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**LIGHTNING INJURIES:**

**PREVENTION AND ON-SITE TREATMENT IN MOUNTAINS AND REMOTE AREAS**

**Intended for Physicians, First Responders, Mountaineers**

***Ken Zafren, Bruno Durrer, Jean-Piere Herry, Hermann Brugger***

Official guidelines of the International Commission for Mountain Emergency Medicine and the

Medical Commission of the International Mountaineering and Climbing Federation

(IKAR und UIAA MEDCOM)

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**SHORT COMMUNICATION**

**LIGHTNING INJURIES: PREVENTION AND  
ON-SITE TREATMENT IN MOUNTAINS AND  
REMOTE AREAS.**

***OFFICIAL GUIDELINES OF THE INTERNATIONAL COMMISSION FOR MOUNTAIN EMERGENCY MEDICINE AND THE MEDICAL COMMISSION OF THE INTERNATIONAL MOUNTAINEERING AND CLIMBING FEDERATION  
(ICAR AND UIAA MEDCOM)***

**Intended for physicians, paramedics and mountaineers**

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## Abstract

Lightning is a hazard during outdoor activities, especially for hikers and mountaineers. Specific preventive measures include staying off ridges and summits, and away from single trees. If possible, stay close to a wall but keeping a distance of at least 1 m away from the wall. All metal objects (carabiners, crampons, ice-axe, ski poles etc.) should be removed and stored away safely. Lightning currents can follow wet ropes. To prevent blunt trauma the helmet should not be removed. Move as quickly as possible away from wire ropes and iron ladders. The crouch position should be adopted immediately if there is a sensation of hair “standing on end”. Crackling noises or a visible glow indicate an imminent lightning strike. Rescue of lightning victims may be hazardous. Airborne helicopters can be struck by lightning with disastrous effects. It is prudent to wait until the danger of further strikes has passed. Treatment of lightning victims is based upon the ABCs – (Assessment) Airway, Breathing and Circulation. Victims who are not breathing can often be resuscitated and should be helped first. Respiratory arrest may be prolonged, but the prognosis can be excellent if breathing is supported. Standard Advanced Life Support (ALS), if necessary, should be given at the scene.

*Keywords:* Cardiopulmonary resuscitation (CPR), Emergency treatment, Lightning injury, Prevention, Mountain Rescue, Respiratory Arrest.

## 1. Introduction

Lightning is estimated to kill about 1000 people worldwide every year [1], but about 70% of lightning injuries are not fatal [2]. Most fatalities are the result of immediate cardio-respiratory arrest [3]. Persons who are merely stunned or lose consciousness without cardio-respiratory arrest are unlikely to die [2]. Lightning is a hazard during outdoor activities, especially for hikers and mountaineers in most temperate and tropical remote areas. For hikers and mountaineers it is often particularly difficult to find a protected place in the wilderness [4]. Nevertheless, lightning injuries are largely avoidable by taking certain precautions [5].

## 2. Mechanisms of injury

In contrast to high voltage e.g. from power lines lightning produces massive current impulse of very short duration. There are different mechanisms of injury [2].

1. Lightning may produce injury by a direct strike on a person in the open. This is often fatal.
2. More often, current splashes from a tree or other object, or from a person standing nearby (side flash).
3. Contact injury occurs if a person is touching an object that is hit or splashed by lightning e.g. the fixtures of a via ferrata (a climbing route using metal ladders and cables).
4. When lightning hits the ground, the current spreads out. If one point of contact is farther from the strike than another, a voltage difference will exist and current will flow across the body between the two points (ground current).
5. Blunt injury may be caused by the shock wave produced by lightning or by muscle contractions caused by the current. Mountaineers may lose balance and fall, or may be knocked down during climbing.

## 3. Prevention

Lightning injuries are largely avoidable by taking proper precautions. A tour should take note of the weather forecast. Thunderstorms with lightning in the mountains occur mainly during summer months in the late afternoon and night.

Lightning is associated with cumulonimbus clouds, but may travel many kilometres in front of a thunderstorm. At such times, it can occur in a clear blue sky and the thunder is too far away to be heard. The beginning and end of a storm are the most dangerous times. The “30-30” rule states that there is a danger of being struck when the interval between seeing the lightning and hearing the thunder is less than 30

seconds (flash-to-thunder time) and that one should not continue climbing until 30 minutes have elapsed after seeing the last lightning and hearing the last thunder [6].

The best place to shelter during a lightning storm is in a hut or mountain refuge, away from open doors or windows. Sheltering in small, open huts may increase risk from side flashes. Tents do not provide protection; metal support poles may act as lightning rods. Large caves and valleys are protective, but small caves, overhangs and wet stream beds may be more dangerous than open areas.

If caught in the mountains, stay off ridges and summits and stay away from single trees, power lines and ski lifts. Close to a wall there is a relatively safe triangle, where the safe distance equals the height of the wall. In order to avoid the risk of ground currents, a distance of at least 1 m away from the wall should be maintained.

In a forest, a low area with small trees is safer than a clearing. In the open, crouch with the feet or knees together and keep contact with the ground over as small an area as possible to minimise injury from ground current. Sitting on a dry pack or dry rope may also help to avoid ground currents. Do not lie flat. Metal does not attract electricity, but it is a good conductor. Any conductor carried above the shoulder level, significantly increases the chances of a direct hit. Metal poles, e.g. skis, ice-axe, ski-poles or an antenna on the rucksack may act as lightning rods.

Mobile phones and radios should be stored in the centre of the rucksack to protect them from electrical discharge. All metal objects (carabiners, crampons, ice-axe, anchors, ski poles etc.) should be removed and stored away. There is an increased risk (including burns) if there is contact with metal. Lightning currents can follow ropes, especially if they are wet. To prevent blunt trauma, the helmet should not be removed and the mountaineer should always stay belayed (attached to a safety rope), especially when abseiling (descending an anchored rope). On a via ferrata, move as quickly as possible away from wire ropes and iron ladders. A person, who feels his or her hair stand on end, or skin tingle, should immediately crouch with feet together. Crackling noises or visible glow (St. Elmo's fire) also indicate an imminent lightning strike.

If a group of people is exposed, they should stay apart, to reduce the number injured by ground current and side flashes between persons. Organisers of events in mountainous areas should have a lightning safety policy with the authority to stop or postpone the event, according to the "30-30" rule [7]. The use of lightning detectors may give advance warning.

#### 4. Injuries due to lightning

Direct lightning injuries are caused by high voltage, heat production, and explosive force [8]. The most important cause of death is cardio-respiratory arrest produced by ventricular fibrillation or asystole [9]. Respiratory arrest may be prolonged (due to paralysis of the medullary respiratory centre) and lead to secondary cardiac arrest from hypoxia. A lightning strike may stop the heart by myocardial depolarization resulting in asystole. Spontaneous return of cardiac activity is the rule in this case if the patient's ventilation is maintained and severe hypoxia does not occur. Death or injury may arise from blunt trauma which may cause head injury, burns, fractures, neurological problems, contusions, tympanic membrane rupture, and haematological abnormalities, such as disseminated intravascular coagulation [10-12].

Neurological syndromes caused by lightning are usually temporary. These include mental confusion, amnesia, loss of consciousness, seizures, deafness [13], blindness [14], and paralysis [15]. Paralysis of the extremities caused by lightning, (keraunoparalysis) is not a neurological injury but is due to intense vasospasm which resolves within hours [16].

Burns may result from the direct effects of lightning or from heat and may be linear or punctate [17]. Feathering refers to skin markings caused by electron showers and is not a burn. It is diagnostic of lightning injury [18]. Because of the extremely short duration of the discharge (flashover), most burns are usually partial thickness (1<sup>st</sup> and 2<sup>nd</sup> degree), in contrast to electrical injury. However entry and exit burns, which are full thickness, also occur.

#### 5. Differential diagnosis

The diagnosis is easy when there are thunderstorms and witnesses. If victims are found later, especially on sunny days without thunder, the diagnosis may not be clear [19]. Persons with linear or punctate burns or feathering should be treated as victims of lightning strike.

#### 6. Risk assessment and management during rescue operations

If the area where the victim is located is at high risk with a continuing thunderstorm, evacuation should be postponed. The rescuers need to decide whether evacuation of the casualty to an area of lesser risk is warranted. In this case, the victims should be moved as rapidly as possible to minimise exposure to lightning.

Air rescuers can be at high risk [20]. Airborne helicopters can be struck by lightning with disastrous effects. People can be struck while standing outside the aircraft [21].

## 7. Assessment of the patient and on-site treatment

Cardiopulmonary activity should be assessed at the site of the accident. Emergency care begins with the ABCs – (Assessment) Airway, Breathing and Circulation [22]. If necessary, start Basic Life Support and Advanced Life Support according to international standards. This includes the use of an AED by lay-responders as soon as possible after the strike, if necessary [23]. Persons who are struck by lightning benefit from prolonged resuscitation efforts, since some cases survive after prolonged CPR without major sequelae [24].

The patient should be monitored with an ECG and pulse oximeter from the beginning. ALS guidelines should be followed. Spinal immobilisation may be required during evacuation and treatment.

Neurological assessment is important. Dilated or non-reactive pupils should never be used as a poor prognostic sign or as a criterion for brain death in a lightning victim.

The amount of external damage does not predict the severity of internal injuries. Serious sequelae, such as seizures, may be delayed for several hours, and all patients should be transported to hospital and admitted for observation, even if they appear well.

## 8. Special triage considerations

One single lightning bolt can strike two or more persons simultaneously if they stay in a group. In contrast to other triage situations with trauma casualties, where victims presenting with vital signs are given priority for emergency treatment and patients in cardio-respiratory arrest are delayed, the rule in lightning strikes is to “resuscitate the apparently dead first” [2]. The normal triage rules for trauma patients do not apply to non-breathing lightning victims. Ventilatory support is often all that is required. If rescue breathing is not administered until spontaneous respiration resumes, death is likely from hypoxia and secondary cardiac arrhythmias.

## 9. Lightning myths

The following statements are not true.

- It is dangerous to touch a lightning victim.
- Lightning never strikes the same place twice.
- Lightning always hits the highest object [25].

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