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LIGHTNING SAFETY IN SPORTS

Background

1. General Information
    - Lightning–results from static charges that occur as a cold high-pressure front moves over a warm, moist, low-pressure area.
        - Friction of air movement results in ionization and other energy charges
    - Lightning is extremely high-voltage direct current.
    - Lightning differs from alternating current electrocution as the direct current often travels over body surface rather than through it[1]

Pathophysiology

1. Pathology of Disease
    - Lightning will occasionally cause injury through blunt force mechanisms.
        - Large current causes rapid heating and cooling of air, resulting in a blast or shock wave[2]
            - Tympanic membrane perforation
            - Internal organ contusion.
    - Lightning may also cause thermal injury[3]
        - Moisture on athlete's skin is transformed into steam
        - Heating of metal objects on the body or in pockets
    - Intense photic injury may damage the retina or produce cataracts.
    - Lightning current can also cause violent muscular contractions, resulting in additional injury.[1]
    - 4 major types of lightning strikes.[3]
        - Direct Lightning Strike
            - Occurs when the victim is struck directly by lightning
            - Produces most serious injuries
            - Direct strikes commonly occur to head and enter bodily orifices.
        - Contact Strike
            - Occurs when a lightning current is conducted to victim through an object they are touching or holding such as a telephone.
        - Side Flash
            - Occurs when a lightning current travels through air from an object that has been struck by lightning to victim.
        - Ground Current or Step Voltage
        - Occurs when lightning current flowing in ground travels up from earth through the victim.
2. Incidence, Prevalence
    - Lightning causes nearly 100 deaths and 400 injuries annually in United States.[4]
3. Risk Factors
    - Sports and recreational activities with the largest numbers of lightning fatalities and injuries are[5]:
        - Mountain activities
        - Golf

        - Ball field games
        - Water sports
    4. Morbidity / Mortality:
        - Lightning is second leading cause of weather related death[3]
        - Lightning is fatal in 1 out of 10 cases.
        - Up to 75% of survivors will have permanent sequelae[5]
        - Cardiac arrest is most common cause of lightning related fatality.

Diagnostics

1. History
    - Victim may present with confusion, agitation, emotional lability, amnesia of short-term and long term memory, cognitive impairment, aphasia, headache, seizures, or prolonged coma[1]
2. Physical Examination
    - Only sign of lightning strike may be an isolated wound
    - Blunt head trauma is common and usually results from a fall or diffuse muscle contractions throwing the victim
    - Occult neck injury should be suspected
    - Spinal cord may be injured as a result of direct injury to spinal cord or from fractures or ligamentous injury to spinal column
    - Prolonged loss of consciousness increases likelihood of intracranial injury
    - At least 50% of victims suffer at least one perforated tympanic membrane.[1]
3. Diagnostic Testing
    - Laboratory evaluation[1]
        - Complete blood count (CBC)
        - Electrolytes
        - Liver Profile
        - Cardiac enzymes with isoenzymes
        - Coagulation factors
        - Arterial blood gases (ABG)
        - Blood type and screen
        - Urinalysis
        - Urine myoglobin
    - Diagnostic imaging
        - X-Ray for fractures as indicated
    - Other studies
        - Initial ECG[1]

Differential Diagnosis

1. Key Differential Diagnoses
    - Cerebrovascular accident
    - Seizure disorder
    - Spinal cord injury
    - Hypertensive encephalopathy
    - Cardiac arrhythmia
    - Myocardial infarction
    - Toxic ingestion

Therapeutics

1. Acute Treatment
    - Pre-hospital care for treating lightning strike victims
        - Survey scene for safety.
        - Activate the local emergency management system.
        - Carefully move the victim to a safe area (if needed).[3]
        - All lightning strike victims should be assessed as victims of trauma with the institution of both advanced trauma and cardiac life support.[1]
        - A patient suffering a serious electrical burn or lightning strike is a trauma patient.
        - Initial management includes evaluation of circulation, airway, breathing
        - Evaluate and treat for apnea and asystole.
        - Initiate CPR as soon as possible.
        - CPR is effective in resuscitating pulseless victims of lightning strike
            - Asystole commonly converts to an organized cardiac rhythm.
        - Respiratory arrest lasts longer than cardiac arrest
            - Leads to secondary asystole from hypoxia.
        - Evaluate and treat for hypothermia and shock.
        - Evaluate and treat for fractures and burns.
2. Further Management (24 hrs)
    - All patients with lightning injuries should be evaluated for admission.
    - Lightning injuries may be managed on an outpatient basis if victim had no initial complications of the lightning strike, has normal findings on physical and laboratory examination, and remains asymptomatic.[1]
    - Cardiac:
        - Survivor of high-energy injury should have cardiac and hemodynamic monitoring due to high incidence of arrhythmia and autonomic dysfunction.[6,7]
    - Fluid:
        - Patients with electrical injuries may require additional fluid replacement.
        - Patients suffering a lightning strike will require less fluid than other electrical injuries. Large fluid shift should be followed closely.[8]
    - Skin:
        - Wounds may be treated similar to flame or other thermal burns.[9]
    - Myoglobinuria
        - Patients should be monitored for compartment syndrome, rhabdomyolysis and renal failure.[10]
    - Gastrointestinal
        - Monitor patients for potential ileus, gastric ulcer and provide prophylactic therapy if patient has sustained a severe burn[10]
3. Long-Term Care
    - Monitor for delayed development of cataracts

- Monitor for psychological sequelae including posttraumatic stress disorder, behavioral disturbances, memory loss, difficulty with concentration and depression.[11]
- Overall outcome of lightning injuries is more favorable than generally reported

Follow-Up

1. Return to Office
   - Management and follow up care is based on signs and symptoms.[12]
   - Reassure asymptomatic patients
2. Recommendations for earlier follow-up
   - Advise that paralysis, mottling, confusion and amnesia usually resolve and patients should seek follow up if these symptoms worsen or do not improve.
   - Patients should seek further treatment for signs of infection, fever, increased swelling, pain, redness or drainage of pus from wounds.
3. Refer to Specialist
   - Ophthalmologic evaluation is warranted in all lightning victims due to the potential for delayed development of cataracts following lighting injury[1]
   - Psychiatric evaluation may be needed in patients who develop behavioral disturbances or posttraumatic stress disorder.[10]
4. Admit to Hospital
   - All patients with lighting injuries should be evaluated for admission.
   - Patients with a history of loss of consciousness, cardiac arrhythmia or confusion should be admitted for observation.
   - Indications for admission to an intensive care unit include:
     - Respiratory or cardiac arrest
     - Cardiac arrhythmia or history of cardiac disease
     - Alteration in level of consciousness
     - Abnormal laboratory or electrocardiographic finings
     - Associated blunt trauma or significant soft tissue injury[1]

Prognosis

1. Up to 74 percent of survivors may have permanent disabilities.[10] Two-thirds of lightning-associated deaths occur within one hour of injury, and are generally due to fatal arrhythmia or respiratory failure.[8,9]

Prevention

1. Prevention and education are key to lightening safety
2. All athletic venues should have lightning safety plan in place[15]
   - Planned instructions for participants and spectators
     - Games and practices
   - Designated warning and all clear signals
   - Designated safe shelter
   - Designated staff person(s) to monitor weather and make decision to remove teams and spectators from athletic site
3. Monitor weather before and during practice and events
   - Designate member of staff as “weather watcher”
   - Access to TV, internet weather monitoring programs

- Be aware of National Weather Service thunderstorm "watches" and "warnings"

4. Know where the closest "safe structure or location" is to field or playing area and how long it takes to get there
   - A safe structure is:
     - Any building frequently used by people that has plumbing and electrical wiring that acts to ground the structure
     - In the absence of a sturdy, frequently inhabited building, any vehicle with a hard metal roof (not a convertible or golf cart) with windows rolled up.
       - Do not touch metal framework of vehicle
       - Some venues rent school buses to use as safe shelters
5. The first flash of lightning, clap of thunder or darkening skies should be a "wake up call" to designated weather watcher.
   - If hear thunder, prepare for evacuation
     - May be hard to hear at large athletic event
   - If see lightning, suspend activities and head to designated safe shelter
6. The "30-30 rule" is a useful guide to direct suspension and resumption of play during lightning activity
   - Play should be halted whenever the time lightning is seen to the time thunder is heard is less than 30 seconds.
     - At this "flash-to-bang time," lightning is within six miles.
   - Play should not resume until at least 30 minutes after last sound of thunder or flash of lightning.
   - Avoid using a landline phone except in emergency
     - People have been killed
     - Cell phone or cordless phones safer
7. If caught in a thunderstorm
   - Avoid contact with the tallest object in an open field or any body of water.
   - The safest position to assume is a crouched position with the feet close together and weight entirely on the balls of the feet.[3]
8. Plan for access to AED for early defibrillation in lightning emergency plan
   - Do not delay CPR waiting for AED

Patient Education

1. Educate staff/athletes regarding lightning emergency action plan
2. Consider annual review and training sessions

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