A Summary: Wilderness Medical Society Practice Guidelines for the Prevention and Treatment of Lightning Injuries

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Lightning is a dramatic and expected part of weather patterns. However, lightning can be deadly. Lightning injuries account for an estimated 24,000 international fatalities and 40 national fatalities annually. The best way to decrease this number is to understand how lightning works and how to best avoid it proactively. It is also important to understand the vast array of injuries that lightning can cause. In 2012, the Wilderness Medical Society convened an expert panel to develop evidence-based guidelines for wilderness medicine practitioners addressing practice guidelines for the prevention and treatment of lightning injuries. These recommendations were updated in 2014.

How injuries occur:

During a thunderstorm, an electrical gradient is formed by the interaction of moisture, warm air, and wind, and this current is eventually discharged as lightning. A bolt of lightning has a massive current ranging from 30,000-110,000 amps. A lightning strike resulting in injury can happen in five different ways.

1. Direct Strike: This occurs when the lightning bolt directly connects with an individual. Fortunately, this type of strike is relatively rare accounting for only 5 percent of lightning strikes.
2. Contact Injury: This occurs when the lightning strikes an object that the person is touching.
3. Side Splash: This occurs when the current from the lightning strike jumps or “splashes” onto the individual following the path of least resistance
4. Ground Current: This occurs when lightning strikes an object on the ground near a person and travels through the ground to the person. This is the most common mechanism of injury accounting for 50 percent of lightning injuries.
5. Upward Streamer: This occurs when the electrical current passes up from the ground through the victim.

Injuries caused by lightning:

Death caused by a lightning strike is a result of cardiac and respiratory arrest because there is simultaneous depolarization of all the myocardial cells, resulting in asystole or ventricular fibrillation. If a patient is found pulseless after a lightning strike, airway and ventilation should be supported and cardiac resuscitation following Advanced Life Support guidelines should occur. If there are multiple injuries, "reverse triage" should be implemented, meaning that patients that are pulseless should receive priority care as there is a good chance for survival. There is no residual current carried by the lightning strike victim and they are safe to touch as long as the scene is otherwise safe.

High risk indicators in lightning strike victims include the following:

1. Suspected Direct Strike
2. Loss of Consciousness
3. Focal Neurological Complaint
4. Chest Pain or Shortness of Breath
5. Major Trauma
6. Burns to the Head, Legs, or Burns >10 percent Total Body Surface Area
7. Pregnancy

If any of the above have occurred, evacuation and medical evaluation is necessary.

The following table explores the injuries that lightning can cause on different organ systems:

Organ System	Symptoms	Recommended Treatment
Cardiopulmonary	**Chest pain** **Shortness of Breath** **AA**	ECG Echocardiogram -Any lightning strike victim with a high risk indicator (see above) should receive an ECG and Echocardiogram -If either is abnormal should be monitored for 24 hours
Neurological	**Transient Symptoms**	Evaluation

	-Loss of Consciousness -Seizure -Headache -Paresthesias -Keraunoparalysis- a transient paralysis after lightning injury. Involves limb pallor, cyanosis, and pulselessness that resolves within several hours **Persistent Symptoms** -Hypoxic Encephalopathy from cardiac arrest -Lightning-induced intracranial hemorrhage **Secondary Trauma from Blast Effect**	Diagnostic imaging May mimic a spinal cord injury! Maintain spinal precautions and obtain imaging to rule out traumatic cause of neurologic deficit Any lightning strike victim with loss of consciousness or abnormal neurologic evaluation should receive diagnostic imaging
Skin	**Lichtenberg Figure**- a feathering pattern that presents following a lightning strike and resolves within 24 hours **Burns** -Linear: often to areas of high sweat concentration -Punctate: a result of the lightning current passing out of tissue, often to the soles of the feet -Full thickness: often where skin is in contact	No specific treatment, but this finding necessitates evaluation of other effects of lightning strike Burn care as needed

	with a metal object or synthetic fabric	
Eye	**Lens injury** from lightning current **Cataracts:** can develop between 2 days to 4 years after injury	Ophthalmologic Evaluation
Ear	**Tympanic Membrane Rupture** **Hearing loss**	Evaluation Most heal spontaneously Requires follow up with otolaryngologist

Prevention of Lightning Injury:

Perhaps the most important part of caring for lightning strike injuries is to prevent them in the first place. No place is absolutely safe from lightning; however, making informed decisions of safer options can greatly reduce risk. It is essential to know the weather patterns in your area and respect the increased risk of mountain and water outdoor activities. In the mountain environment, individuals are responsible for knowing the local weather patterns. High ridgelines and summits should be accessed early in the day in order to be down at a safer and lower elevation before weather begins to move in.

When thunder is heard, one should avoid or leave high risk areas such as:

- Ridgelines and exposed high altitude terrain
- Mountain summits
- High structures such as ski lifts, cell phone towers, and isolated trees
- Avoid open or exposed areas such as a field, golf course, or picnic shelter
- Swimming pools, lakes, and open water
- Move away from the shoreline

Safer options include:

- The largest enclosed building, away from doors or windows
- A hardtop vehicle with doors and windows closed

- A dense forest (avoid isolated trees, trees on the edge of a meadow, or the edge of tree line)
- A deep cave (avoid shallow caves because of the risk of side splash and ground current injuries)

If you are unfortunately caught in a lightning storm consider the following options:

-Remove metal objects

-Lightning position (last resort)

This position involves crouching with your feet touching to create only one point of contact with the ground. One may also sit on an insulated pack (no metal), a coil of rope, or sleeping pad. If sitting on an insulated pack or pad, lift feet off the ground to avoid ground current.

-Group safety

Separate group members at least 20 feet apart to avoid side splash to limit the potential for multiple victims.

-Climbers

Should tie-off individually as lightning is able to conduct over wet climbing ropes, affecting both the climber and belayer.

After a storm has passed, one should wait a minimum of 30 minutes before resuming outdoor activities in high-risk areas to allow the trailing edge of the storm to fully leave the area.

Conclusion:

Lightning can cause extensive injury. This summary provides an evidence-based overview of the injuries that can be caused by lightning. If a strike occurs, those with high risk factors should be evaluated and treated. The best treatment is avoidance through preparation, knowledge of weather patterns of the area, and proactive planning.

Reference:

1. Davis, C, Engeln, A, Johnson, E, et al. Wilderness Medical Society Practice Guidelines for the Prevention and Treatment of Lightning Injuries: 2014 Update. *Wilderness and Environmental Medicine.* 2014; 25:S86-S95.

2. Davis, C, Engeln, A, Johnson, E, et al. Wilderness Medical Society Practice Guidelines for the Prevention and Treatment of Lightning Injuries. *Wilderness and Environmental Medicine*. 2012; 23:260-269.