



**ISMM**  
**NEWS**

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The Newsletter of the International Society for Mountain Medicine is the official bulletin of the Society and is the trait d'union between all its members. Its aim is to keep the members informed about the Society and to bring news regarding topics related to Mountain Medicine.

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<b>FROM THE EDITORS</b>	<b>1</b>
<b>MOUNTAIN MEDICINE AND THE INTERNET</b>	<b>2</b>
<b>THE 1996 EVEREST TRAGEDY</b>	<b>2</b>
<b>LIGHTNING AND MOUNTAINS</b>	<b>3</b>
<b>ON SITE TRIAGE OF AVALANCHE VICTIMS</b>	<b>6</b>
<b>ANNOUNCEMENTS</b>	<b>8</b>

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## LIGHTNING AND MOUNTAINS: INJURIES AND PREVENTION

**L**ightning injury (LI) is only an exception in the lowlands, but in the mountain its incidence increases. So Craig (2) states, that in the USA 300-600 persons die yearly after lightning stroke, and several thousands injured people survive. This number is larger than toll of any other type of natural catastrophe including tornadoes. During the period of 1951-1981 there were 3109 injuries reported in mountaineering activity in the USA and Canada (7). 36 (1.16%) had been caused by lightning, but there was no fatal LI among 178 mortal casualties. In 1979-1984 the German Alpine Union reported 1112 injuries, of which 9 (0.8%) had been due to lightning (4). In the High Tatras in Slovakia altogether 814 fatal casualties were recorded among all visitors over a long span of time (1650-1986). Only 12 cases (1.47%) of these deaths were after a lightning stroke. Durrer stated that, in the period 1991-1993 there were 3438 people rescued in the Swiss Alps. Only 23 of them (0.7%) were caused by lightning. 40% of them were hikers, 35% mixed climbers, and 25% rock climbers. All LI were during July and August and 30% of them died. Burtscher described 12 fatal accidents (0.65%) among all 1833 alpine fatalities in Austria during the period 1986-1992 (5).

### The Origin Of Lightning

The essence of the electric charge in the clouds is the buildup of static electricity due to collision of water droplets and ice particles. This gives rise to positively charged clouds with respect to the ground. Lightning is characterized by a saltatory expanding discharge directed from the clouds to another cloud or the earth. The discharge can reach a current intensity up to 200 kA, a voltage of 100-200 MV, the duration of the discharge lasting approximately 0.1 s, and the visual effect 0.6 s, with the total energy amounting up to 1000 kWh. A lightning stroke is a discharge of explosive character and the temperature reaches up to 30000 degrees Celsius. Several types of lightning can be distinguished. The "cold lightnings" are discharges of short duration and without thunder. "Incidentary lightning" is characterized by relatively low current intensity and comparatively long duration. The "common lightning" is one of high voltage and high current strength. Among the phenomena of induction we reckon the fire of Elias, buzzing of the ice-axe, electrization of suit, etc. "Ball lightning" and its variants represent, from the physical point of view, yet not explained problem (3).

### The Effect Of Lightning On Humans

It is estimated that 20-30% of the victims die, and 75% of the survivors have some permanent sequelae. The effects of lightning on the human body depend on the mode of the stroke. A "direct stroke" can cause heavy sequelae or death (80%). A "side stroke" is an indirect stroke with the discharge conducted to the man from the immediate neighborhood - from a tree, a rock formation, or another man. Ground currents - "stride potential" - can injure to a distance of a few hundred meters from the place of discharge. A "forked flash" means thunderbolt, the channel of which branches in the air and strikes plural points on the ground. The injuries caused on persons inside houses associated with lightning to the houses are classified as "indoor incidence". Abrupt lightning can injure the eyes and superficial layers of the skin, whereas the inner organs are relatively preserved, by so-called "flash-over phenomenon". The electric current flows only around the victims body owing to well conducting surface (wet outfit, sweat-through clothes, rain).

The etiology of the various lightning injuries lies in: 1. The effects of heating, both internal to the body and external over the surface. 2. The direct effects of electrical current on the conductive tissues. 3. The effect of pressure, or blast, resulting from the acoustic shock wave accompanying the stroke. 4. Secondary changes occur by fall in the exposed terrain, often direct expulsion of the body by generalized convulsion (abrupt muscular contraction caused by the discharge), lesions of bones and muscles. 5. Metallic parts of the outfit can damage skin and soft tissue (necklace, bracelet). Magnetization of metallic objects lasts months and years after a stroke of lightning and is important for forensic reasons (1).

**Table 1. Organ injuries caused by lightning**

- **Neurologic:** Loss of consciousness, cerebral edema, keraunoparalysis, seizures, respiratory arrest
- **Cutaneous:** Burns and abrasions
- **Musculoskeletal:** Swelling, rupture
- **Renal:** Renal failure (myoglobine)
- **Gastrointestinal:** GI bleeding, gastric atony
- **Ocular:** Lid burns, corneal lesions, lens dislocation, retinal injuries, cataracts
- **Cardiovascular:** Dysrhythmias, myocardial injury, vasomotor spasms, hypertension
- **Auditory:** Tympanic membrane rupture, tinnitus, hearing loss
- **Psychiatric:** Personality changes, phobias

## First-Aid Measures

Because frequently many people are injured at once, the unconscious victims ought to be resuscitated first, although they appear to be dead. This will ensure, that those victims without changes of consciousness will have a good prognosis prospectively even when they have suffered severe injuries. Owing to the deceleration of degenerative changes in the brain from anoxia the success of the resuscitation appears to be frequent also after prolonged delay. Following technical rescue and securement of the victims against possible further injury (fall) in an exposed terrain, cardiopulmonary resuscitation begins. An initial stroke on the breastbone is the important measure in attempting to return the spontaneous sinus heart rhythm. The follows clearing of the airways, mouth-to-mouth breathing, and outer heart massage. The next acts of paramedical self-help and mutual help are treatment of other injuries,

**Table 2. Fatal casualties**

- **Cardiac:** Heart arrest, dysrhythmias
- **Neurologic:** "Direct stroke" to the head, breathing paralysis (central, peripheral), brain edema, intracranial hemorrhages
- **"Late death":** Renal failure (myoglobinuria), brain (subdural haematoma, etc.), spinal (demyelinating myelopathy)

anti-shock measures, and transport of the victim.

Medical aid includes qualified help on the spot, during the transport, and in the health center. Every person injured by lightning should be monitored (ECG) and observed in an intensive care unit. Victims of LI have to be managed as patients with polytrauma, burns, and developing shock. Shock control is very important, so is hydration (also in myoglobinuria by the crush syndrome), administration of corticoids, management of fractures and injuries of the skin and muscles (in muscle swelling fasciotomy is necessary "compartment syndrome"). Intravenous administration of beta-blockers is very effective, if there are signs of excessive catecholamine release with tachycardia, hypertension, and pallor. Epileptic seizures usually disappear soon after intravenous diazepam. tetanus prophylaxis is necessary in all victims, but antibiotics need not be given (6).

## Preventive Measures Of Lightning Injuries

According to the newest investigation of Kitigawa (Central Lightning Protection, Japan) we can critically evaluate some "rules" in the prevention of LI.

Shall we throw away all metal pieces to avoid lightning incidence? Among 24 directly struck

persons he found 9 with metallic objects higher than their heads (umbrellas - 2, tennis racket raising over head - 1, raising left hand with safety pin - 1, hair pin on head - 1, metal pieces attached on hats - 4). But metal object not reaching over the head does not influence the incidence of LI.

Is kneeling or squatting posture safe enough? He found 5 cases of LI of persons in these postures, and states, that safety cannot be realized only by the posture.

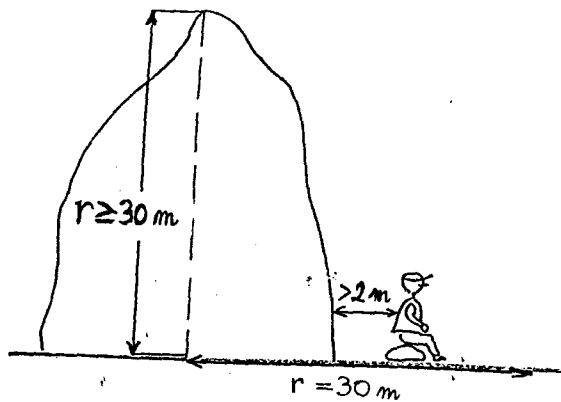
Does step voltage cause heavy injury? Of all his 63 investigated cases 40 cases include also persons stricken by ground current. But in any case the ground surface potential difference due to the close thunderbolts caused no heavy injuries.

Features of lightning discharges involving human bodies. There is no proven insulating effect of human skin, costume, vinyl raincoat or rubber boots against lightning. The metallic pieces on human bodies trigger and enhance surface discharges and tend to reduce to conduction current through bodies. Standing within 2 m distance from the tall objects, such as trees, tent poles, chimneys, which are not equipped with lightning conductors is more hazardous than standing on open field. It is highly probable to get a side-stroke from such objects. In case of direct stroke, about 80% of struck persons are killed and rest 20% of persons are heavily injured. About 10% of direct strokes occur on sitting or squatting persons. In 9.5% of lightning accidents, lightning channels branch in the air and strike plural persons directly.

Safe space against lightning incidence. The inside of the Faradays cage (cars, airplanes, trains, concrete buildings) is a perfect space against lightning incidence. The wooden buildings also provide safe space, but in small huts the probability of side flash from roofs, walls, or columns remains and fatal accidents are reported to have occurred. In the open fields there are "safety spaces" around the tall objects, with the radius that equals the height of the tall objects (e.g. high lightning conductor).

## Practical Ways To Minimize Lightning Injuries

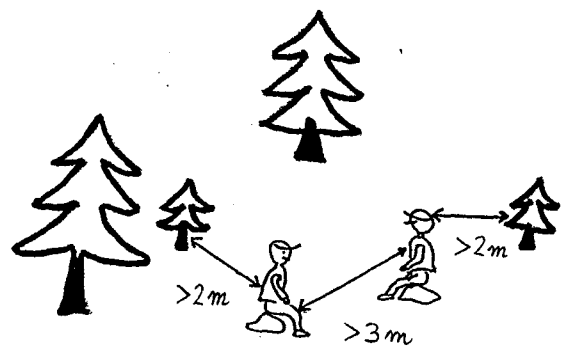
- Stay inside buildings, cars, buses, or trains. As a second best safe space, enter within the corner space formed by the top point of a tall object and the circle, centering the foot of the tall object and having radius of the height of the object, and keep 2 m distance from the object. In case the object is a tree, keep the distance from all twigs and leaves and lower yourself. When the height exceeds 30 m, take the radius as 30 m. Leave the objects not higher than 4 m. (Fig. 1, see top of next page).



- When you are outdoors, look around for safe spaces or depressions and enter the nearest one. Move into the safer space during the intervals of thunderbolts.
- When you are in a mountainous area, leave peaks and ridges as early as possible and take the same measure as in the outdoors. Do not be afraid of touching the ground and rock with wide contact area and take care not to fall off.
- When you hear thunder or observe some symptoms of storm, take the above measures as soon as possible.
- When you find a fainted person struck by lightning, check his pulse and respiration. In case they are arrested, resuscitate him applying CPR.
- Stay in the safe place until you ascertain the thunderstorm is further than 10 km (calculate to 30).
- When you plan an outdoor event, pay attention to the weather information, and adjust the plan not to encounter thunderstorms.

Darvenizza (5) published "Precautions against lightning injuries while bush-walking", where some specific recommendations are stated. He recommends observation and differentiation of thunderstorm clouds. During the thunderstorm you can continue a trip after time from flash to thunder is more than 15 seconds, it is 5 km. During the storm there are to avoid some activities: Use a telephone, handle appliances connected to outside electrical conductors, TV or radio set. During thunderstorm you ought to get away from cliffs and

lookouts, keep away from the large trees. In the forest choose to be near small trees and stay a distance of more than your height from the nearest tree trunk. If with a group, keep at least 3 m apart and do not walk in pairs or in closely packed groups. If you have found some safer location, stop walking, stand in the crouched position keeping your feet together, and sit with your feet tucked in close to our body, and wait till the thunderstorm has passed from your location. (Fig. 2).



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