blue: Lightning injuries

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Introduction

Lightning injuries are as old as mankind. Lightning injuries were described in Hindu mythology and Bible. It continues to be an enigma, and many myths are still in circulation.¹ Lightning causes 1000 deaths worldwide every year and is second only to floods as far as environmental disasters are concerned. In 70% of cases the lightning injuries are non-fatal and many cases of lightning injuries are often unreported.² Lightning affects multiple systems and sometimes difficult to diagnose unless characteristic features or eyewitness history is available. Here we report a series of nine serving soldiers hit by lightning while operating in a mountain terrain.

Case report

We received nine patients 11 h after having apparently struck by lightning. The individuals were deployed in a mountainous terrain performing operational tasks at night when it started raining heavily punctuated by lightning strikes. They were exposed in the open with weapons in their hands and there was a large tree six feet away. The lightning bolt struck the tree nearby and thereof to individuals in the vicinity with such severity that all of them were thrown off and all of them sustained transient loss of consciousness. A thorough examination after evacuation to the hospital including pulse, blood pressure, respiratory rate and systemic examination including ear and eye examination was done. The details of clinical examination are given in Table 1. The investigations that were carried out included complete blood count, urine analysis including myoglobulinuria, cardiac enzyme tests, serial ECG monitoring, and serum electrolytes. All patients had transient loss of consciousness immediately after the lightning strike which lasted for few minutes and at the time of admission they were conscious. Two patients had ventricular ectopics on the electrocardiogram which disappeared after three days. Six of nine patients had bradycardia <60/mt initially for three days. Five patients sustained keraunoparalysis involving lower limb in three patients and upper limb in two. All of them were ambulant after 48 h. Two patients had pain in the left upper limb which was of moderate severity.

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Table 1 – Showing the clinical findings.

Findings	No. of patients (%)
Age group	28–35 (Avg 29 yrs)
Keraunoparalysis	5 (55%)
Skin findings	5 (55%)
Limb pain	9 (100%)
Bone fractures	1 (10%)
Cardiac arrhythmia	2 (22%)
Bradycardia	6 (66%)

One patient had sustained fracture left clavicle. Five patients had skin finding in which two had classical Lichtenberg figures (Fig. 1) one on left shoulder and left arm respectively. Two patients had streaky erythematous changes on their left gluteal region.⁶ None of them had exit wounds. None of the patients had elevated cardiac enzymes, myoglobinuria,

electrolyte imbalance, eye and ear findings. They were administered Anti tetanus prophylaxis.

Discussion

Lightning is caused by a unidirectional, massive, current impulse with several return strokes back to the cloud, which is neither the direct nor alternating current, lasting for a very short period, leading to mild superficial burns to various systemic injuries.³ An individual's chance of getting hit by lightning is highest either at the beginning or end of a storm. Lightning strikes are more common during late afternoon or early morning,¹ but in our study the injuries were sustained during the night. Lightning occurs in many forms, like streak lightning (most common), sheet lightning, bead lightning and least common called Ball lightning.⁴ The clinical features of

Fig. 1 – Showing skin findings. (A) and (B) depicting fern type and (C) and (D) depicting erythematous streaks.

Table 2 – Clinical features.

Body system	Injuries
Skin	Linear, punctuate, burns, Keraunographic markings
Cardiac system	Ventricular arrhythmias, asystole, ST-T changes, myocardial infarction
Nervous system	Amnesia, loss of consciousness, seizures, peripheral nerve damage, paralysis, cold mottled extremities
Eyes and ears	Dilated non reactive pupils (not due to death), uveitis, cataract, vitreous haemorrhage, temporary/permanent deafness, tympanic membrane perforation
Other injuries	Myoglobinuria (rare), myalgias, hypothermia, blunt trauma to skull, vertebra, ribs, and extremities

lightning are described in Table 2. Lightning commonly affects nervous system, cardiovascular system or skin.³

In our series all the patients were males less than 35 yrs of age. In general lightning injuries are more common in males with male to female ratio of 5:1.⁵ The mechanisms by which the lightning can cause injuries are described in Table 3. Direct strike by lightning constitute <5% and often fatal. Of the indirect injuries splashes are more common.⁵ Lightning electricity as with all electric energy will travel the path of least resistance. In body tissues the order of least to greatest resistance are nerve < blood < muscle < skin < fat < bone. From prognostic point of view lightning injuries may be classified into minor, moderate and severe injuries. The features are described in Table 4. In severe injury, patients sustain severe cardiac arrest with ventricular standstill or fibrillation and the prognosis is usually poor.¹

In our series five patients (55%) developed keraunoparalysis, a type of transient limb weakness after lightning injury considered to be due to hyperadrenergic state.⁷ The paralysis usually improves in 48–72 h as it was in our series. It commonly involves lower limbs more than upper limbs. The incidence of keraunoparalysis in lightning injuries may be as high as 80%.¹⁰ Two patients had muscular pain upper limb requiring analgesics which was recovered in 3 days. In our series one patient sustained fracture clavicle. The musculo-skeletal findings that can occur in lightning injuries are documented.⁸

Table 3 – Mechanism of lightning injury.

Type	Mechanism
Direct strike	Most of the current flows through the body; highest mortality
Contact voltage	Occurs when lightning strikes an object such as a car or metal pole that the victim is touching
Side flash	Splashing of current from a nearby object or person onto the victim
Ground current	Ground current passes from the strike point through the ground into the victim
Upward streamer	Passage of lightning from the victim upwards
Blast injury	Sudden expansive explosion of the air around the lightning channel causing blunt trauma

Table 4 – Severity of lightning injuries.

Severity	Clinical features
Minor	Dysesthesias in affected limbs, temporary deafness/blindness, confusion, amnesia, tympanic membrane rupture, transient hypertension
Moderate injury	Disorientation, coma, motor paralysis, mottled skin, absent pulses, temporary asystole, seizures, post traumatic stress disorder, burns
Severe injury	Cardiac arrest with ventricular standstill, or ventricular fibrillation, tympanic membrane rupture with haemotympanum, cerebrospinal fluid otorrhoea, direct brain damage

Skin findings are one of the common features of lightning injuries although the characteristic Lichtenberg figures are rare. There are four types of skin effects, Ferning or Lichtenberg figures, linear burns, punctuate burns and thermal burns. In our series five patients had skin findings as depicted in Fig. 1 and of them two had characteristic Lichtenberg figures. Lichtenberg figures or Keraunographic or arborescent burns are pathognomonic of lightning and are not true burns because there is no damage to skin. They are transient and do not conform to any vascular pattern or nervous pathways. Lightning injuries usually cause superficial burns because of extremely short contact time (0.0001–0.003 s) with electricity.

In our series two patients had ventricular ectopics and six patients had transient bradycardia. Cardiac involvement is seen in 46% of patients as described by Slesinger et.al.⁹ It has been found that the entire myocardium is depolarized when lightning strikes and that the heart remains in forced, sustained contraction until termination of the current which may cause cell necrosis, heart enzyme elevation, T-inversion, QT prolongation, myocardial damage, pericardial effusion, conduction disturbances, and dysrhythmias.

Management of lightning injuries is usually symptomatic. Keraunoparalysis which is usually associated with paralysis and pulseless extremities should not be treated with fasciotomy as steady improvement is the rule than exception as with electrical injuries. An important aspect while declaring death is that, dilated non-reacted pupils should not be considered as diagnostic, since they may be present as ocular manifestation of lightning.¹ While dealing with mass casualties due to lightning “reverse triage” or “resuscitation of the dead” is the rule because victims who show some return of consciousness or who have spontaneous breathing are already on the way to recovery. Some of the precautionary measures during lightning are outlined in Table 5. An important aspect in prevention is the 30–30 rule i.e when the time between seeing lightning and hearing thunder is 30 s or less, persons are in danger and should seek shelter. Also outdoor activities should not be carried out till 30 min after the last thunder or lightning is seen because lightning can strike even if there is no rain.

Conclusion

Lightning injuries are rare, but they have the potential to cause mass casualties, more so in a hilly terrain. In our series

Table 5 – Precautions during lightning.

DO's	Dont's
If you are in group stand atleast 20 ft away from each other as lightning can jump upto 15 ft between objects	Don't be tallest object or stand next to metal objects
Take lightning position i.e. squatting both feet together and covering both ears with hands. Or kneel on the ground or sit cross legged	Stand under a tree
Avoid power lines, poles, fences	Wear big buckle metal belts
Take shelter in a substantial building or inside heavy metal vehicles with windows rolled upwards	Stand inside tents with metal poles, soft top vehicles
Follow 30–30 rule	Use telephones, carry golf sticks, weapons

patients had characteristic skin findings and Keraunoparalysis. All the patients survived with no residual deformity at the time of discharge. Although no form of prevention is absolutely safe, knowledge of preventive measures and taking adequate precautions can decrease the incidence of these injuries.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Zane RD, Gatewood MK. Lightning injuries. *Emerg Med Clin North Am.* 2004;22:369–403.
2. Lightning associated deaths – United States – 1980–1995. *MMWR Morb Mortal Wkly Rep.* 1998;47:391–394.
3. Wig N, Malviya S. Electric shock and lightening injury. In: Munjal YP, Sharma SK, Agarwal AK, Gupta P, Kamath SA, eds. *Api Text Book of Medicine*. 9th ed. vol. 2. Jaypee Bros; 2012:2009–2010.
4. Andrews CJ, Cooper MA, Darveniza M, et al. *Lightning Injuries: Electrical, Medical and Legal Aspects*. Boca Raton (FL): CRC Press; 1992:192.
5. Pfortmueller CA, Yikun Y, Haberkern M, Wuest E, Zimmermann H, Exadaktylos AK. Injuries, sequelae, and treatment of lightning-induced injuries: 10 years of experience at a Swiss Trauma Center – research article. *Em Med Intl.* 2012;1–6.
6. Copper MA, Andrews CJ, Holle RJ, et al. Lightning injuries. In: Auerbach PS, ed. *Wilderness Medicine*. 4th ed. St. Louis (MO): Mosby; 2001:74–76.
7. Cherington M, Yarnell PR, London SF. Neurologic complications of lightning injuries. *West J Med.* 1995;162(50):413–417.
8. Hsu HT, Wang TL. Lightning injuries. *Ann Disaster Med.* 2004;3(suppl 1):S1–S7.
9. Slesinger TL, Bank M, Drumheller BC, et al. Immediate cardiac arrest and subsequent development of cardiogenic shock caused by lightning strike. *J Trauma.* 2010;68(1):E5–E7.
10. Duis HT, Klasen HJ. Keraunoparalysis, a specific lightning injury. *Burns.* 1985;12:54–57.