Burns

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We have no financial disclosures.

Objectives

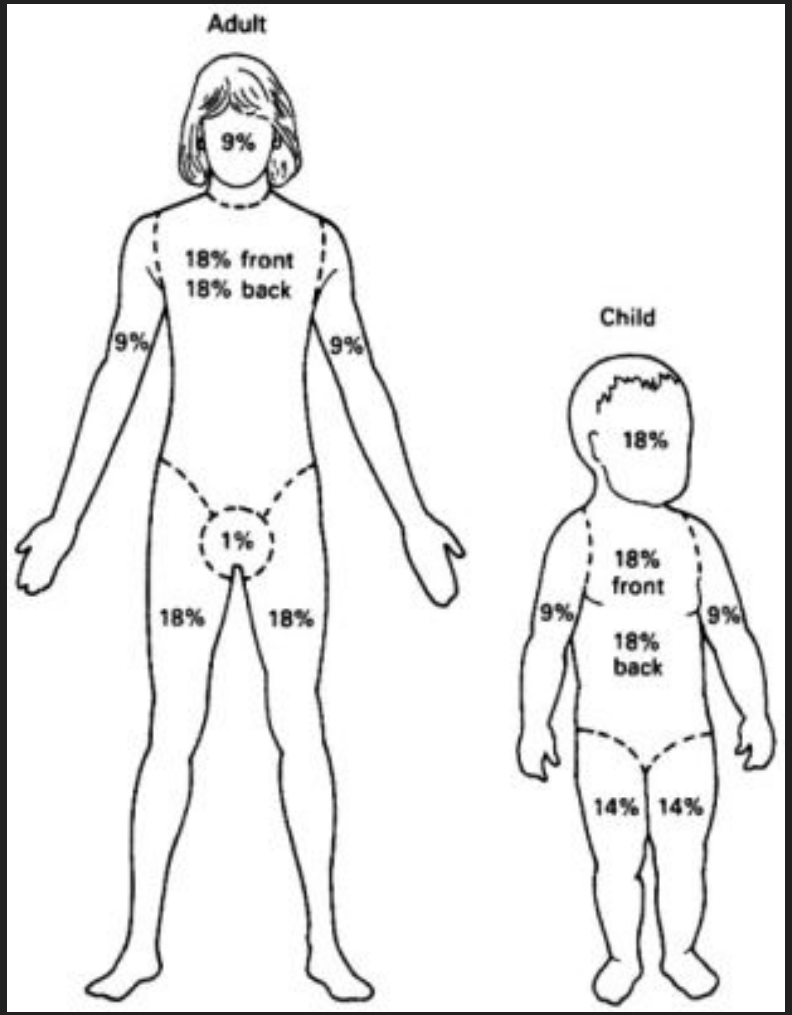
1. Thermal Injury
2. Chemical Injury
3. Electrical Injury
4. Cases
5. Wrap-Up/Questions

Thermal Injury

What is a thermal injury?

- Any kind of injury caused by too much heat: fires, steam or boiling water, hot objects
- Burns are classified both by how deep they go, and by how much of the body is burned.
- Thermal injury cause both local injury (to the direct area burned) and systemic injury (to the whole body) when more than 20% of the body is affected.

BURN DESCRIPTION	APPEARANCE	CAP REFILL	SENSATION/ PAIN	HEALING	
1st SUPERFICIAL THICKNESS	ERYTHEMA	FAST	+	7-14D	
SUPERFICIAL PARTIAL THICKNESS 2nd	WET, PINK, BLISTERS,	FAST	++	2-4 WEEKS	
DEEP PARTIAL THICKNESS	LESS WET, RED, +/-BLISTERS,	SLUGGISH OR ABSENT	+/-	3-8WKS WITH SEVERE SCARRING; NEEDS **GRAFTING**	
3rd FULL THICKNESS	DRY, WHITE	ABSENT	ABSENT	NEEDS **GRAFTING**	


Adult
9%
18% front
18% back
9%
9%
1%
18%
18%
Child
18%
18%
front
18%
back
9%
9%
14%
14%

A

Airway can be damaged multiple ways in burns:

1) Direct inhalation injury of smoke, chemicals, or heat
2) Local edema/swelling from thermal injury to the airway
3) Systemic edema from an allover response to burn

Suspect the airway may be at risk if:

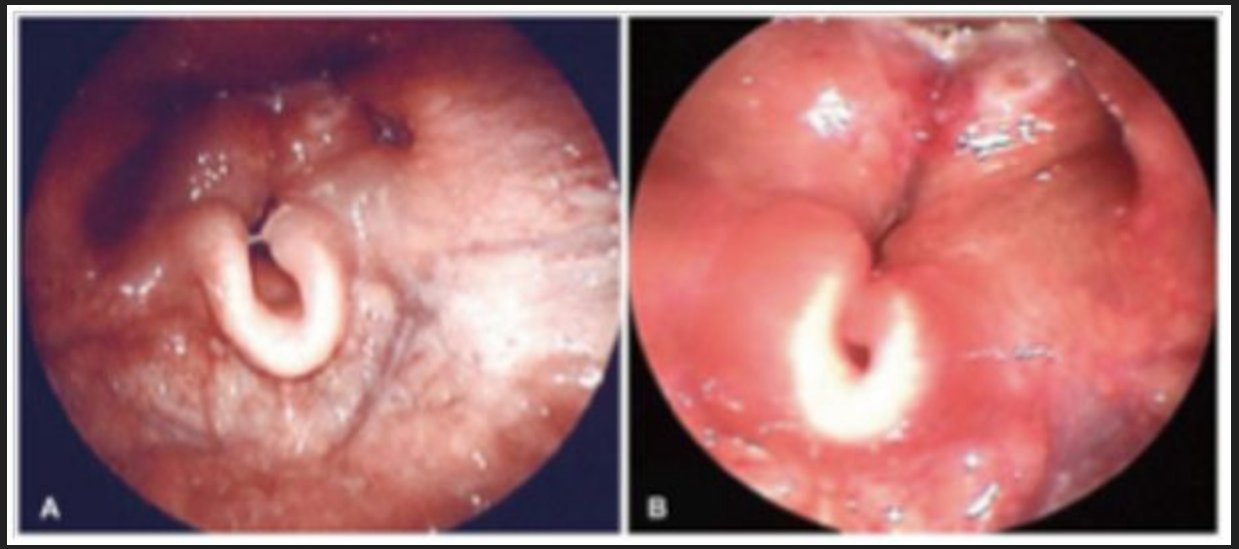
1) Change in voice
2) Cough or stridor (late, emergency finding!!)
3) You can see burns on the face, if the head/neck are swollen, or if the facial hair is burned
4) There are burns all the way around the neck, face, or head

Pic from : www.vicburns.org.au

A

Think about intubation early.

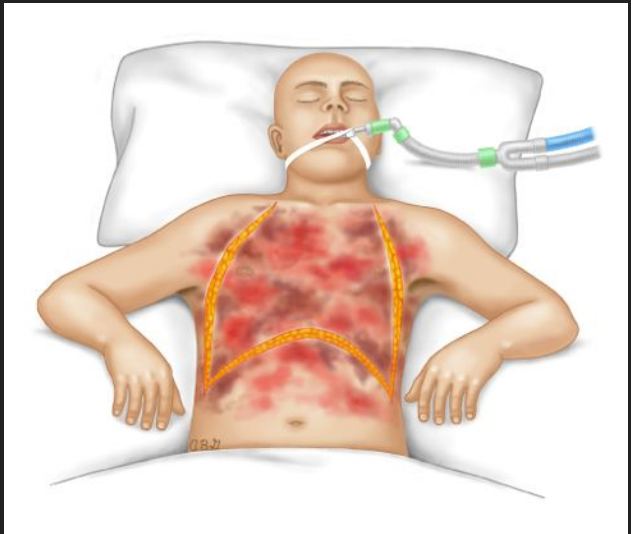
Burn injury may cause airway swelling that is not obvious at first, but will develop in hours.



Airway swelling after laryngeal burn induced by swallowing hot food: Korean J Otorhinolaryngol-Head Neck Surg. 2015 Sep;58(9):634-636.

B

- Rare to see direct thermal injury to the lower airway. May see this if person was breathing smoke for a long time or was burned in an enclosed area.
- Breathing can be affected if the whole chest is burned and may require an escharotomy to allow the chest to move



C

All burns over 20% of body surface area require fluid resuscitation.

Patients with these large burns need fluid because the burn itself causes fluid loss, and when burns happen, cardiac output goes down and fluid shifts in the body in response to the injury.

Giving too much fluid can cause pulmonary edema

Insert a Foley if possible to track patient input/output of fluid. Goal is to maintain urine output between 0.5 and 1 mL/kg/hour in adults, and between 1.0 and 1.5 mL/kg/hour in children

C

Resuscitation formulas (fluids for the first 24 hours)

The Parkland formula:
Total burned Body surface area * Body weight (kg) * 4 = CC of crystalloid fluid to give

The Brooke formula:
Total burned Body surface area * Body weight (kg) * 2 = CC of crystalloid fluid to give

Give 1/2 of the total in the first 8 hours and ½ the last 16 hours

D

Burn patients may have a decreased level of consciousness if:

1) Inadequate oxygenation

1) Inhalation of smoke or chemicals may lead to a decreased level of consciousness.

Behaviour	Response
 Eye Opening Response	4. Spontaneously 3. To speech 2. To pain 1. No response
 Verbal Response	5. Oriented to time, person and place 4. Confused 3. Inappropriate words 2. Incomprehensible sounds 1. No response
 Motor Response	6. Obeys command 5. Moves to localised pain 4. Flex to withdraw from pain 3. Abnormal flexion 2. Abnormal extension 1. No response

E

– The patient should be completely exposed and clothing removed to identify all injuries. If clothing is stuck on and headed to OR, may cut around and remove in OR
– Give tetanus vaccine
– Fresh burns are considered clean, try not to contaminate them
– How to care for blisters is controversial, as is application of antibiotic ointment. Follow your local protocols
– Applying ice or cold water to burns can be unsafe in patient with burns covering more than 10% of the body and can cause hypothermia

When to transfer to a Burn Center / Higher Level of Care

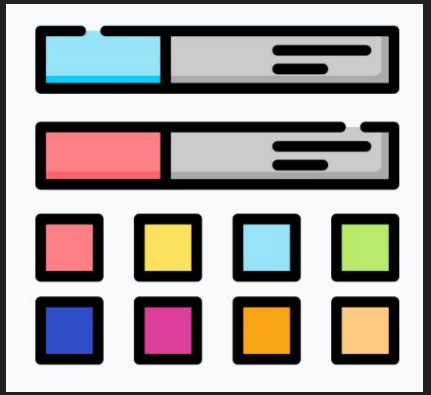
This depends on your local practice and local resources.
In the United States, there is some local variation. Major things to think about:

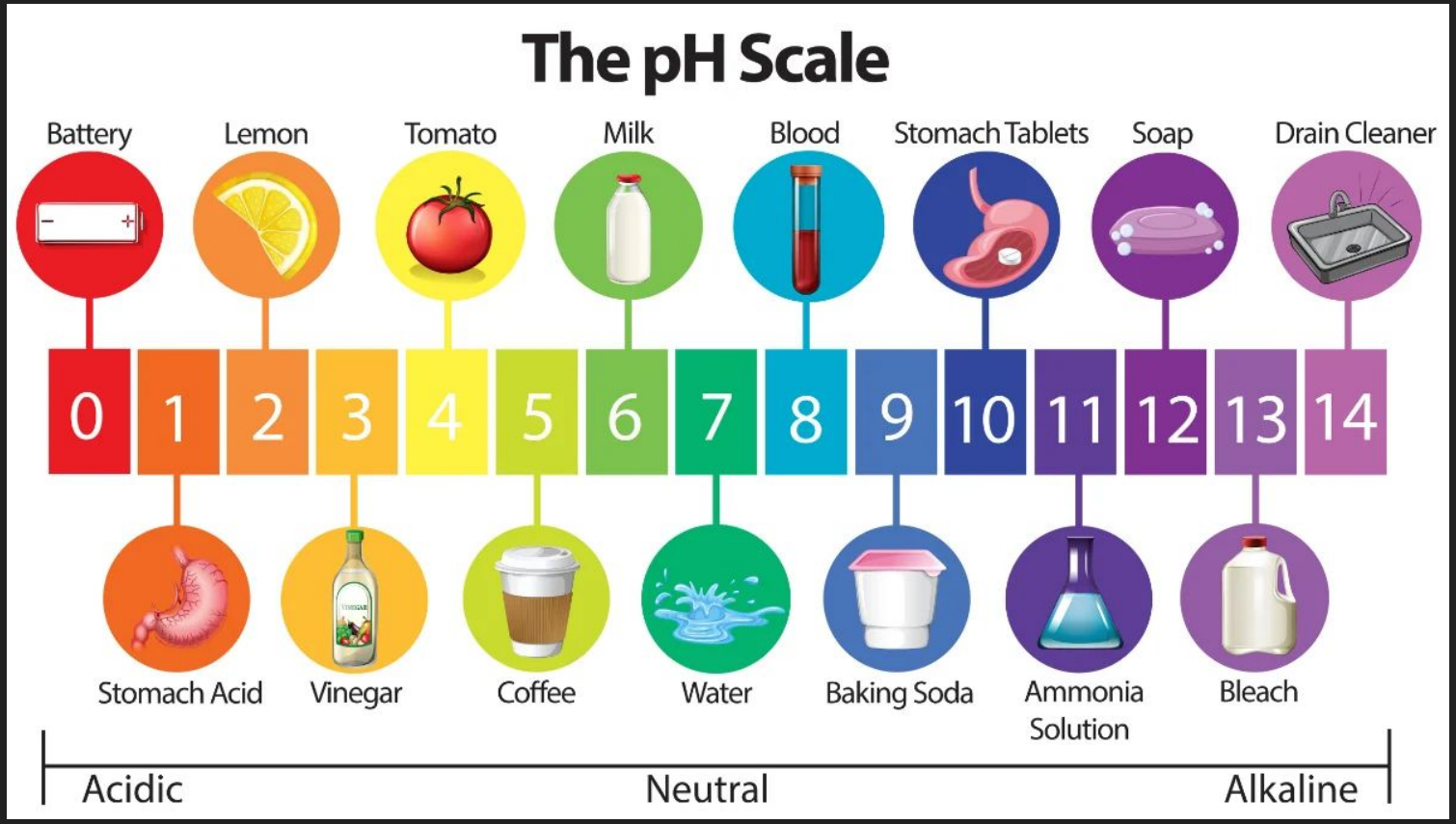
1) How much of the body surface is burned?
2) Are there any circumferential burns?
3) Do you have the ability to transfer the patient?
4) Does the patient have other medical conditions or other trauma that needs care at a different hospital?

Thermal Injury Take-Home Points

1) Calculate the surface area burned. If over 20%, you may start seeing overall swelling, not just local injury
2) Resuscitate appropriately using one of the fluid resuscitation formulas and track urine output so that you do not over resuscitate

Chemical Injuries




The pH Scale
Battery
Lemon
Tomato
Milk
Blood
Stomach Tablets
Soap
Drain Cleaner
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Stomach Acid
Vinegar
Coffee
Water
Baking Soda
Ammonia Solution
Bleach
Acidic
Neutral
Alkaline

- Alkaline burns: liquefaction necrosis
  - Can interact with fats, tissues, and will also take water from surrounding tissue. The tissues lose shape and turn to liquid, allowing the chemical reaction to continue on more tissues
  - Penetrates faster and deeper than acidic burns

Acidic burns: Coagulation necrosis

- Acid denatures the proteins in the tissue (changes their shape), which kills the tissue
- The damaged tissue can become firm, which then form a barrier of damaged tissues
- Limited depth of injury

A + B

We approach chemical burns the same as thermal burns for airway and breathing. If there is a larger surface area burned, the patient is more likely to require intubation. Inhalation of chemicals may require intubation and ventilation. Too much fluid resuscitation may lead to pulmonary edema, and burns all around the chest may require escharotomy

C

- Large surface area chemical burns may require IV fluid resuscitation, as thermal burns do.
- When calculating body surface area of a burn, assume the burn is full thickness if you are unsure.
- Some chemicals, like Hydrofluoric acid may cause dangerous electrolyte abnormalities, like hypocalcemia, and hypomagnesemia. These abnormalities have to be treated, along with the resuscitation.

D

The same principles for Disability apply to chemical burns as for thermal burns

Protecting medical workers is very important when treating patients with chemical burns! Have all staff wear gloves, gowns, and protective equipment!

E

The main principles of managing a chemical burn are all exposure related:

1) Remove the patient's clothing
2) If there is dry chemical on the skin brush it off with a towel or brush, then irrigate with water
3) Irrigate all areas of burn with water for 15 minutes to 2 hours. If available, you can use pH strips to monitor your progress to neutral pH every
4) Acid burns will need less irrigation time than alkali burns
5) If possible, irrigate with water in a way that does not drip water onto unburned areas of the body
6) Irrigate eyes and face first
7) Use low pressure (high pressure may push chemicals into the skin)
8) Cover the body after irrigation to prevent hypothermia

Exceptions to Irrigation:

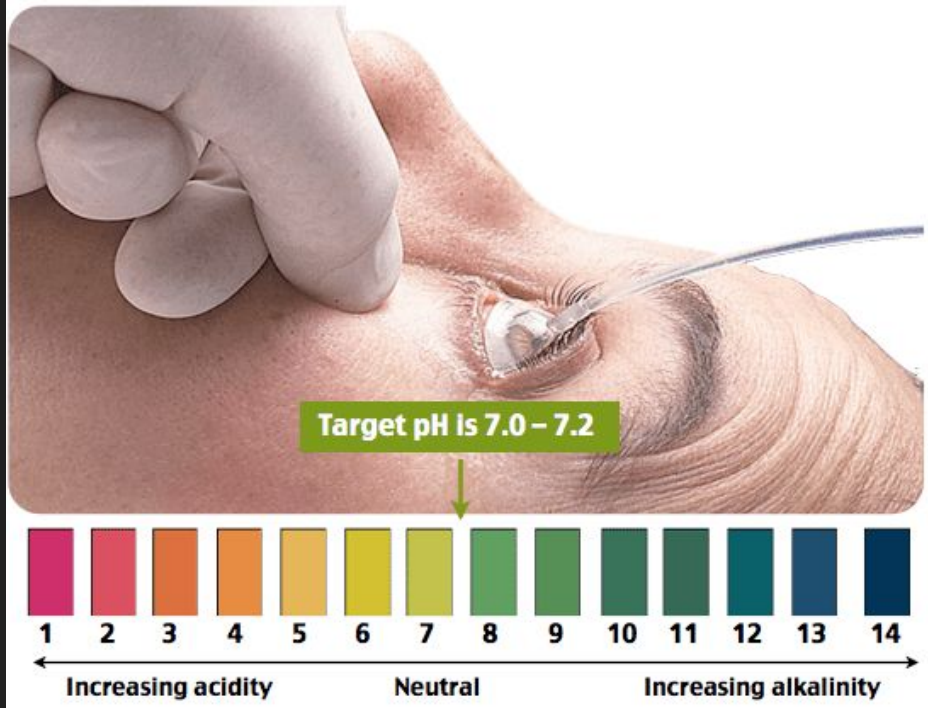
1) Dry lime. Try to brush it all off prior to irrigation. Irrigation of dry lime will cause a reaction that creates heat and will burn the patient
2) Metals (potassium, magnesium, phosphorous, lithium, cesium, and titanium tetrachloride): These will also burn when exposed to water. Brush these off the skin, then put the metals under oil and rub oil on the skin. Remaining particles can be removed in the operating room
3) Phenols: Use sponges soaked in 50 percent polyethylene glycol (PEG) to decontaminate before washing with water. Use lots of water, as a dilute phenol solution is easier for skin to absorb than a concentrated solution

Precautions with burns

–Do not try to neutralize the burn with other chemicals. This can cause further injury
–Do not try to make the patient vomit ingested chemicals. They may aspirate and injure the lungs or re-damage tissues that have already been burned

Chemical Burn to Eye

→ Immediately initiate copious irrigation



Acid burn

- Results in **protein coagulation**
- Limited depth of injury

Alkali burn

- Results in **liquefaction necrosis**
- Lipophilic
- Penetrates faster than acidic burns
- Can rapidly damage cornea, iris, and lens
- Blindness

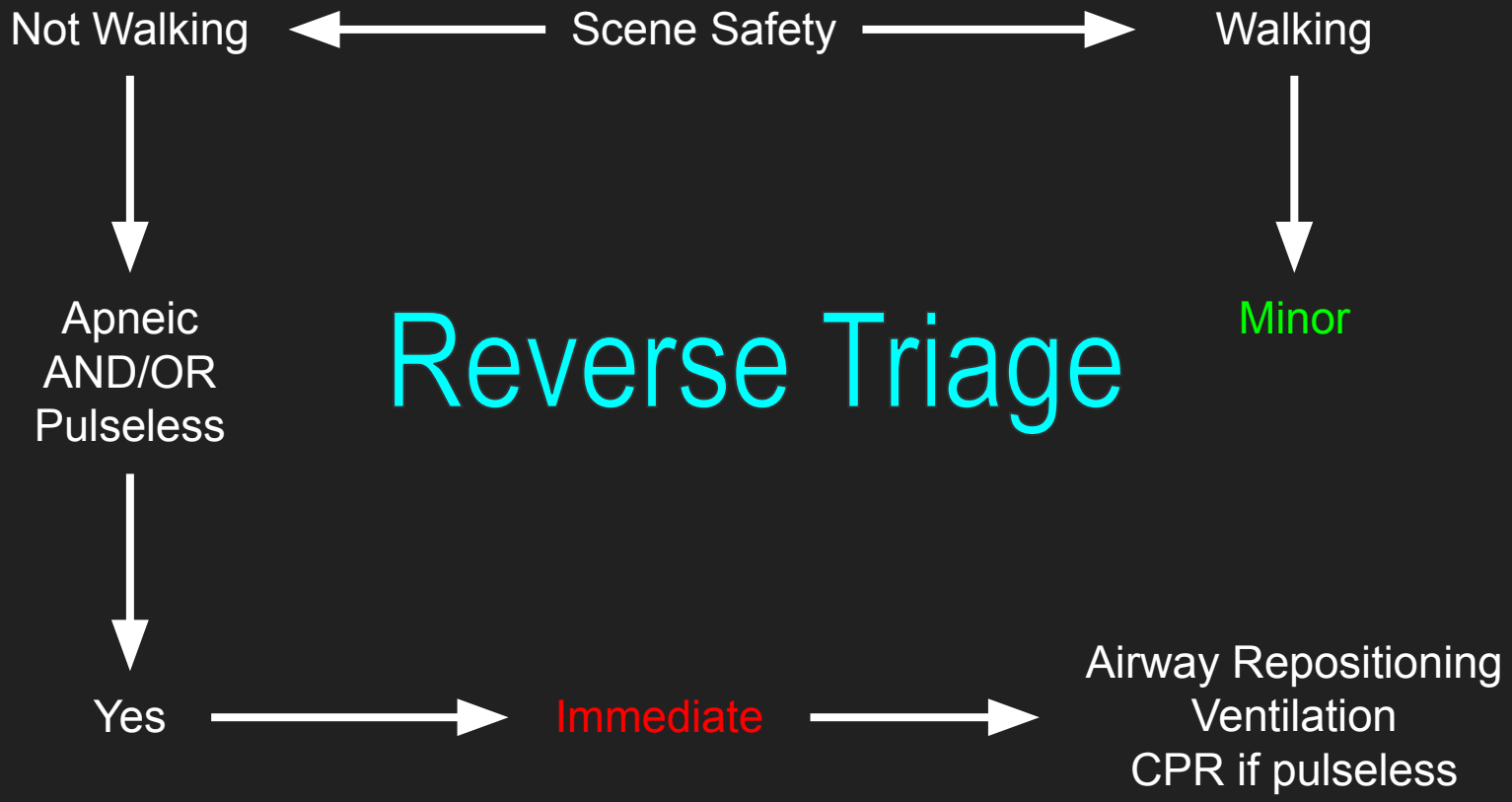
2'

Chemical Injury Take-Home Points

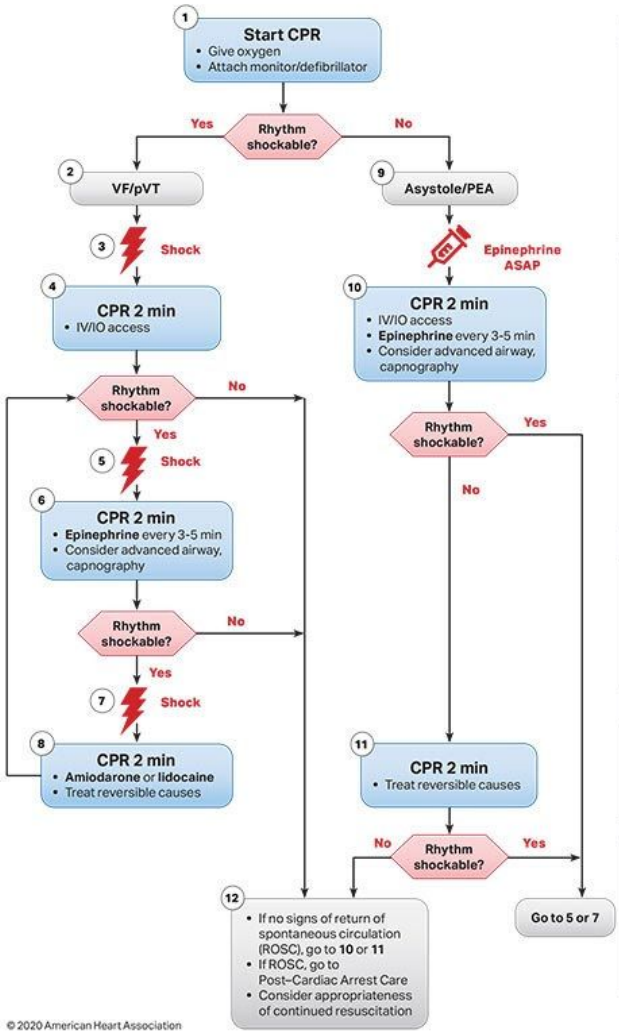
1) Protect staff with appropriate gowns, gloves
2) Remove patient's contaminated clothing
3) Irrigation is the most important part of treatment

Lightning and Electrical Injuries

A/B


Not Walking
Scene Safety
Walking
Apneic
AND/OR
Pulseless
Reverse Triage
Minor
Yes
Immediate
Airway Repositioning
Ventilation
CPR if pulseless

Adult Cardiac Arrest Algorithm (VF/pVT/Asystole/PEA)



CPR Quality

- Push hard (at least 2 inches [5 cm]) and fast (100-120/min) and allow complete chest recoil.
- Minimize interruptions in compressions.
- Avoid excessive ventilation.
- Change compressor every 2 minutes, or sooner if fatigued.
- If no advanced airway, 30:2 compression-ventilation ratio.
- Quantitative waveform capnography
  - If P_{ETCO_2} is low or decreasing, reassess CPR quality.

Shock Energy for Defibrillation

- **Biphasic:** Manufacturer recommendation (eg, initial dose of 120-200 J); if unknown, use maximum available. Second and subsequent doses should be equivalent, and higher doses may be considered.
- **Monophasic:** 360 J

Drug Therapy

- **Epinephrine IV/IO dose:** 1 mg every 3-5 minutes
- **Amiodarone IV/IO dose:** First dose: 300 mg bolus. Second dose: 150 mg.
  or
  Lidocaine IV/IO dose: First dose: 1-1.5 mg/kg. Second dose: 0.5-0.75 mg/kg.

Advanced Airway

- Endotracheal intubation or supraglottic advanced airway
- Waveform capnography or capnometry to confirm and monitor ET tube placement
- Once advanced airway in place, give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions

Return of Spontaneous Circulation (ROSC)

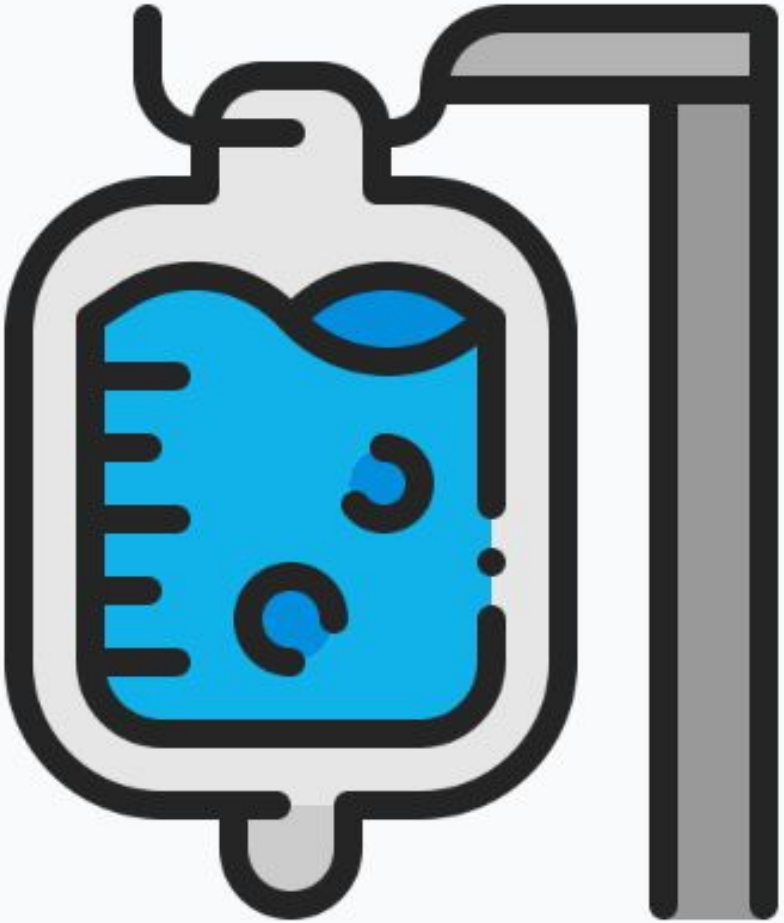
- Pulse and blood pressure
- Abrupt sustained increase in P_{ETCO_2} (typically ≥40 mm Hg)
- Spontaneous arterial pressure waves with intra-arterial monitoring

Reversible Causes

- Hypovolemia
- Hypoxia
- Hydrogen ion (acidosis)
- Hypo-/hyperkalemia
- Hypothermia
- Tension pneumothorax
- Tamponade, cardiac
- Toxins
- Thrombosis, pulmonary
- Thrombosis, coronary

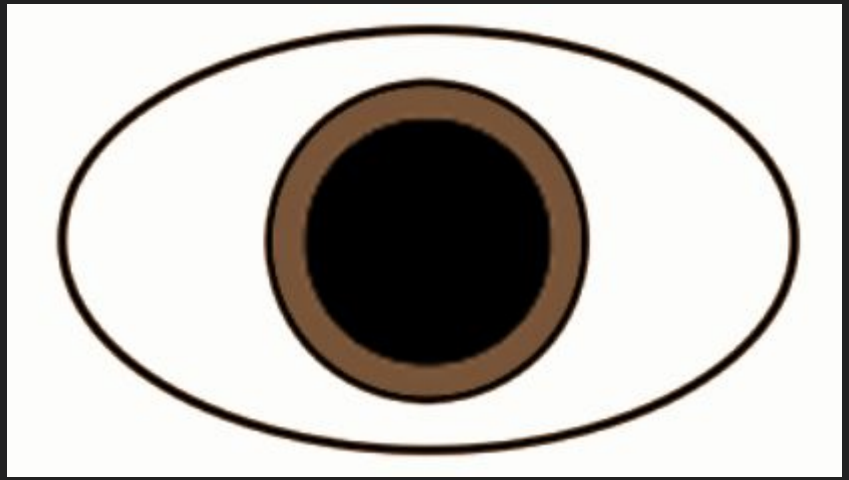
C

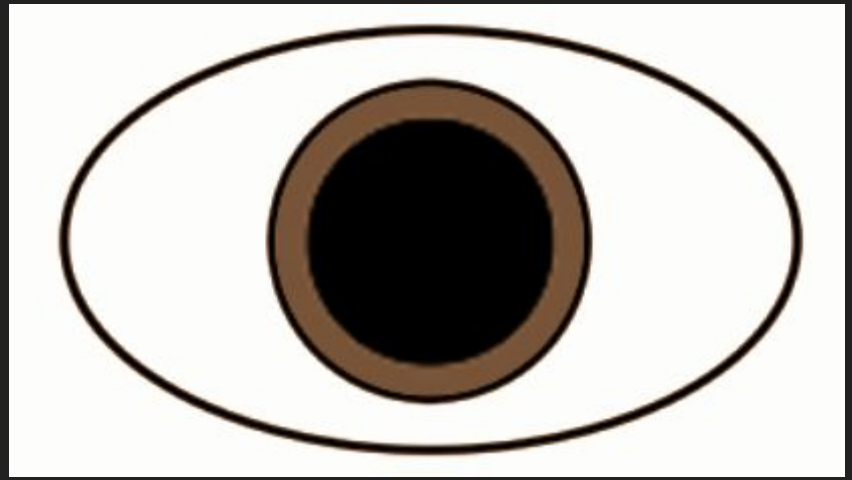
C



C

D



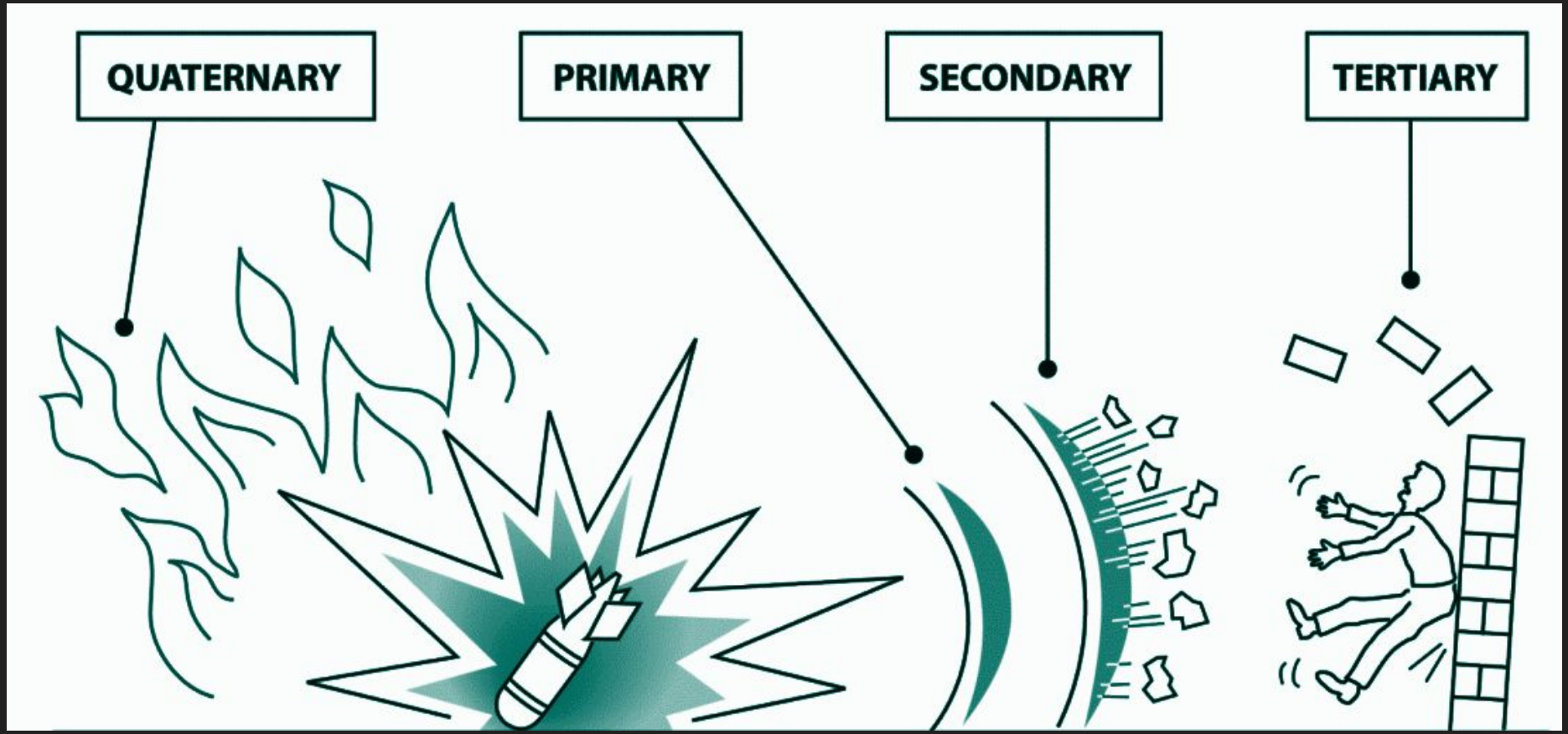


D

E

2'


L


QUATERNARY
PRIMARY
SECONDARY
TERTIARY

Lightning and Electrical Injury Take-Home Points

- Reverse triage 2/2 respiratory arrest

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- Reverse triage 2/2 respiratory arrest
- Dysrhythmias

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- Dysrhythmias
- Autonomic dysfunction

Lightning and Electrical Injury Take-Home Points

- Reverse triage 2/2 respiratory arrest
- Dysrhythmias
- Autonomic dysfunction
- Burns (can be deep)

Lightning and Electrical Injury Take-Home Points

- Reverse triage 2/2 respiratory arrest
- Dysrhythmias
- Autonomic dysfunction
- Burns (can be deep)
- Blast trauma

Cases

Case 1

A 14-year-old male presents to the emergency department via EMS after a structural fire. His respiratory rate is 35 bpm, heart rate is 130 bpm, blood pressure is 90/60 mmHg, and oxygen saturation is 92% on nasal cannula at 3 liters/minute. You note singed eyelashes and nose hairs, and there is soot in his nose and mouth. What is the next best step in management?

A. Non-invasive ventilation
B. Intravenous crystalloids
C. Discharge to home
D. Early intubation

Case 2

A 45-year-old man presents to the emergency department after being rescued from a house fire. The patient is unresponsive on arrival and intubated for airway protection. Vital signs are remarkable for oxygen saturation of 87%, HR 55, RR 38, and BP 85/55. On physical examination the patient has partial and full thickness burns noted on 30% of his body sparing the mouth and face. There were no airway burns. He has an elevated anion gap acidosis with a lactate 12 mmol/L. What is the most likely cause of his acidosis?

A. Carbon monoxide poisoning
B. Cyanide toxicity
C. Inhalation injury
D. Methemoglobinemia

Question Adapted from Rosh Review

Case 3

A 63-year-old female with COPD on chronic home oxygen was smoking a cigarette and caused a fire. She was intubated in the field by EMS. On arrival to the emergency department, you note burns to her entire face and anterior torso. She weighs 60 kg. What volume of crystalloid fluids should she receive in the first 8 hours based on the Brooke formula?

A. 1300 mL
B. 1350 mL
C. 1400 mL
D. 1450 mL

Case 4

A 14-year-old female presents after an alkaline chemical exposure to the left eye. Irrigation is started with normal saline. Which of the following is the most proper endpoint of irrigation?

A. Absence of fluorescein uptake
B. Normal intraocular pressure
C. pH 7.0–7.4
D. Two liters of crystalloid irrigation

Question Adapted from Rosh Review

Case 5

A 42-year-old male is involved in a high-voltage direct current industrial electrical accident. He is exhibiting labored breathing with a respiratory rate of 30 bpm, heart rate of 120 bpm, blood pressure of 100/60 mmHg, and oxygen saturation 90% on room air. He has circumferential burns around his chest. What is the next best step in management?

A. Intubation
B. Chest x-ray
C. Escharotomy
D. Positive-pressure ventilation

Case 6

You are the first person to arrive on scene after a lightning strike, and you are conducting triage. Which of the following patients should be attended to FIRST?

A. 56-year-old female thrown into a building by the lightning blast with multiple fractures. RR 18, capillary refill < 2 seconds, follows commands
B. 35-year-old male with keraunoparalysis. RR 12, capillary refill < 2 seconds, follows commands
C. 80-year-old female who is confused but talkative and is not following commands. RR 15, capillary refill < 2 seconds
D. 15-year-old female who is not breathing despite airway repositioning. No pulses

Adult Triage

S.T.A.R.T.
Simple Triage And Rapid Treatment
Algorithm

Able to walk on command and no major injuries.	MINOR
No respirations after head tilt.	DECEASED
Respirations after head tilt. ~ *Skip if already breathing* ~	IMMEDIATE
Respirations: Over 30 per min.	IMMEDIATE
OR	
Perfusion: Radial pulse absent. (Control bleeding)	IMMEDIATE
OR	
Mental status: Unable to follow simple commands.	IMMEDIATE
All others.	DELAYED

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TriageTags.com

Pediatric Triage

JumpSTART
Algorithm

Able to walk. No major injuries. (re-evaluate in secondary triage)	MINOR
Apneic and no pulse after head tilt.	DECEASED
Apneic with pulse after 5 rescue breaths.	DECEASED
Respirations after head tilt or 5 rescue breaths. ~ *Skip if already breathing* ~	IMMEDIATE
Respirations: Less than 15 or over 45 per minute.	IMMEDIATE
OR	
Perfusion: Radial pulse absent. (Control bleeding)	IMMEDIATE
OR	
AVPU: P inappropriate or U.	IMMEDIATE
All others. (A, V or P appropriate)	DELAYED

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Adult Triage

S.T.A.R.T.

Simple Triage And Rapid Treatment

Algorithm

Able to walk on command and no major injuries. ☐ ▶ **MINOR**

No respirations after head tilt. ☐ ▶ **DECEASED**

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~ Skip if already breathing ~

Respirations: Over 30 per min. ☐ ▶ **IMMEDIATE**

OR

Perfusion: Radial pulse absent. (Control bleeding) ☐ ▶ **IMMEDIATE**

OR

Mental status: Unable to follow simple commands. ☐ ▶ **IMMEDIATE**

All others. ☐ ▶ **DELAYED**

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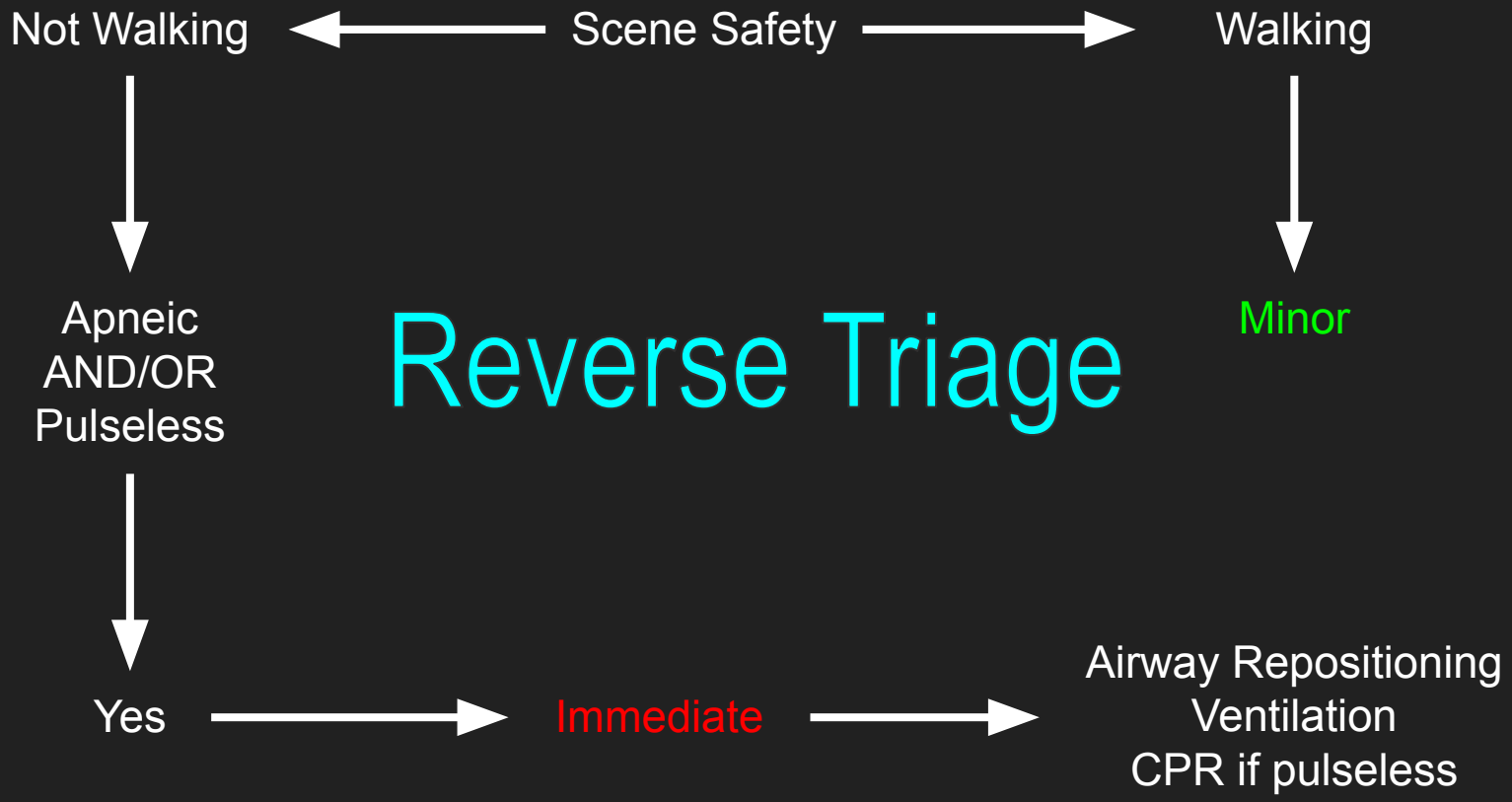
Not Walking
Scene Safety
Walking
Apneic
AND/OR
Pulseless
Reverse Triage
Minor
Yes
Immediate
Airway Repositioning
Ventilation
CPR if pulseless

Case 7

A 30-year-old female presents to the emergency department after sustaining a high-voltage, alternating current electrical burn. Which of the following should guide his fluid resuscitation?

A. Compartment pressures
B. Hourly urine output in urinary catheter
C. Time exposed to the electrical current
D. Total body surface area burned

Question Adapted from Rosh Review

Final Take-Home Points

- ABCDE

Final Take-Home Points

- ABCDE
- Beware: inhalation burns and exposures

Final Take-Home Points

- ABCDE
- Beware: inhalation burns and exposures
- Fluid resuscitation for burns

Final Take-Home Points

- ABCDE
- Beware: inhalation burns and exposures
- Fluid resuscitation for burns
- Fluid irrigation for chemical burns

Final Take-Home Points

- ABCDE
- Beware: inhalation burns and exposures
- Fluid resuscitation for burns
- Fluid irrigation for chemical burns
- Electrical burns go deep!

Final Take-Home Points

- ABCDE
- Beware: inhalation burns and exposures
- Fluid resuscitation for burns
- Fluid irrigation for chemical burns
- Electrical burns go deep!
- Reverse triage for lightning

References - Thermal Injuries

1. Thermal Burns: StatPearls. https://www.ncbi.nlm.nih.gov/books/NBK430773/
2. Emergency Medicine Cases: https://emergencymedicinecases.com/burn-inhalation-injuries/
3. Trauma Victoria: https://trauma.reach.vic.gov.au/guidelines/burns/secondary-survey
4. Minnesota Dept of Public Health: https://www.health.state.mn.us/communities/ep/surge/burn/module3basic.html
5. RECM learning: https://www.rcemlearning.org/modules/major-trauma-burns/
6. Vic Burns: https://trauma.reach.vic.gov.au/guidelines/burns
7. American Burn Association: https://ameriburn.org/wp-content/uploads/2019/08/2018-abls-providermanual.pdf

References - Chemical Injuries

1: American burn association: https://ameriburn.org/wp-content/uploads/2019/08/2018-abls-providermanual.pdf

2: StatPearls: Chemical burns: https://www.ncbi.nlm.nih.gov/books/NBK499888/

3. An Atypical Cause of Alkali Chemical Burn: a Case Report: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3188272/

4. Life in the Fast Lane: Burns. https://litfl.com/burns/

5. Topical chemical burns: Initial assessment and management
https://www.uptodate.com/contents/topical-chemical-burns-initial-assessment-and-management/print

References - Lightning and Electrical Injuries

1. Abraham V, Li A. Lightning Strike Emergencies Part 1: Triage and Cardiac Emergency. AAEM RSA Resident Blog. Published August 6, 2020. http://aaemrsa.blogspot.com/2020/08/lightning-strike-emergencies-part-1.html
2. American Heart Association. Adult Cardiac Arrest Algorithm. Published online 2020. Accessed April 5, 2023. https://cpr.heart.org/-/media/CPR-Files/CPR-Guidelines-Files/Algorithms/AlgorithmACLS_CA_200402.pdf
3. Bickle I. *Posterior Shoulder Dislocation*.; 2020. Accessed April 5, 2023. https://doi.org/10.53347/rID-74689
4. Borek H, Kopatic M. Chemical Burns. In: *CorePendium*. CorePendium, LLC; 2022. Accessed March 28, 2023. https://www.emrap.org/corependium/chapter/recFfH9xqOYCXmt74/Chemical-Burns
5. Chamber A. *Blast Injury Classification*. Accessed April 5, 2023. atma.net.au/resources/Documents/Assoc%20Prof%20John%20Moloney%20-%20Blast%20Injuries.pdf
6. Chen P, Kidder Buckman A. Chapter 130: Electrical and Lightning Injuries. In: *Rosen's Emergency Medicine: Concepts and Clinical Practice*. e2. Elsevier; 2023:1781-1787. Accessed April 5, 2023. https://www-clinicalkey-com.beckerproxy.wustl.edu/#!/content/book/3-s2.0-B9780323757898001304
7. Cooper MA. *Fig. 130.3 Kissing Burn*.; 2023. Accessed April 5, 2023. https://www-clinicalkey-com.beckerproxy.wustl.edu/#!/content/book/3-s2.0-B9780323757898001304
8. Dekoning EP, Elder J. Thermal Burns. In: *CorePendium*. CorePendium, LLC; 2022. Accessed March 28, 2023. https://www.emrap.org/corependium/chapter/recD7oYdGbUJ7wZoM/Thermal-Burns#h.r6xvo0z2ic9l
9. 1.
10. Disaster Management Systems. *START/JumpSTART Triage Wallet Cards*.; 2022. Accessed April 11, 2023. https://www.triagetags.com/start-jumpstart-triage-wallet-cards
11. Dutta B. *Figure 2: Photograph Showing the Characteristic of "Lichtenberg Figure."*; 2016. Accessed April 5, 2023. https://e-ijd.org/article.asp?issn=0019-5154;year=2016;volume=61;issue=1;spage=109;epage=111;aulast=Dutta;type=3
12. Ganti A, McAnaney C. Lightning and Electrical Injuries. In: *CorePendium*. CorePendium, LLC; 2022. Accessed March 28, 2023. https://www.emrap.org/corependium/chapter/recvSOMEAyiX3hmtw/Lightning-and-Electrical-Emergencies
13. Henry S. *Advanced Trauma Life Support: Student Course Manual*. Tenth edition. American College of Surgeons; 2018.
14. Knipe H, Radswiki T. Posterior shoulder dislocation. In: *Radiopaedia.Org*. Radiopaedia.org; 2010. doi:10.53347/rID-12243
15. Murrel D, Prusak R. *Pharmacologic Mydriasis*. Accessed April 5, 2023. https://fingertips.neuro-ophthalmology.med.umich.edu/Pupil_Disorders/Pharmalogic_Mydriasis.html
16. Regan A, Hotwagner DT. Burn Fluid Management. Published online January 2023. Accessed April 5, 2023. https://www.ncbi.nlm.nih.gov/books/NBK534227/
17. Rosh Review. Question 124146. Published online August 2021. Accessed April 11, 2023. https://app.roshreview.com/subscribers/exams_questions/23340
18. Rosh Review. Question 342851. Published online August 2021. Accessed April 11, 2023. https://app.roshreview.com/subscribers/exams_questions/8236
19. Rosh Review. Question 534370. Published online August 2021. Accessed April 11, 2023. https://app.roshreview.com/subscribers/exams_questions/2950
20. Stryker Surgical. *Intra-Compartmental Pressure Monitor System*.; 2009. Accessed April 5, 2023. http://site.aaawholesalecompany.com/Files/Stryker_Pressure_Monitor_System.pdf
21. Swaminathan A, Boucher J. Blast Injuries. Accessed April 5, 2023. https://www.emrap.org/episode/emrap2019august/blastinjuries

The Local Context: Dr. Alenyo