Emergency Department Case Studies

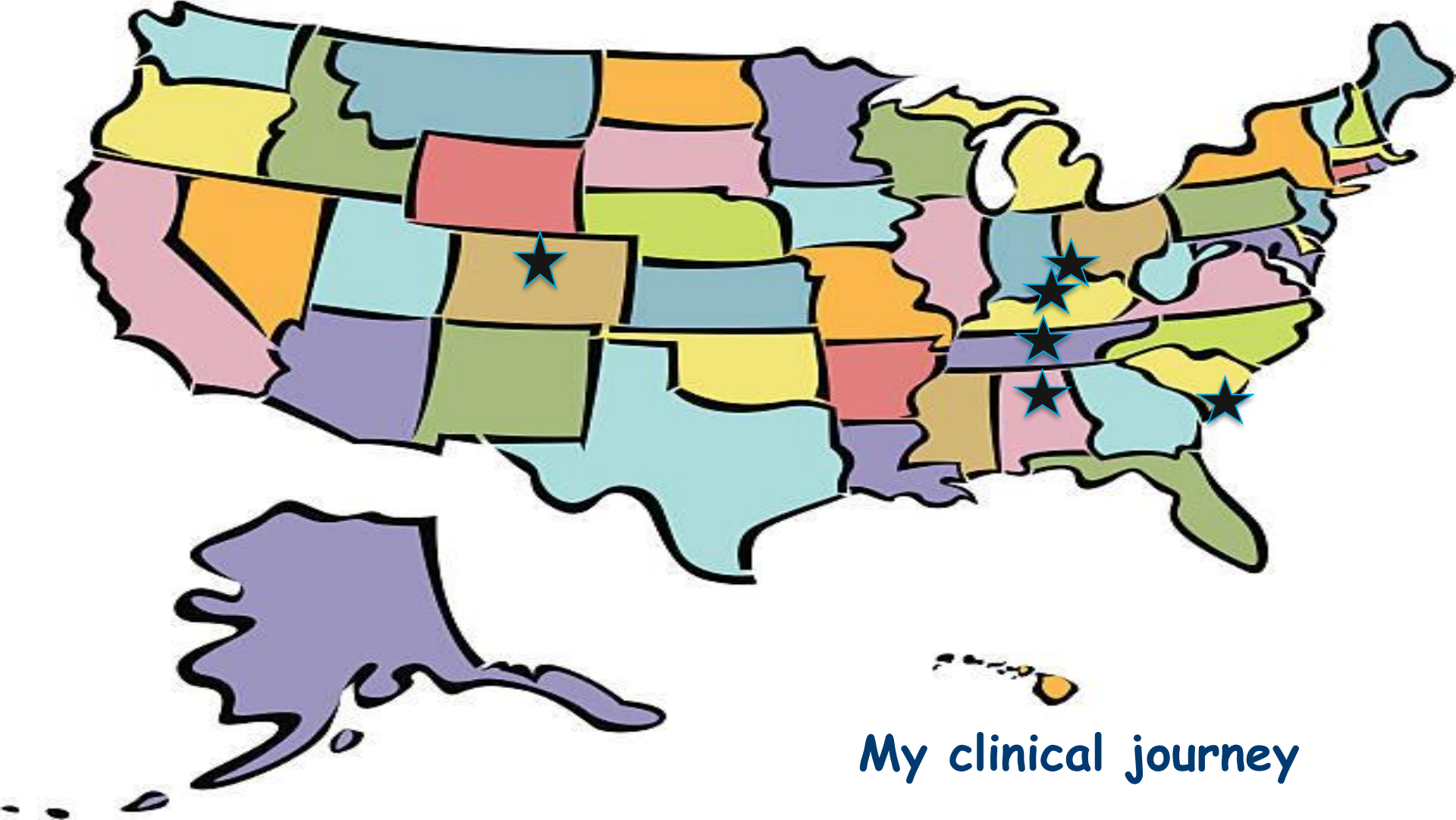
Timothy Givens, MD

Children's Hospital Colorado
Here, it's different.™

Disclosures

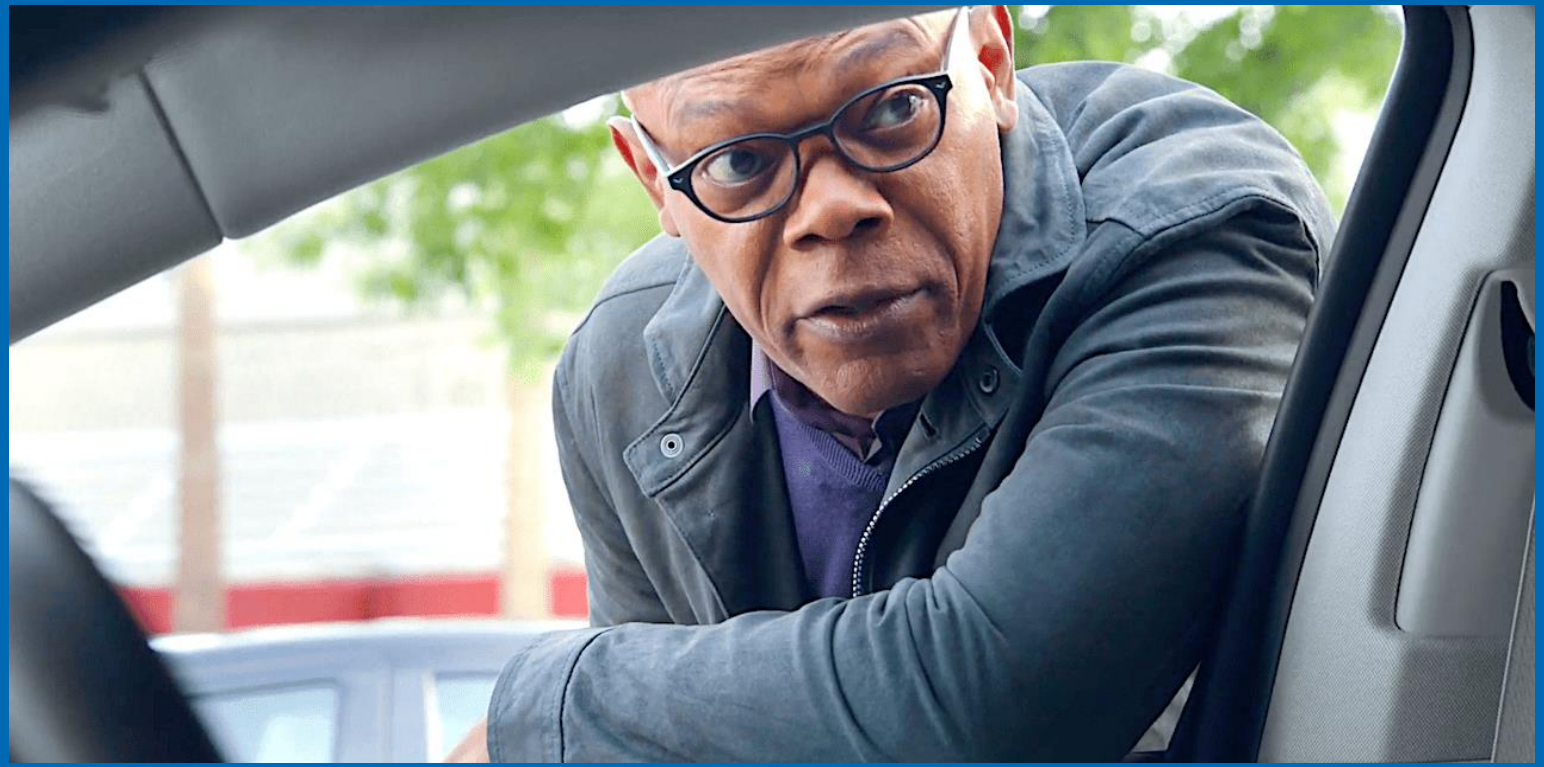
I have no relevant financial relationships with any commercial interests or conflicts to disclose.

Timothy Givens, MD



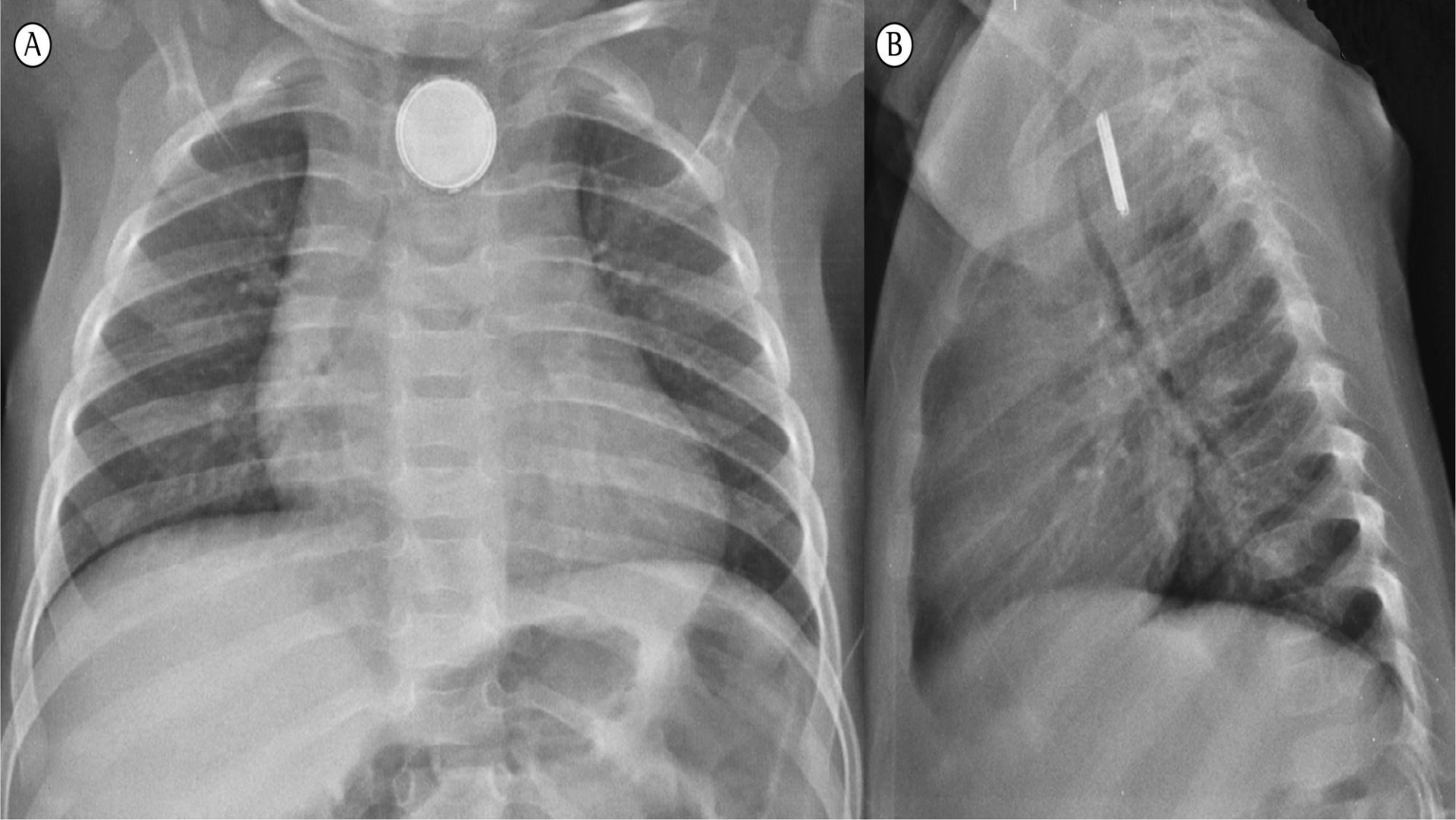
My clinical journey

What's in your environment?

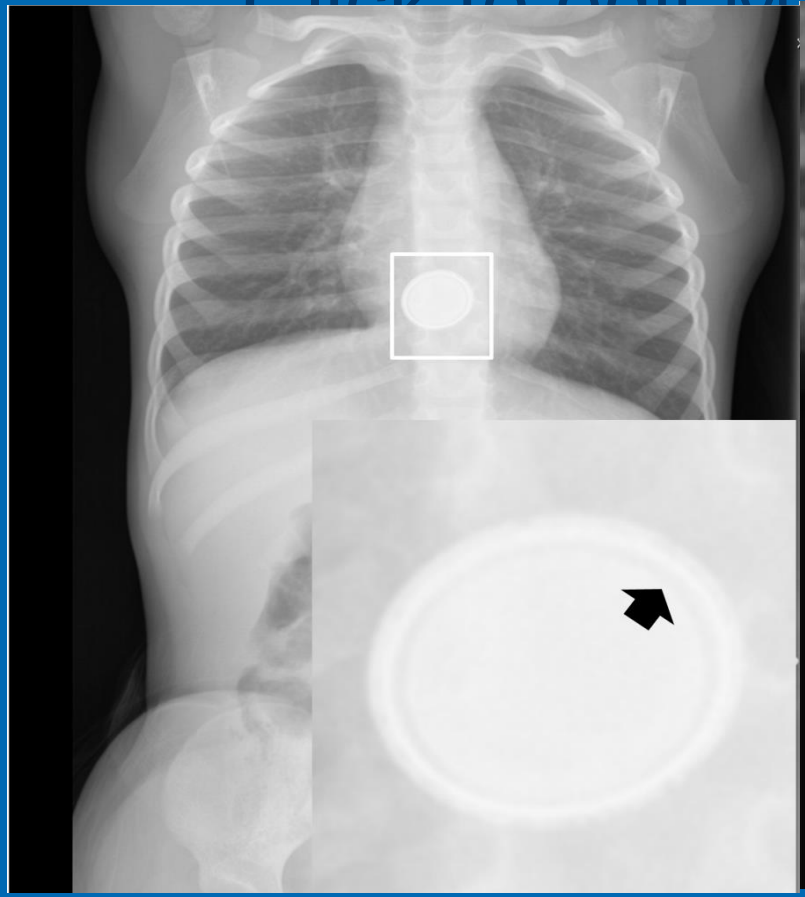


Case: 2 year old ingestion

- 2 yo M choked on something 20—30 minutes ago
- Now drooling, won't eat or drink
- Mom saw him playing on the floor but didn't see what he put into his mouth
- Vital signs normal, looks uncomfortable
- Lungs clear
- Patient drooling
- Nothing visible on inspection of mouth
- What to do???


A
B

Button Battery - Radiography



Advantages of lithium

- Lightest metal on the periodic table
- Higher voltage: 3 volts vs. 1.5 volts in alkali batteries
- Wide range of operating temperature
- Long shelf life
- Non-corrosive

Alkaline – 11mm

Lithium – 20mm

Common items button batteries are found in


watch


car remote


thermometer


calculator


torch keyring

musical card & other novelty items


remote

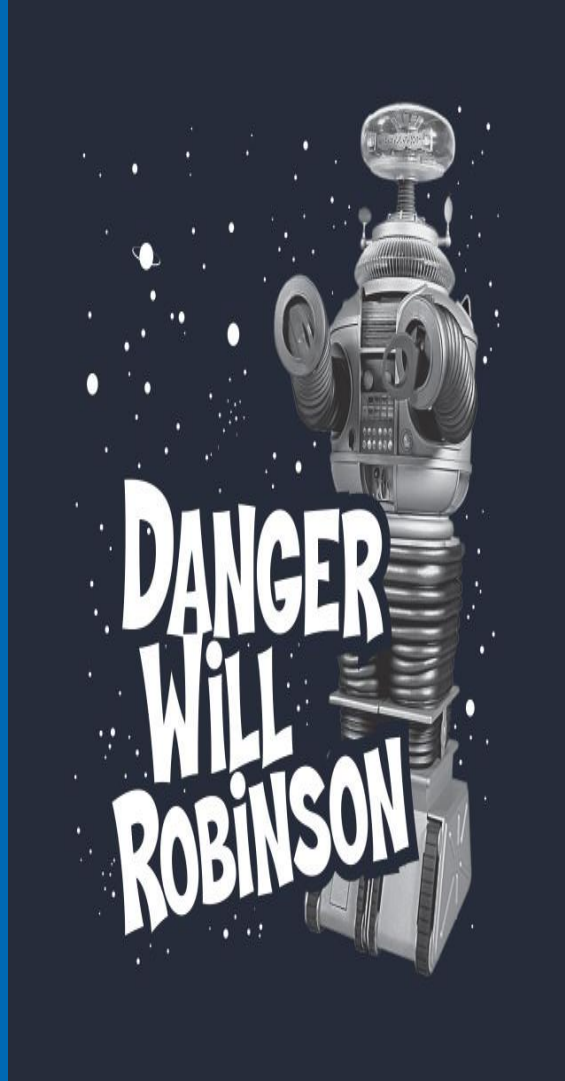

fake candle


kitchen scales


hearing aid

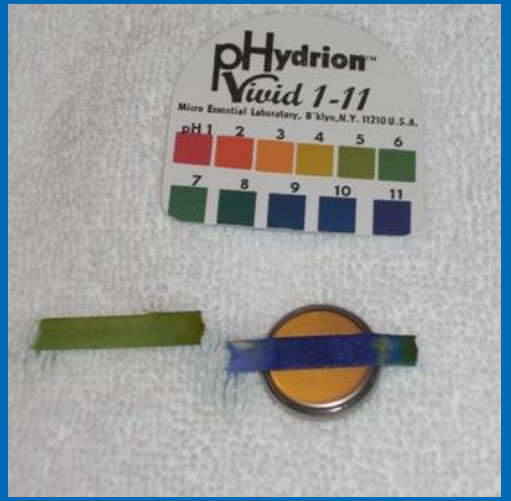
Button batteries—real danger!

- Esophageal button batteries are a *TRUE EMERGENCY!!!*
- Cause injury in as little as 2 hours, perforation in as little as 6 hours
- Mechanisms of injury include:
  - Caustic leakage → liquefaction necrosis
  - Pressure necrosis
  - Completion of an electrical circuit → current injury
- Brumbaugh D, et al, *JPGN* 2011; 52(5):585-589.



High pH leads to Cell Death and Tissue Injury

30 seconds



2 minutes

Lithium battery with drops of saline


After 2 hr
45 mins


Saline
Honey
Carafate®

Triage and treatment

1. Suspect the diagnosis!!!
    1. Symptoms: acute airway obstruction, drooling, wheezing, vomiting, chest pain, refusal to eat, coughing/choking/gagging
    2. Presumed "coin" or other FB ingestion
2. Do not induce vomiting; NPO *except…*
3. Administer HONEY immediately and *en route* to ED if:
    1. 12 months or older
    2. Incident occurred within past 12 hours
    3. Child able to swallow
    4. Dose: 10 mL every 10 minutes for up to 6 doses
    5. Use commercial honey if available (not specialized/artisanal)
4. Transport immediately—honey slows but does not stop battery injury and is no substitute for removal

CHCO (updated) transport protocol

- Transport via CCT helicopter
- If CCT helicopter unavailable, nearest CCT ground or ALS ambulance
- Teams will bring trauma blood & dose Carafate q10min (10 mL/dose)

CHCO hospital ED management

CLINICAL PATHWAY

Children's Hospital Colorado

INGESTED BUTTON BATTERY

ALGORITHM Treatment of Button Battery Ingestion

Known or Suspected Button Battery Ingestion

Active Bleeding or Sentinel Bleed?

Yes

Trauma Rod Activation

Obtain chest x-ray to assess for battery location if patient is stable without active bleeding. If patient is actively bleeding, proceed to Hybrid Cardiac Catheter lab and use flouroscopy (c-arm) to assess for battery location.

Hybrid operating room

Massive transfusion protocol for actively bleeding patient

Blakemore tube to bedside

Consults to cardiovascular surgery, gastroenterology, and interventional cardiology

No

Emergent Chest X-ray

In esophagus?

Yes

Emergent endoscopic removal in OR

No

Is battery greater than 20mm? *And* child less than 5 y.o ?

Yes

Consider endoscopy to assess esophagus and remove battery

No

Observation

Follow-up with x-ray:
- In 48 hours for batteries greater than or equal to 20mm
- In 10-14 days for batteries less than 20mm

Endoscopic removal if battery still in stomach at repeat x-ray

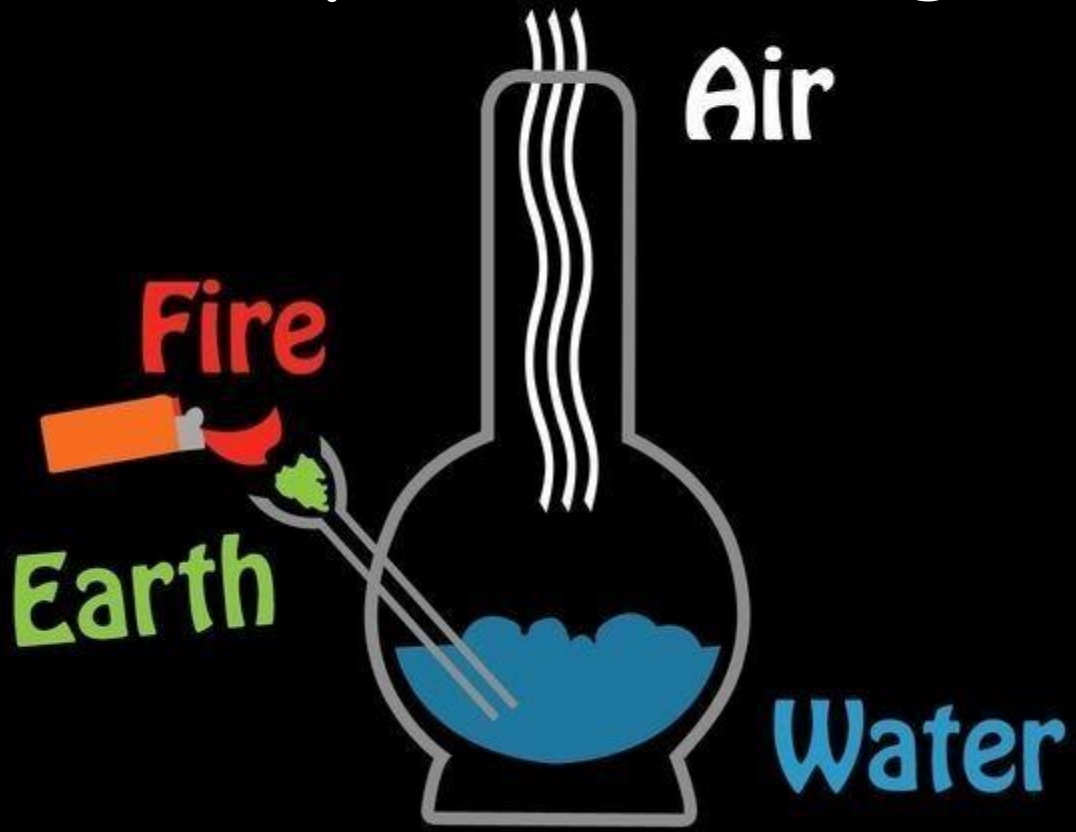
Inclusion Criteria:
Any patient with suspected or known ingestion of a button battery

Exclusion Criteria:
Patients with ingestion of foreign bodies other than button batteries

What's in your environment?

The Four Elements

Rocky Mountain High



Case: child struck by lightning

- 10 yo M helping dad on the farm when thunderstorm began
- Was holding metal rake when struck by lightning bolt and thrown 4-5 feet
- Initally brief LOC; now awake but dizzy and confused
- EMS summoned
- Patient tachycardic but VS otherwise normal
- ECG: sinus tachycardia

Lightning facts

- Lightning strikes earth > 100 times/second
- Estimated 150-300 deaths/year in USA
  - Used to affect outdoor workers; now, larger % are hikers, campers, golfers, etc.
  - Most occur in daytime, in summer
  - Prevalent in high mountainous areas, around large bodies of water
  - Greatest proportionate fatality: CO, WY, MT

Lightning myths

- Lightning strikes are invariably fatal
  - 30% mortality
  - Generally only those with immediate CP arrest expire
- Lightning victim is "electrified"
  - Belief delays resuscitation efforts
- Lightning never strikes in the same place twice

Mechanisms of lightning injury

1. High voltage
2. Secondary heat production
3. Explosive force

Primary injury mechanisms

- Direct hit
  - Usually in the open (no shelter)
  - Carrying a conductor (metal)
- Splash
  - Tree/building hit, splashes onto nearby victim
  - Path of least resistance
- Contact—holding object which is struck
- Step voltage
  - Hits ground near victim, spreads in wave through victim's feet
- Blunt trauma—thrown by explosive forces

Lightning injuries

- Minor
  - Confusion, amnesia, temporary LOC, blindness/deafness
  - Paresthesias, muscle pain
  - Transient hypertension
- Moderate
  - CNS changes (disoriented, comatose), seizures, motor paralysis
  - Loss of pulses due to arterial spasm
  - Burns
  - Tympanic membrane rupture
- Severe
  - Cardiac arrest (Vfib or asystole)
  - Direct brain damage

High-voltage electricity vs. lightning injuries

- Lightning contact with body is instantaneous, leads to flashover (over the body rather than through it)
  - Seldom burns of any magnitude
- High-voltage electricity exposure more prolonged, victim freezes to the circuit
  - Energy through tissues with little resistance to flow: massive internal thermal injury, myoglobin release, renal failure, compartment syndrome (fasciotomy?)

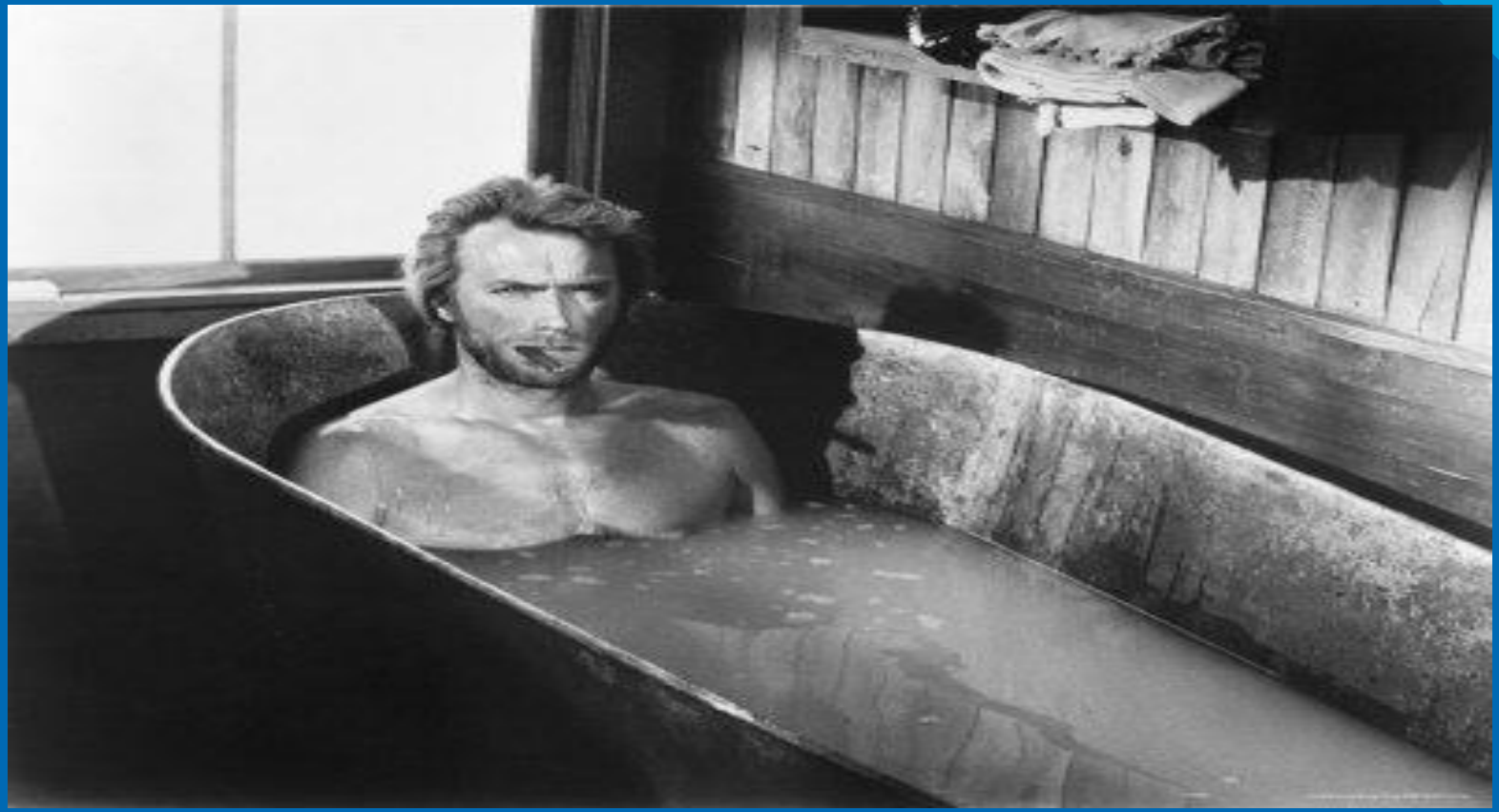
Care of lightning victims

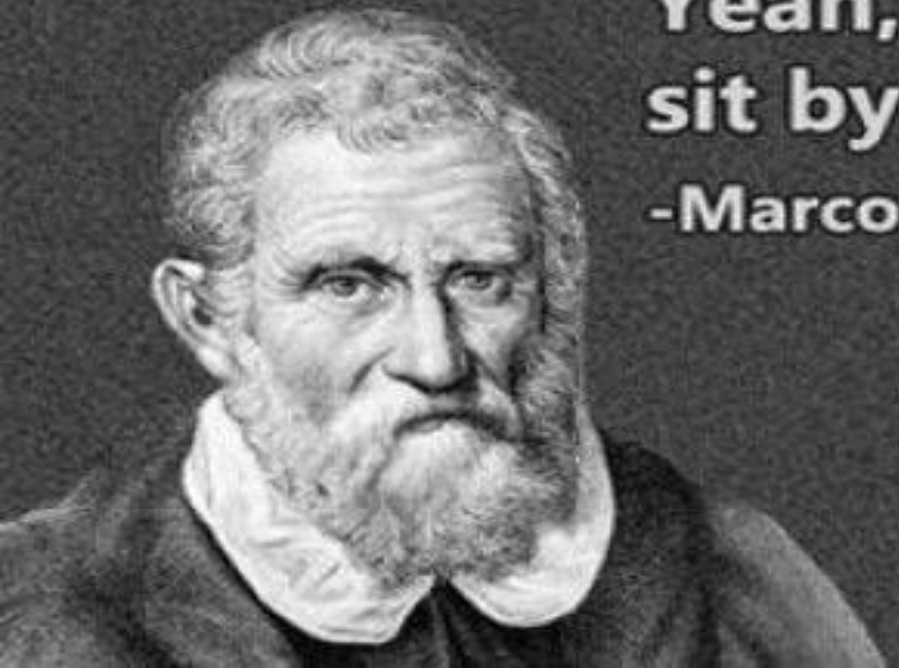
- ABC's
  - "Prolonged" CPR unnecessary
- Spinal precautions
- IVF/O2
- Splint fractures
- Transport

Case: young child found in lake

- 5 yo F wandered away from family campsite while they were cooking dinner
- 5 minutes later, found face down in water at edge of lake
- Father pulled her out of water, gave rescue breaths
- Child vomited some water, sputtered, had some labored breathing
- Family drove to nearest hospital 40 minutes away
- On arrival, patient awake, tachypneic with oxygen sats 88%

Submersion incidents





Yeah, I pretty much never sit by the pool anymore

-Marco Polo

Submersion statistics

- > 1000 deaths/year in 1-19 yo age group
- Males predominate
  - 4x as likely as females
- Intoxicants (EtOH) frequently involved
  - 30-50% of adolescent drownings
- Ability to swim not consistently related to death rates
- Estimated total lifetime costs > $ 2.6 B for 0-14 yo

Submersion survival

- Medical care for severe submersion episodes → little effect on improving survival
- "Survival" does not equal intact neurologic function
- ??Better decision-making in prehospital arena
- Children swimming less in natural bodies of water, more at pools & beaches with lifeguards → better access to early CPR
- Submersion duration best predictor of outcome
  - No protective effect of cold H_2O

- Recent decline in pediatric mortality , hospitalization rates with submersion incidents
  - Particularly in South and West USA
  - Likely due to targeted prevention efforts

Bath time supervision

Four-sided pool fencing

Use of personal flotation devices

Swimming in supervised areas

Swimming lessons


BATHTUBS, BASINS, SHOWERS AND
JETTED BATHTUBS – about 100 children
drowned each year
TOILETS
20 children
drowned
since 1990
5-GALLON BUCKETS
more than 275 children
drowned since 1984
BABY BATH SEATS OR
RINGS ARE NOT
SAFETY DEVICES
DIAPER PAILS

Submersion injury pathophysiology

- Panic & struggling
- Breath-holding
- Voluntary suppression of respiration is overcome
  - 15% laryngospasm ("dry drowning")
  - 85% aspirate liquid ("wet drowning")
- Common denominator is *hypoxia*
- LOC → airway reflexes lost → CP arrest

Associated hypothermia

- Cold water submersion – better prognosis???
  - (especially pediatric patients)
- Obtain core temperature, resuscitate until temp WNL

Other considerations

- Possible medical emergency could have preceded submersion incident
  - Trauma (head/neck)
  - Seizure
  - Dysrhythmia
  - Toxic ingestion
  - NAT

Submersion treatment--prehospital

- Assume spinal injury
  - Immobilization
  - Maintain precautions during transport
- Rescue breathing & supplemental oxygen
- ?CPR—start on almost all patients
- Begin rewarming

Q. Should all victims of submersion incidents be evaluated in an emergency department?

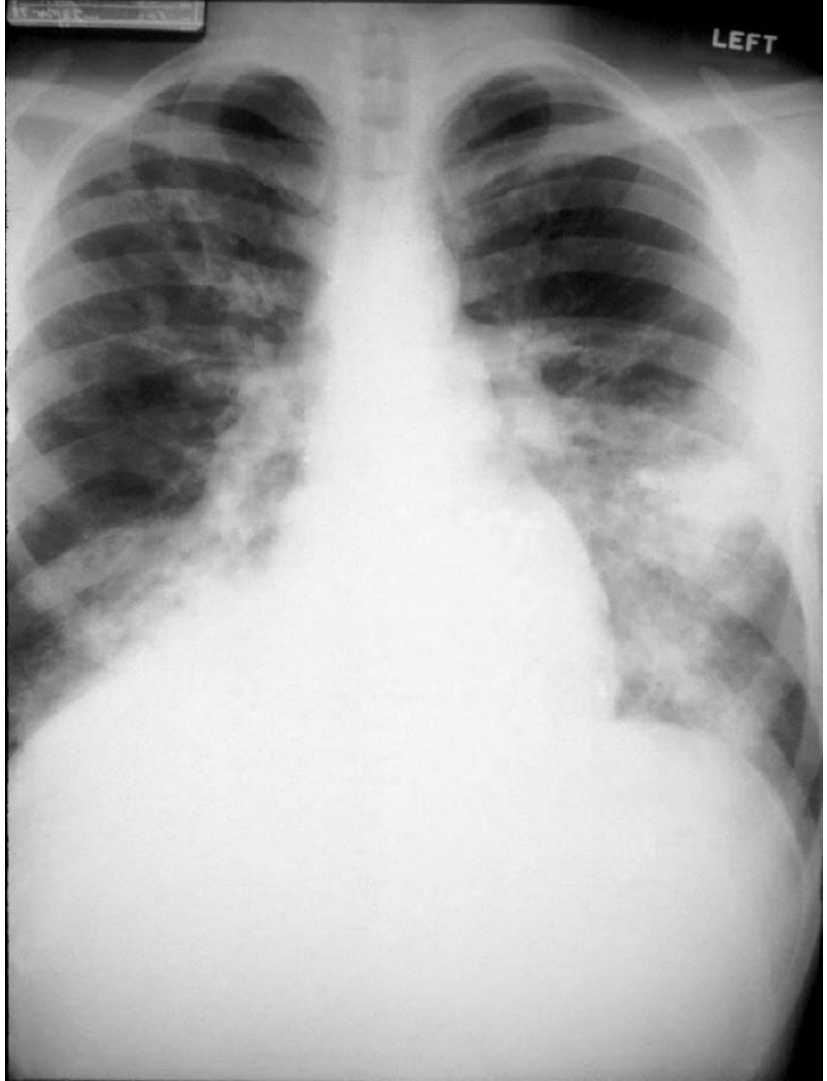
A. Any patient with residual symptoms should be transported to an ED for observation for progressive respiratory insufficiency for 4-6 hours

- Coughing
- Wheezing
- Tachypnea
- Low oxygen saturation

- EVEN IF AWAKE & COGNIZANT!

Submersion treatment--ED

- Unless obviously dead, assume survivability
  - Especially children
- Intubate if unable to oxygenate/ventilate
  - PEEP improves ventilation and volume
  - Shifts fluid into capillaries
- ACLS algorithms if indicated
- Rewarm patient per hypothermia protocols


LEFT

Who gets admitted?

- CNS compromise
- Respiratory compromise
- Any symptoms after observation
- Abnormal vital signs

- If normal RA oxygen saturation, normal lung exam, GCS > 13 may be safely discharged home

Case: "Texas Teenager" on spring break

- 19 yo collegiate M flew from Houston to Denver 3 days ago
- He & friends drove immediately to mountains for ski trip
- Has been skiing hard and partying harder for 3 days
- This morning, awakened with difficulty getting breath
- Speaks only in short sentences, is tachypneic to 30's
- Mountain clinic documented oxygen sats of 85%


BRONCOS

AMS

Acute Mountain Sickness

How does the height affect?

No medical exam can determine a person's aptitude to height. There is no difference in sex or age. The height and the cold are the two variables that are more dangerous in climbing to the summit of America.

The Altitude

- 6.962 m — 37% Lung capacity
- 5.000 m — 50% Lung capacity
- 3.000 m — 75% Lung capacity
- Nivel mar — 100% Lung capacity

As we ascend, the air pressure and partial of oxygen decreases progressively and this may be the cause of many height inconveniences.

About 50% of the Aconcagua climbers had suffered one or more AMS's symptoms.

The cold

The temperature decreases by 1 ° every 100m climbed

In summer, nights at 5000m are around -20 ° c. At the summit temperatures down to -35 ° cody.

Temperature

Should be 37 °, hypothermia is less than 35 °.

Mild
Between 32 and 33 ° tremors, clumsiness, remains conscious.
Shelter and seek possible freezing of the extremities

Severe
Less than 32 °. Loss of consciousness, very weak heartbeat.
Minimize movement. Shelter. Emergency evacuation stretcher medical service.

Freezing
The extremities of the body swell and lose sensitivity. Then turn white and rigid.
Place heat in the extremities. Urgent medical attention.

Symptoms of AMS

- *Headache*
- *Insomnia*
- Digestion is impaired by the lack of oxygen — *Gastrointestinal symptoms*
- *Pulmonary symptoms* — From 3000 m dry mucous membranes
- *Mild hypothermia*
- *Lassitude* — Profresiva fatigue in 24 to 48 hours
- *Ataxia* — Lack of esquilibrio
- *Urine retention*
- *Peripheral edema* — Swelling around the eyes and face, hand or foot

How to prevent Acute mountain sickness

1. Ascent graduate. Start the rise below 3000 mt.
2. A night of acclimatization every 1000 meters.
3. Abundant hydration (5 liters per day).
4. You can achieve higher blood oxygen levels with a diet with 70 to 80% carbohydrate.

Source: Aconcagua, la cima de America.

Mild AMS

Mild headache, a bit of insomnia, anorexia and shortness of breath while exercising. You can continue climbing. More time for acclimatization

Moderate AMS

The headache may be severe. It is possible to note some lassitude, weakness, loss of appetite, nausea and perhaps difficulty to coordinate. You should climb down.

Severe AMS

It is characterized by the presence of pulmonary edema and / or brain, require immediate descent and medical assistance

Altitude cerebral edema
Presents: headache, vomiting, ataxia, lassitude and low volume of urine. Shortness of breath or cough. There is sometimes confusion and may suffer amnesia or hallucinations. Weakness or paralysis on one side of the body.

Altitude pulmonary edema
is the progressive flooding of the pulmonary alveoli, marked shortness of breath even at rest. Dry cough, headache, lassitude and reduced urine output, peripheral edema and ataxia.

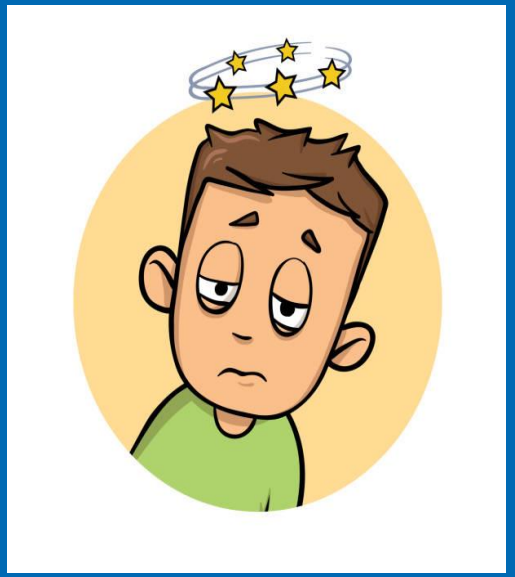
The Descent is the only therapy. Oxygen should be given.

Altitude definitions:

- Moderate: 8-10,000 feet
- High: 10-18,000 feet
- Extreme high: > 18,000 feet

High altitude sickness

- Can occur at altitude > 5,000 feet
- Influenced by:
  - Rate of ascent
  - Final altitude
  - Duration at altitude
  - Sleeping altitude



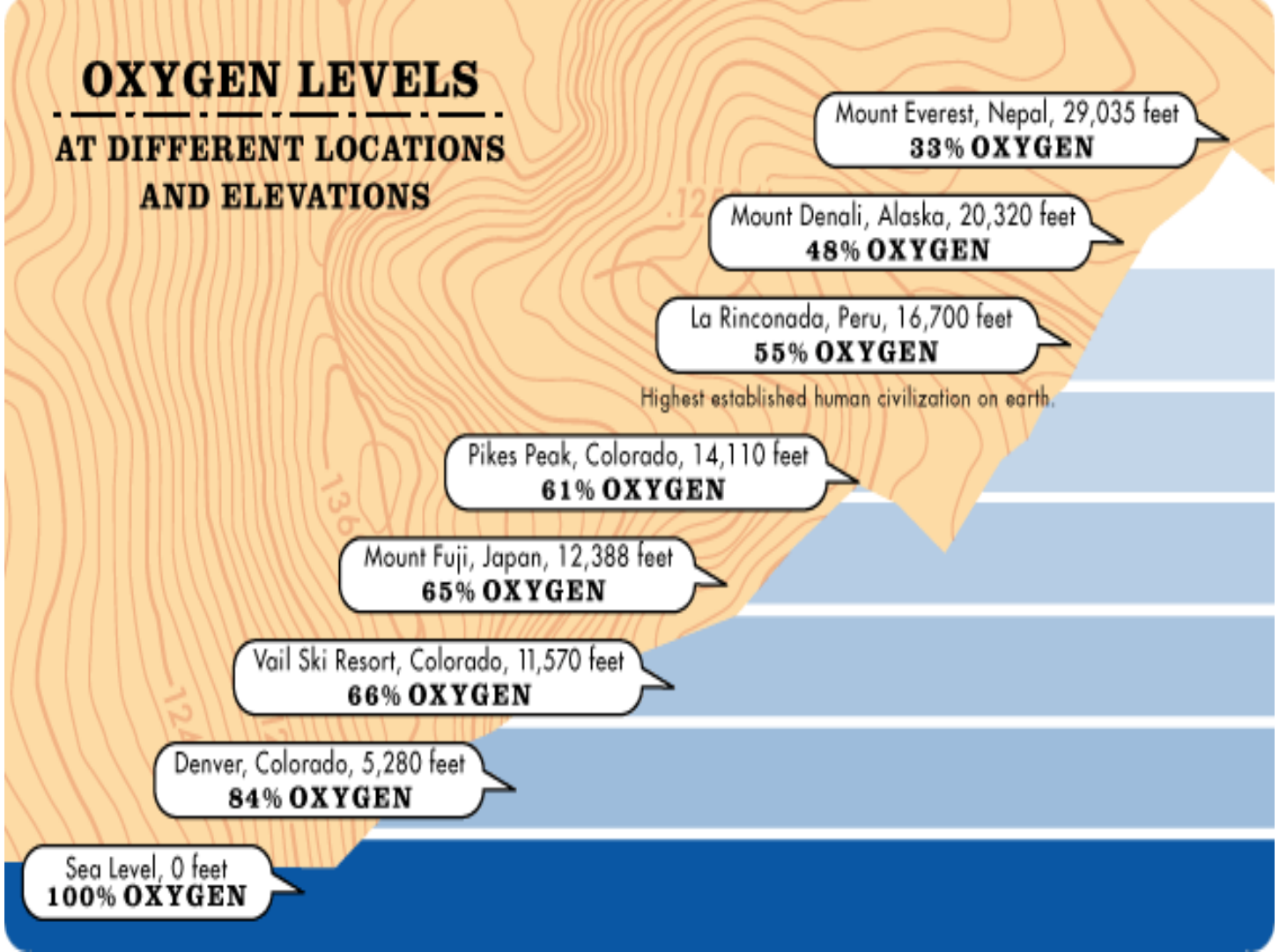

WHAT IT'S LIKE BEING HIGH IN PUBLIC

Who is at risk?

- Hard to predict
- Those at greater risk include:
  - Younger > older
  - Male > female
  - History of previous altitude sickness
    - Can occur in previously unaffected
  - Overexertion
  - Alcohol, sedatives, smoking
  - State of physical fitness NOT protective

Physiology

- Hypoxia due to ↓ barometric pressure
- Hypoxemia due to ↓ pO_2 of inspired air
- Impact on the cell variable
  - Ability to acclimatize/compensate
  - Pre-existing medical conditions


OXYGEN LEVELS
AT DIFFERENT LOCATIONS AND ELEVATIONS
Mount Everest, Nepal, 29,035 feet
33% OXYGEN
Mount Denali, Alaska, 20,320 feet
48% OXYGEN
La Rinconada, Peru, 16,700 feet
55% OXYGEN
Highest established human civilization on earth.
Pikes Peak, Colorado, 14,110 feet
61% OXYGEN
Mount Fuji, Japan, 12,388 feet
65% OXYGEN
Vail Ski Resort, Colorado, 11,570 feet
66% OXYGEN
Denver, Colorado, 5,280 feet
84% OXYGEN
Sea Level, 0 feet
100% OXYGEN

Acclimatization

- Ventilation—increases almost immediately
- Cardiovascular
  - Increased cardiac output (CO)
  - Increased pulmonary perfusion
    - Increases V/Q mismatch
- Increase in cerebral blood flow
- Hematologic
  - Relative increase in hemoglobin (diuresis)
  - Erythropoietin—stimulates bone marrow → ↑ RBC production
    - Effect takes weeks

Beware—some people acclimatize better than others!!

Types of illness

- Altitude-exacerbated conditions
  - NOT the focus of this talk, but be aware!
    - Congenital heart disease
    - Pulmonary hypertension
    - Coronary artery disease
    - Congestive heart failure
    - Sickle cell disease/trait
    - Obstructive sleep apnea
    - Pregnancy

High altitude illnesses

- Acute mountain sickness
- High-altitude cerebral edema (HACE)
- High-altitude pulmonary edema (HAPE)

Acute Mountain Sickness

- Defined as headache, plus one or more of:
  - Anorexia
  - Nausea/vomiting
  - Dizziness
  - Fatigue/weakness
  - Difficulty sleeping
  - Lightheadedness
- Typically 6-10 hours after ascent
- Usually self-limiting

Acute Mountain Sickness--Treatment

- Rarely need to descend—slow/halt ascent
- Analgesics/antiemetics prn
- Consider acetazolamide 125-250 mg BID
  - Speeds acclimatization
- Descend if symptoms do not improve
  - Dexamethasone 4 mg po/IM if unable to descend
- Graded ascent is best preventive measure (600 m/day)

High Altitude Cerebral Edema (HACE)

- AMS symptoms progress → global cerebellar dysfunction
  - Ataxia or altered mental status
  - Vertigo, diplopia, (rarely) seizures
- Usually > 12,000 feet (has occurred at > 9,000 feet)
- Begins > 12 hours after onset of AMS
- Symptoms typically global
  - Isolated focal seizures → think CVA/TIA

HACE--Treatment

- Immediate descent = definitive treatment
- Supplemental oxygen @ highest flow → sats > 90%
- Dexamethasone 8 mg po/IM, then 4 mg q6hrs
- If cannot descend, hyperbaric therapy

High Altitude Pulmonary Edema (HAPE)

- Non-cardiogenic pulmonary edema
- Accounts for most high-altitude deaths
- Occurs 1-3 days after arrival at altitude
  - Rarely occurs after 4 days—consider alternative diagnosis
- 1-2% of high-altitude climbers
  - 15% of those with rapid ascent

HAPE Pathophysiology

- Hypoxia leads to pulmonary artery hypertension
  - Increased pulmonary vascular resistance
  - However, occurs in everyone, not just HAPE
- Pulmonary capillary pressure increases
  - Leads to over-perfusion, capillary leakage
  - Fluid as well as proteins leak out → exudative fluid
- With descent, pressure decreases
- Inflammatory mediators likely not primary process, but secondary to leaked proteins

HAPE Treatment

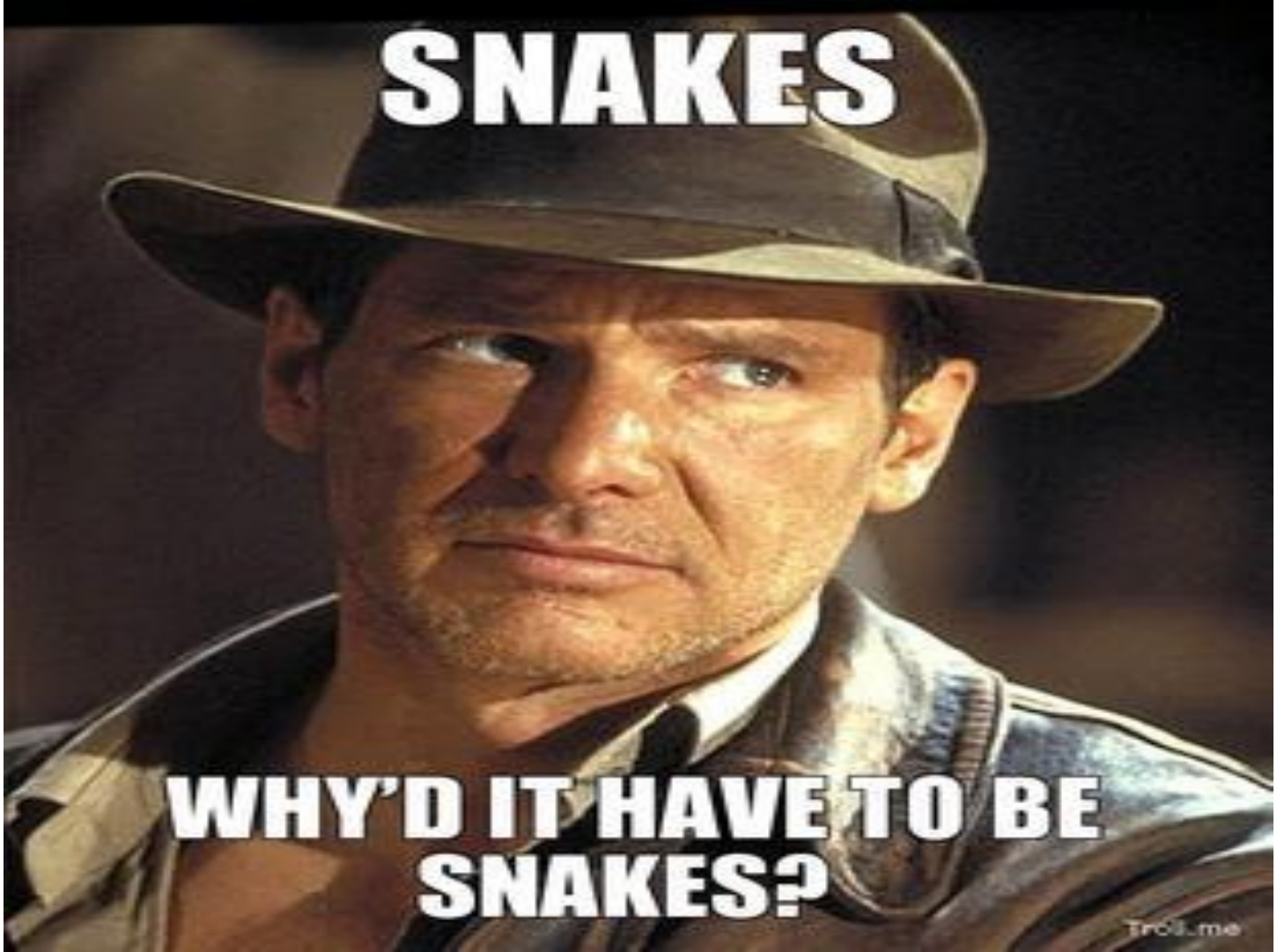
- Immediate descent
- Supplemental oxygen
  - Decreases pulmonary artery pressure up to 50%
- Beta-agonists
  - Increase fluid clearance from alveolar spaces
- No role for dexamthasone


KINGDOM

Case: snakebit

- 16 yo M hiking with buddies
- Came across rattlesnake on trail
- Tried to fend it off with a stick
- Snake bit patient on forearm approx. 2 hours ago
- Now, with pain, swelling, discoloration of forearm spreading from bite site
- Tachycardic, tachypneic, dizzy and sweaty


BITE ME


SNAKES
WHY'D IT HAVE TO BE SNAKES?
Troll.me

Snakebite stats

- Global
  - > 2 million annually
  - 20,000– 94,000 deaths
- USA
  - 6-8,000 snakebite envenomations/year
  - 5-6 deaths/year (kids, elderly, delayed care)
  - 99% Crotalidae (pit vipers)
    - 5 subspecies of copperheads
    - 3 subspecies of cottonmouths
    - > 60 subspecies of rattlesnakes


PHOTO BY CASEY KANODE

The typical bite victim

- **D**efinitely male
- **U**nder 30 years old
- **M**ostly warm months
- **B**itten on extremity
- **A**lcohol involved
- **S**tupidity: attempt to handle, harm, or kill a snake
- **S**enseless risks

Snake venom

- Pit vipers' (Crotalidae) venom contains zinc-dependent metalloproteinases
  - Direct capillary damage → hemorrhage & fluid extravasation
  - Tissue necrosis
  - Hemotxicity: consumptive coagulopathy → DIC
- Coral snakes' (Elapidae) venom contains alpha neurotoxins
  - Direct neurotoxicity

Autonomic "terror" reactions must be differentiated from envenomation effects.

Envenomation effects

- Majority: painful swelling at injury site; conservative management
- Smaller % significant morbidity: consumptive coagulopathy, renal failure, hypovolemic shock, anaphylaxis
- Children at higher risk: smaller size, higher concentration of venom

Manifestations of pit viper envenomation

- Fang marks
- 30-60 minutes: pain, edema, erythema, ecchymosis at or around bite site
- Early systemic: nausea/vomiting, perioral paresthesia, fingers/toes tingling, lethargy, weakness, myokymia
- Rubbery, minty, or metallic taste
- Systemic: hypotension, tachypnea, tachycardia, altered sensorium

Snakebite treatment: in the field

- Move victim beyond striking distance
- Place victim at rest
- Keep victim warm
- Transport immediately to nearest emergency medical facility
- Remove constrictive clothing, jewelry
- No stimulants

What NOT to do

- Tourniquets
- Incision and suction
- Cryotherapy (ice)
- Electric shock therapy

- IF a tourniquet has been placed as first aid, leave in place until hospital evaluation/initiation of antivenom Rx

Snakebite treatment in ED

- Supportive care with IV fluids
- Screening labs for coagulopathy (draw from unaffected limb)
- Observe affected limb with leading edge of edema demarcated and time q30”
- Prophylactic antibiotics discouraged

Use of antivenom

- Not well-defined
  - Moderate or increased swelling (progression)
  - Lab evidence of coagulopathy
  - Systemic signs
  - All coral snake bites (due to risk of respiratory muscle paralysis)

Cro-Fab

- First approved in 2000
- Ovine (sheep) Fab_2 fragment
- Made from venom of 4 snakes
  - Eastern diamondback rattlesnake
  - Western diamondback rattlesnake
  - Mojave rattlesnake
  - Cottonmouth (Water moccasin)
- Preferred therapy for envenomation

Cro-Fab

- Dose: 4-6 vials IV load (diluted in NS) initially; can reload if progression
  - Not "per kg" dosing—clinical effects due to venom dose, not patient weight
- 2 vials q6-8hours maintenance dose
- Stops progression; does not resolve symptoms (takes days to weeks)
- Adjunctive analgesia required
- 14.3% reaction rate (urticaria mostly; serum sickness possible for 1-3 weeks)

AnaVip

- First approved in 2018
- Equine (horse) F(ab')2 fragment
- Longer elimination half-life than Crofab
- Theoretically, requires less vials of antivenom dosing
- Dose: 10 vials loading dose IV
- Cost: Crofab $3400/vial; Anavip $1200/vial wholesale

- Early trials indicate more vials Anavip used vs. Crofab
- Late coagulopathy complications due to longer half-life

Disposition

- Observe all patients with pit viper bites in ED for minimum 8-12 hours
  - If no clinical or lab manifestations during this time, may discharge
- If treated with antivenom, should be admitted and monitored in an ICU


LOG OFF.
SHUT DOWN.
GET OUT.

Thank you

Case: hiker between mother & baby

- 7 yo F hiking with mother & siblings in Breckenridge
- Got off the path and wandered between mother moose and her calf
- Mother moose charged patient, knocked her to ground and stomped on her head
- Patient transported to local hospital
- Awake, crying, GCS 13
- Large scalp lac with underlying crepitus, depression palpable

Wild animal attacks: general

- Tearing, cutting, crushing, penetrating injuries
- Accompanying blunt trauma (falls, large animal forces)
- Local infection, variety of pathogens
- Transmission of systemic disease
- Remote wilderness areas → delay in notification, rescue, definitive care

HOW TO SURVIVE ANIMAL ATTACKS

Best defense is avoidance

- Keep a clean camp
- Treat garbage like you would food
- Never take food into a tent
- Don't sleep in the same clothes you cooked dinner in
- Don't feed wild animals—even deer, squirrels (it attracts the bigger animals)

Be prepared

- Pepper spray
- Club
- Substantial knife
- ?Firearm

How to survive an animal attack

- Know thy enemy's physical weak points
  - Nose/snout
  - Eyes
  - Neck
  - Testicles
  - Inside leg

How to survive an animal attack

- Know thy enemy's psychological weak points
  - Loud noises
    - Scream & yell
  - Aggressive behavior
    - Wave your hands/clothing around
  - Appearance of size

How to survive an animal attack

- If you can't scare the animal off, you have 2 choices:
  - RUN
  - FIGHT
    - Use sharp objects/weapons, if you have them
    - Improvise: grab a big stick or a log
    - Strike at weak points, yell, make erratic movements

- Caveat: animals can usually run and fight better than you can

What to do for the attack victim

Field management of attack victim

- First, assure scene safety
  - Rescuer safety
  - Victim safety
  - Will the animal return?
- Things to consider
  - What equipment is available?
  - Is help reasonably close?
  - Can the victim walk?
  - Consider mechanism of injury

Field management of attack victim

- Airway
- Breathing
- Circulation
- Disability
- Exposure
- Wound care: irrigate, debride, dress, splint

Trauma management & wound care

- ATLS principles
- Wound care
  - Explore
  - Cleanse
  - Irrigate
  - Debride
  - To close or not to close?
  - Antibiotic coverage
  - Tetanus prophylaxis