Living in the South has provided me with many entertaining expressions from my grandparents and other wise mentors. One of my favorites was “that person is too dumb to come in out of the rain” or “common sense is not common.” While many of the expressions were considered prudent rules to live by, others have proven to be total folklore or superstitions.

Some of the weather-related folklore addresses the mysteries of lightning. Mythology is also full of stories about lightning, such as the Greek god Zeus, who used lightning bolts as a weapon. Other stories include the scheduling of battles or the predication of good fortune that were based on the observations of lightning by kings and priests of the day. Even in my childhood, I can remember my grandmother saying that when lightning struck nearby it meant someone was sick or had died. Those days are long gone, yet many people still don’t know the difference between the facts and myths of lightning and how to avoid becoming a victim of a lightning strike.

What is lightning?
Lightning is created by strong electrostatic discharges in thunderstorm clouds. Most lightning strikes occur within the thunderstorm clouds—only 10 percent of lightning strikes travel from cloud to ground. A lightning strike begins with a short burst of 30 to 50 meter streams of energy called step leaders. These electrical charges move down the leader, then retreat, and then move back to the end of the original channel before branching off in another direction.

The electrostatic energy from the base of the cloud is saturated with strong negatively charged ions. As step leaders move closer to the surface of the earth, a pool of positively charged ions forms under the cloud on the surface of the earth. The size of this pool can be anywhere from 30 to 50 meters in diameter.
Positive and negatively charged ions are attracted to each other. The positive charges on the ground are pulled up in the form of leaders or “streamers”, as they move toward the incoming negative step leaders from the clouds. The positive leaders often extend up from structures, towers, fences, the human body, and even something as small as a leaf on a bush or a blade of grass. When a negative and a positive leader connect, a channel is formed, and the negative charges rush down to fill the channel. When the channel is filled the energy moves back to the cloud, and that return creates the light of the lightning strike. Most people do not realize that lightning strikes seen with the naked eye are actually flashing up, not down.

What is thunder?
When a lightning strike occurs, the air around it is rapidly heated to extreme temperatures and then rapidly cools down. The super-heated air quickly expands and causes vibrations in the atmosphere that we hear as thunder. We see the lightning before we hear the thunder because light moves faster than sound! This point is important in the prevention of lightning injuries, which will be addressed in another section.

Lightning behavior
Lightning strikes within a 30 to 50 meter radius of the last leader’s branch. In that 50-meter radius, lightning will strike the tallest, pointed, isolated object. This fact should heighten your sense of awareness at any scene during a storm. If an object or person is alone in the middle of an open field and the last leader branch is within a 50 meter radius, chances are high that the object or person will be struck by lightning. The “pointedness” of the object may not pertain to responders unless they are carrying upright objects such as metal ladders or other tools. For responders, the safest place to be is inside an enclosed vehicle (windows up) or a solid enclosed structure (not under a shelter). Taking cover in open shelters can actually increase the chance of becoming a victim of a lightning strike. The shelter acts to increase the height of the victim and has no side cover from lightning strikes.

Lightning has an incredible amount of energy in each strike, an equivalent estimated at 100 million volts of electricity, and a strike can reach temperatures as high as 50,000 degrees (F). Because lightning is not the same type of energy as electricity in your home or car (AC or DC), it does not produce entrance and exit wounds, like high voltage electrical or gunshot wounds. The terms entrance and exit wounds are not used when referencing lightning strikes. With all of its energy, however, you would think most victims of a lightning strike would suffer massive burns. Instead, the duration of contact is usually less than 1/1000th of a second, and when contact does occur, the lightning more often flashes over the surface of the body rather than through the victim, so burns are less severe.

Risk factors
Knowing the range of risk factors can help identify patients who are potential lightning strike victims and will aid in being prepared for a lightning strike call.

Men are five times more likely to be injured or killed than women. This is directly related to outdoor occupations and recreation activities. Children under the age of 16 and adults from age 25 to 35 are the most common victims. Acknowledging the potential for injury, the NCAA recommends outdoor sports activities be stopped when lightning enters a 10-mile radius of the area; activities may resume 30 minutes after the last lightning strike.

The frequency of injuries is highest on Saturdays, Sundays and from 12 pm to 6 pm on Wednesdays. This is again related to an increase in outdoor activities during those times. As might be expected, injuries occur most frequently in the spring and summer months—during the typical storm seasons; however, lightning in snow storms has been observed.
Lack of knowledge of the dangers of lightning and how to avoid them, simple denial and distractions (cell phones, MP3 players) can also contribute to an increased risk of injury from lightning. The most effective method of avoiding injury is to seek shelter when lightning is present. Individuals who ignore weather predictions and warnings, who believe “lightning won’t really strike me” or who do not understand what constitutes a proper shelter, are at an increased risk of being injured by lightning strikes.

**Lightning injuries**

About 55 deaths in the United States occur each year as a result of lightning strikes. I live in north central Florida, which is known as the lightning capital of the United States. Texas also has one of the highest rates of lightning injuries. Data collected for lightning fatalities from 1990 to 2003 by the National Weather Service ranked Texas second highest, with 52 people killed, and Florida ranked number one with 126 fatalities in that time period. Lightning injury numbers are probably three times higher than fatality statistics, but they are often not reported or coded correctly. Lightning strikes are second only to floods as the most frequent cause of fatalities during storms.

The following are the primary ways that lightning injures people.

- **Ground current spread**—occurs when lightning strikes the ground and the current spreads outward in all directions as far as 60 feet. This may often be the mechanism for lightning-related multi-casualty incidents. It accounts for approximately 50 to 55 percent of lightning injuries.
- **“Side splash”**—occurs when lightning “splashes” from another object onto a person. This results in approximately 30 to 35 percent of lightning injuries. This type of injury happens often when people seek shelter under a tree. When the tree is struck by lightning, the energy jumps or “splashes” from the tree to the victim.
- **Upward streamer**—the upward movement of charged streamers may contain hundreds of amperes of current and the danger is often underestimated. The strong charge may move through or around the victim. They are associated with approximately 10 to 15 percent of lightning injuries.
- **Direct strike**—The victim receives a direct strike. This occurs when the lightning strike comes in direct contact with the victim’s body. It results in approximately 3 to 5 percent of lightning injuries. Although you may hear reports that a person was “struck by lightning”, the direct strike is relatively rare compared to other types of lightning injuries.
- **Contact potential**—a person is injured by touching an object that is struck or while touching an object that is directly connected to another object that is struck, such as a corded telephone or household plumbing. This type of activity is associated with approximately 3 to 5 percent of lightning injuries.

Two secondary causes of injury can be the result of lightning strikes: A person can suffer blunt trauma from being thrown by the force of the strike and can suffer barotrauma from being in close proximity to the explosive pressure of the lightning strike. The barotrauma results in eardrum perforation due to pressure changes in the air outside of the ear. The perforated eardrum is found in more than 50 percent of victims of a lightning strike.

The fatality rate from lightning injuries is approximately 8 to 10 percent; however, the collection of lightning injury data is problematic because
reports are often based on anecdotal stories, news media reports or autopsies.

**Physiological effects on the body systems**

**Cardiovascular and respiratory system**

Cardiac arrest is the most common cause of death in a lightning strike scenario. Lightning will act as a massive defibrillation, resulting in asystole. As is often seen in the field, the heart may recover if the primary pacemaker of the heart (the SA node) begins depolarization.

Unfortunately, the respiratory system fails as well because of simultaneous neurological injury from the lightning strike. When this occurs, the patient remains in respiratory arrest until ventilations are provided. Prolonged respiratory arrest will lead to hypoxia, resulting in ventricular fibrillation. Respiratory system support through ventilation and oxygenation may be required for long periods of time after circulation is restored during resuscitation. This scenario illustrates the importance of “reverse triage,” which will be discussed in detail in another section.

Additional cardiac problems such as bradycardia, tachycardia and hypertension have also been observed in a small percentage of patients. Prolonged ECG changes in T wave and ST segments are seen in approximately 10 percent of patients. Elevated cardiac enzymes (CK-MB, myoglobin and troponin) have also been documented.

Vascular spasms may occur, as well as instability of vasomotor control. This can produce cool, pale or cyanotic extremities with weak or no palpable pulses.

**Neurological system**

Lightning injuries are primarily neurological, affecting the brain and autonomic and peripheral nervous systems.

*Effects on the brain/central nervous system:* A loss of consciousness, anterograde amnesia and confusion are common findings. You may also find other symptoms that mimic head injuries, including seizures, dizziness, nausea, vomiting, headaches and repeated questions about the incident.

For assessment purposes, it is important to realize that victims will often have cognitive and memory problems. It may become difficult for them to process new information and recall older information. Think of the injury as a loss of the ability to multitask.

When multiple first responders are on scene, it is paramount that only one person interviews the patient. Give the patient plenty of time to understand and respond to your questions.

*Effects on the autonomic nervous system:* Pulse rate, blood pressure regulation, respiratory rate, pupillary response and sexual arousal issues have been observed in victims of lightning injuries. Dilated pupils in this patient may not represent head injury or death, but more likely injury to the autonomic nervous system.

*Effects on peripheral nervous system:* Patients often present with upper (69 percent) and lower (30 percent) extremity paralysis or paresthesia (aka: keraunoparalysis) which may prove to be transient in nature. Chronic pain and sensory problems often persist after the injury as well.

**Other physical effects**

*Integumentary system:* Burns are usually superficial and can be related to an object the victim was holding or jewelry that is heated during the exposure. You may also see unusual markings on the patient’s skin known as a *Lichtenberg figure*. This unique marking is red and creates a fern-like pattern on the skin. They are indicative of a lightning injury. Images of the Lichtenberg figure can be found at [http://en.wikipedia.org/wiki/Lichtenberg_figure](http://en.wikipedia.org/wiki/Lichtenberg_figure).

A patient may also present with
traumatic injuries. A lightning strike can produce intense muscle contractions (similar to being hit by a Taser gun) or the force of the current itself can knock victims to the ground or throw them some distance. Be aware of the increased risk of secondary injuries to anyone working outdoors, such as construction workers. A possible scenario is a roofing contractor who was struck by lightning and then suffered additional trauma as a result of falling from the roof. Looking for occult traumatic injuries when responding to a reported victim of a lightning strike should be part of your assessment process.

Penetrating trauma should be considered when a patient is found near a tree that has been struck. Lightning can cause the sap and moisture inside the tree to become super-heated, resulting in an explosion. The wood fragments from the tree then become dangerous projectiles. Some fragments have been documented as large as 200 pounds and six feet in length!

The patient may suffer a rupture of the tympanic membrane (ear drum), resulting in hearing loss. These perforations occur in more than 50 percent of lightning injuries. Injury to the retina, resulting in visual disturbances and severe pain, is also possible.

**Psychological/lifestyle problems:** Survivors’ reports also include sleep disturbances, attention and memory deficits, cognitive problems, hyperirritability, fatigue, high anxiety and post-traumatic stress disorder. As a result of these issues many survivors often become depressed and isolated. They may be unable to return to work or perform the tasks associated with their employment.

**Triage**

In the event of a mass casualty incident (MCI) created by a lightning strike, responders should perform reverse triage. In reverse triage, the pulseless and apneic patients are treated first, due to the high likelihood of survival with simple compressions and ventilations. Aggressive resuscitation of respiratory arrest is the key to survival in this type of patient. The amount of resources on the scene may limit how many patients can be treated before permanent injury or death occurs. The first arriving responder should try to quickly separate the patients who are awake, breathing and walking around the scene, in order to reveal the patients who are unresponsive and in need of immediate support.

In July 2009, a group of 100 people were gathered outside for a 4th of July celebration in central Florida. A lightning strike injured 18 people and resulted in one fatality. A total of 19 people were transported for evaluation and ten more treated on scene. The most common complaint was chest pain/tightness, headache, numbness and confusion. Witnesses reported a drizzle of rain overhead, but no lightning or thunder in the area. Local TV news confirmed a thunder storm was located several miles to the south at the time of the incident. Ironically, I had just presented the lightning injury lecture the day before at a Florida EMS conference less than 20 miles away.

**Treatments**

As always, in the case of responding to an individual patient, local medical protocols will dictate how you treat and transport the patient. Standard BLS and ALS treatments are utilized to address the types of injuries outlined in earlier sections. While there are no special treatments for lightning victims, the following actions are paramount to survival of your patient:

- Ventilation and airway management (especially for patients with facial burns)
- Prompt, high-quality CPR and defibrillation when indicated
- Fluid resuscitation for hypovolemic shock
• Immobilize as indicated by mechanism of injury

Responder safety

As the old saying goes: A dead rescuer will save no one!

Our industry is finally beginning to get serious about safety, and I saved this section for last to emphasize the message of staying safe during your response to a lightning injury.

Prevention and awareness are the keys to staying safe at any scene, especially in the outdoor settings. An awareness campaign for children organized by the National Weather Service, teaches children these simple words: “When thunder roars, go indoors!” Unfortunately, in our business we cannot always go indoors, but we can become informed about lightning safety. Every department should develop a safety policy for lightning on scene and for outside training exercises when lightning is in the area.

Knowing when to seek shelter and knowing what constitutes an appropriate shelter are vital to maintaining scene safety any time there are storms in the area.

How close is the lightning?

If you are outside and see lightning flash in the distance, count the number of seconds between the flash and the sound of thunder, divide that number by five, and that will give you a rough idea of how many miles away the strike occurred. For example, you see a lightning strike and count 30 seconds before you hear thunder. Thirty seconds divided by five equals six miles. You should seek shelter when lightning is this close. Lightning has been documented to strike as far as eight miles from the center of a storm in what appeared as a clear blue sky. The NCAA policy for lightning states that if there is 30 seconds between the lightning strike and thunder, all individuals should have already left the athletics site and reached a safer structure or location.

Where is the safest place to be?

You should be inside your metal roof-top vehicle (with the windows up) or in an enclosed significant structure when lightning is a threat. A “pole barn,” carport, bus stop, or other open shelter will not provide adequate protection. You are safe inside your vehicle because of the faraday cage effect. When lightning strikes a metal-roofed vehicle, the metallic surface will conduct the energy to the ground; the rubber tires are not what protects you from lightning. If you are inside your EMS or fire vehicle, and it has a radio attached to an external antenna, consider using a portable radio instead of the vehicle-mounted radio. In May of 1998, Sgt. Mark Pearson of the Prince George Police Department was struck while sitting in his vehicle during a routine traffic stop. Fortunately, Officer Pearson survived the injury, but the radio antenna wiring was a direct link to the inside of the vehicle and exposure to lightning.

The faraday cage effect also applies to solid structures, where wiring and/or plumbing will direct the energy to the ground. However, taking a shower or talking on a corded telephone during a storm are not considered safe activities because the pipes and cord can carry the electrical current directly to a person.

Should I use an AED or manual defibrillator in a storm?

There is potential for injury in this situation when a defibrillator is being used while treating a patient outside during a storm. I can tell you from experience, using a defibrillator while on a golf course during a storm is not safe and should be avoided! If you are treating a patient outside during a storm, the safest procedure would be to continue CPR and move the patient and crew into an ambulance or a safe structure. A defibrillator will not attract lightning; rather, lightning will strike the tallest, most isolated, pointed object in a 30 to 50 meter radius.
Lightning never strikes in the same place twice.

This is a total myth. A video recording of the CN Tower in Toronto, Canada, shows the tower being struck eight times during a single storm. It normally receives an average of 75 strikes per year. For humans, the record goes to forest ranger Roy Sullivan, who was struck seven times in his 35-year career, including once when both he and his wife were injured at the same time!

While lightning can be one of nature’s greatest light shows, it can be very dangerous, too. Be informed about lightning safety and your local weather status, be aware of your surroundings, stay safe and help others in your community do the same thing.

This article is provided for education only. Always consult with your medical director and follow your local protocols in making treatment decisions.

References

Internet resources
www.lightningsafety.com/nlsi_lls/fatalities_us.html
www.struckbylightning.org/index.cfm
www.nws.noaa.gov/