

IN THE NAME OF GOD

بسمه تعالی

سوختگی

siamakraei

Educator

## (BURN سوختگی (به انگلیسی:

نوعی آسیب به پوست یا بافت است که بر اثر گرما، برق، مواد

شیمیایی، اصطکاک یا پرتو به وجود می‌آید. سوختگی‌هایی که تنها بر سطح پوست اثر می‌گذارند را سوختگی‌های سطحی یا سوختگی‌های درجه اول می‌نامند. سوختگی با ضخامت نسبی یا سوختگی درجه دوم هنگامی اتفاق می‌افتد که لایه‌های زیرین پوست آسیب می‌بینند. در سوختگی با ضخامت کامل یا سوختگی درجه سوم به همه لایه‌های پوست آسیب می‌رسد. در سوختگی نوع چهارم بافت‌های عمیق‌تر مانند عضلات یا استخوان آسیب می‌بینند.

# BURNS

## سوختگی

از جمله حوادث اجتناب ناپذیر است که در تمام

## جوامع

کم و بیش مشاهده میگردد

- ▶ سوختگی‌ها توسط منابع خارجی زیادی از جمله منابع گرمایی، شیمیایی، الکتریکی و تشعشعی به وجود می‌آیند. [۱۳] رایج‌ترین عوامل سوختگی در آمریکا عبارت است از: آتش یا شعله (۴۴٪)، آب گرم (۳۳٪)، وسایل داغ (۹٪)، برق (۴٪) و مواد شیمیایی (۳٪)

## ▶ گرما [ویرایش]

- ▶ در آمریکا آتش و مایعات داغ رایج‌ترین عوامل سوختگی هستند. [۱۵] سیگار ۲۵٪ و وسایل گرمایشی ۲۲٪ علل آتش‌سوزی‌های خانه که منجر به مرگ می‌شود را تشکیل می‌دهند. [۱۱] تقریباً نیمی از آسیب‌ها بر اثر اقدام به درست کردن آتش می‌باشد. [۱۱] سوختگی با آب یا بخار داغ به وسیله گازها یا مایعات داغ به وجود می‌آید و در اکثر اوقات به وسیله تماس با مایعات داغ و آب شیر داغ در دستشویی یا حمام، روغن داغ یا بخار آب اتفاق می‌افتد. [۱۷] آسیب‌های ناشی از سوختگی با آب یا بخار داغ بیشتر در کودکان زیر پنج سال رایج است. [۹] و در آمریکا و استرالیا، این گروه در حدود دو سوم سوختگی‌ها را تشکیل می‌دهند. [۱۵] تماس با اشیای داغ تقریباً علت ۲۰-۳۰٪ سوختگی‌ها در کودکان می‌باشد. [۱۵] به‌طور کلی سوختگی با آب یا بخار داغ سوختگی نوع اول یا دوم هستند، اما اگر تماس فرد زیاد باشد ممکن است سوختگی نوع سوم نیز اتفاق بیفتد. [۱۸] آتش بازی یکی از رایج‌ترین عوامل سوختگی به ویژه در ایام تعطیلات در بسیاری از کشورها می‌باشد. [۱۹] آتش بازی یک کار مخاطره‌آمیز خاص برای مردان بالغ می‌باشد. [۲۰]

## ▶ مواد شیمیایی [ویرایش]

- ▶ مواد شیمیایی از ۲ تا ۱۱٪ علت سوختگی‌ها را به خود اختصاص می‌دهند و علت ۳۰٪ مرگ‌های ناشی از سوختگی می‌باشند. [۲۱] سوختگی‌های ناشی از مواد شیمیایی می‌توانند به وسیله بیش از ۲۵۰۰۰ ماده شیمیایی به وجود آیند، [۹] که بیشتر آن‌ها باز قوی (۵۵٪) یا اسید قوی (۲۶٪) هستند. [۲۱] اکثر مرگ‌های ناشی از سوختگی شیمیایی در درجه دوم اهمیت نسبت به بلع این مواد قرار می‌گیرند. [۹] عوامل شیمیایی رایج شامل این موارد می‌شوند: اسید سولفوریک که در پاک‌کننده‌های حمام و دستشویی یافت می‌شود، سدیم هیدروکلریت که در سفیدکننده‌ها یافت می‌شود و هالوآلکان که در رنگ زدها یافت می‌شود. [۹] هیدرو فلوئوریک اسید می‌تواند باعث به وجود آمدن سوختگی‌های عمیقی شود که ممکن است تا مدتی بعد از تماس علائم بیماری را نشان ندهد. [۲۲] فرومیک اسید ممکن است باعث از کار افتادن تعداد قابل توجهی از گلوبول‌های قرمز شود. [۶]

## ▶ برق

## ▶ برق [ویرایش]

- ▶ آسیب‌ها یا سوختگی‌های الکتریکی به ولتاژ بالا (برابر یا بیشتر از ۱۰۰۰ ولت)، ولتاژ پایین (کمتر از ۱۰۰۰ ولت)، یا سوختگی حاصل از برق ترکش اتمی که در درجه دوم اهمیت نسبت به قوس الکتریکی قرار می‌گیرد دسته‌بندی می‌شوند. رایج‌ترین علل سوختگی در کودکان سوختگی به وسیله سیم‌های برق (۶۰٪) و به دنبال آن سوختگی به وسیله پریش‌های برق (۱۴٪) می‌باشند. [۱۵] صاعقه نیز می‌تواند باعث سوختگی الکتریکی شود. [۲۳] عوامل ریسک‌پذیری که منجر به برخورد صاعقه می‌شود شامل انجام فعالیت‌هایی مانند کوه‌نوردی، گلف و ورزش‌هایی که در فضای باز انجام می‌گیرد و همچنین کار کردن در فضای باز می‌شود. [۸] مرگ و میر ناشی از برخورد صاعقه در حدود ۱۰٪ می‌باشد. [۸] اگرچه آسیب‌های الکتریکی منجر به سوختگی می‌شود، اما ممکن است باعث شکست یا ناجایی و در مرحله بعد ترومای ناقص یا انقباض عضله شوند. [۸] در آسیب‌های ناشی از ولتاژ زیاد، بیشتر آسیب ممکن است داخلی باشد و به همین دلیل نمی‌توان وسعت آسیب را صرفاً به وسیله بررسی پوست برآورد کرد. [۸] ممکن است تماس با ولتاژ بالا یا ولتاژ پایین آریتمی قلب یا ایست قلبی را به همراه داشته باشد.



## ▶ تشعشع [ویرایش]

- ▶ سوختگی تشعشعی ممکن است بر اثر تماس طولانی با پرتو فرابنفش (مانند اشعه خورشید، کیوسک‌های برنزه شدن یا جوشکاری با قوس الکتریکی یا از پرتو یونی مانند پرتو درمانی، پرتو ایکس یا تابش پرتو) به وجود آید.<sup>[۲۴]</sup> تماس با نور خورشید رایج‌ترین علت سوختگی‌های تشعشعی و به‌طور کلی رایج‌ترین علت سوختگی‌های سطحی می‌باشد.<sup>[۲۵]</sup> افراد مختلف به شکل‌های مختلف و بر اساس نوع پوست خود دچار آفتاب سوختگی می‌شوند.<sup>[۲۶]</sup> اثری که پرتو یونی بر روی پوست می‌گذارد به میزان تماس با محل بستگی دارد و به دنبال آن بعد از ۳ گری ریزش مو مشاهده می‌شود، بعد از ۱۰ گری سرخی پوست، بعد از ۲۰ گری افتادن پوست‌های مرطوب و بعد از ۳۰ گری مردگی بافت مشاهده می‌شود.<sup>[۲۷]</sup> سرخی پوست، اگر اتفاق بیفتد، مدتی پس از تماس بروز می‌کند.<sup>[۲۷]</sup> سوختگی‌های تشعشعی همانند سوختگی‌های دیگر درمان می‌شوند. سوختگی‌های ریز موجی به وسیله گرمایش حرارتی حاصل از مایکروویو رخ می‌دهند.<sup>[۲۸]</sup> اگرچه تماسی به کوتاهی دو ثانیه ممکن است باعث آسیب شود، اما به‌طور کل سوختگی به وسیله مایکروویو اتفاق نادری است.<sup>[۲۸]</sup>

## ▶ عمدی



# Burn Management

# Functions

- ▶ Skin is the largest organ of the body
- ▶ Essential for:
  - Thermoregulation
  - Prevention of fluid loss by evaporation
  - Barrier against infection
  - Protection against environment provided by sensory information

# Types of burn injuries

- ▶ Thermal: direct contact with heat  
(flame, scald, contact)
- ▶ Electrical
  - A.C. – alternating current (residential)
  - D.C. – direct current (industrial/lightening)
- ▶ Chemical
- ▶ Frostbite

# Classification



- ▶ Burns are classified by depth, type and extent of injury
- ▶ Every aspect of burn treatment depends on assessment of the depth and extent

# First degree burn

- ▶ Involves only the epidermis
- ▶ Tissue will blanch with pressure
- ▶ Tissue is erythematous and often painful
- ▶ Involves minimal tissue damage
- ▶ Sunburn



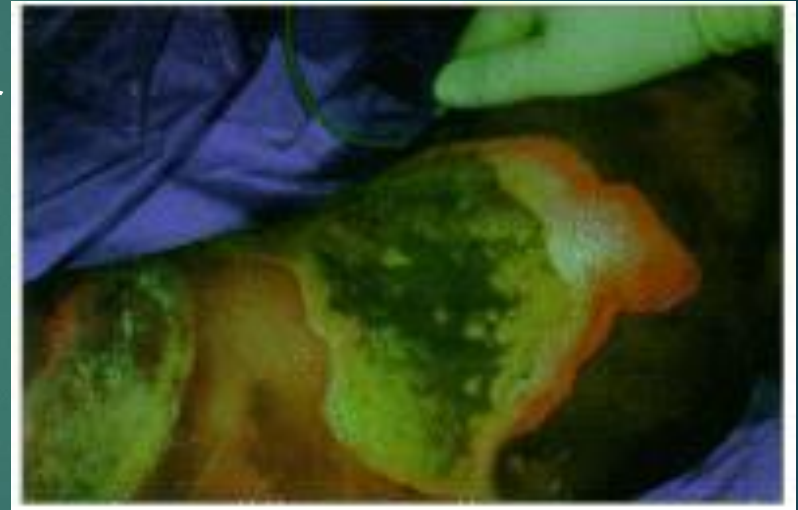
# Second degree burn

- ▶ Referred to as partial-thickness burns
- ▶ Involve the epidermis and portions of the dermis
- ▶ Often involve other structures such as sweat glands, hair follicles, etc.
- ▶ Blisters and very painful
- ▶ Edema and decreased blood flow in tissue can convert to a full-thickness burn



# Third degree burn

- ▶ Referred to as full-thickness burns
- ▶ Charred skin or translucent white color
- ▶ Coagulated vessels visible
- ▶ Area insensate – patient still c/o pain from surrounding second degree burn area
- ▶ Complete destruction of tissue and structures





# Fourth degree burn

- ▶ Involves subcutaneous tissue, tendons and bone



# Burn extent



Burn extent is calculated only on individuals with second and third degree burns

Palmar surface = 1% of the BSA

# Measurement charts

- ▶ **Rule of Nines:**

Quick estimate of percent of burn

- ▶ **Lund and Browder:**

More accurate assessment tool

Useful chart for children – takes into account the head size proportion.

- ▶ **Rule of Palms:**

Good for estimating small patches of burn wound

# Lab studies

## **Severe burns:**

- ▶ CBC
- ▶ Chemistry profile
- ▶ ABG with carboxyhemoglobin
- ▶ Coagulation profile
- ▶ U/A
- ▶ CPK and urine myoglobin (with electrical injuries)
- ▶ 12 Lead EKG

# Imaging studies

- ▶ CXR
- ▶ Plain Films / CT scan: Dependent upon history and physical findings

# Criteria for burn center admission

- ▶ Full-thickness > 5% BSA
- ▶ Partial-thickness > 10% BSA
- ▶ Any full-thickness or partial-thickness burn involving critical areas (face, hands, feet, genitals, perineum, skin over major joint)
- ▶ Children with severe burns
- ▶ Circumferential burns of thorax or extremities
- ▶ Significant chemical injury, electrical burns, lightning injury, co-existing major trauma or significant pre-existing medical conditions
- ▶ Presence of inhalation injury

# Initial patient treatment

- ▶ Stop the burning process
- ▶ Consider burn patient as a multiple trauma patient until determined otherwise
- ▶ Perform ABCDE assessment
- ▶ Avoid hypothermia!
- ▶ Remove constricting clothing and jewelry

# Details of the incident

- ▶ Cause of the burn
- ▶ Time of injury
- ▶ Place of the occurrence (closed space, presence of chemicals, noxious fumes)
- ▶ Likelihood of associated trauma (explosion,...)
- ▶ Pre-hospital interventions



# Airway considerations

- ▶ Maintain low threshold for intubation and high index of suspicion for airway injury
- ▶ Swelling is rapid and progressive first 24 hours
- ▶ Consider RSI to facilitate intubation – cautious use of succinylcholine hours after burn due to K<sup>+</sup> increase
- ▶ Prior to intubation attempt: have smaller sizes of ETT available
- ▶ Prepare for cricothyrotomy for tracheostomy
- ▶ Utilize ETCO<sub>2</sub> monitoring – pulse oximetry may be inaccurate or difficult to apply to patient.

# Airway considerations

- ▶ **Upper airway injury (above the glottis):**  
Area buffers the heat of smoke – thermal injury is usually confined to the larynx and upper trachea.
- ▶ **Lower airway/alveolar injury (below the glottis):**
  - Caused by the inhalation of steam or chemical smoke.
  - Presents as ARDS often after 24-72 hours

# Criteria for intubation

- ▶ Changes in voice
- ▶ Wheezing / labored respirations
- ▶ Excessive, continuous coughing
- ▶ Altered mental status
- ▶ Carbonaceous sputum
- ▶ Singed facial or nasal hairs
- ▶ Facial burns
- ▶ Oro-pharyngeal edema / stridor
- ▶ Assume inhalation injury in any patient confined in a fire environment
- ▶ Extensive burns of the face / neck
- ▶ Eyes swollen shut
- ▶ Burns of 50% TBSA or greater

# Pediatric intubation

- ▶ Normally have smaller airways than adults
- ▶ Small margin for error
- ▶ If intubation is required, an uncuffed ETT should be placed
- ▶ Intubation should be performed by experienced individual – failed attempts can create edema and further obstruct the airway

$$\frac{\text{AGE}}{4} + 4 = \text{ETT size}$$

# Ventilatory therapies

- ▶ Rapid Sequence Intubation
- ▶ Pain Management, Sedation and Paralysis
- ▶ PEEP
- ▶ High concentration oxygen
- ▶ Avoid barotrauma
- ▶ Hyperbaric oxygen

# Ventilatory therapies

- ▶ Burn patients with ARDS requiring

PEEP > 14 cm for adequate ventilation should receive prophylactic tube thoracostomy.

# Circumferential burns of the chest

- ▶ Eschar - burned, inflexible, necrotic tissue
- ▶ Compromises ventilatory motion
- ▶ Escharotomy may be necessary
- ▶ Performed through non-sensitive, full-thickness eschar



# Carbon Monoxide Intoxication

Carbon monoxide has a binding affinity for hemoglobin which is 210-240 times greater than that of oxygen.

Results in decreased oxygen delivery to tissues, leading to cerebral and myocardial hypoxia.

Cardiac arrhythmias are the most common fatal occurrence.



# Signs and Symptoms of Carbon Monoxide Intoxication

- ▶ Usually symptoms not present until 15% of the hemoglobin is bound to carbon monoxide rather than to oxygen.
- ▶ Early symptoms are neurological in nature due to impairment in cerebral oxygenation

# Signs and Symptoms of Carbon Monoxide Intoxication

- ▶ Confused, irritable, restless
- ▶ Headache
- ▶ Tachycardia, arrhythmias or infarction
- ▶ Vomiting / incontinence
- ▶ Dilated pupils
- ▶ Bounding pulse
- ▶ Pale or cyanotic complexion
- ▶ Seizures
- ▶ Overall cherry red color – rarely seen

# Carboxyhemoglobin Levels/Symptoms

0 – 5	Normal value
15 – 20	Headache, confusion
20 – 40	Disorientation, fatigue, nausea, visual changes
40 - 60	Hallucinations, coma, shock state, combativeness
> 60	Mortality > 50%

# Management of Carbon Monoxide Intoxication

- ▶ Remove patient from source of exposure.
- ▶ Administer 100% high flow oxygen

*Half life of Carboxyhemoglobin in patients:*

- ▶ Breathing room air      120-200 minutes
- ▶ Breathing 100% O<sub>2</sub>      30 minutes

# Circulation considerations

- ▶ Formation of edema is the greatest initial volume loss
- ▶ Burns 30% or <  
Edema is limited to the burned region
- ▶ Burns >30%  
Edema develops in all body tissues, including non-burned areas.

# Circulation considerations

- ▶ Capillary permeability increased
- ▶ Protein molecules are now able to cross the membrane
- ▶ Reduced intravascular volume
- ▶ Loss of  $\text{Na}^+$  into burn tissue increases osmotic pressure → this continues to draw the fluid from the vasculature leading to further edema formation

# Circulation considerations



- ▶ Loss of plasma volume is greatest during the first 4 – 6 hours, decreasing substantially in 8 –24 hours if adequate perfusion is maintained.

# Impaired peripheral perfusion

- ▶ May be caused by mechanical compression, vasospasm or destruction of vessels
- ▶ Escharotomy indicated when muscle compartment pressures  $> 30$  mmHg
- ▶ Compartment pressures best obtained via ultrasound to avoid potential risk of microbial seeding by using slit or wick catheter



# Fluid resuscitation

- ▶ **Goal:** Maintain perfusion to vital organs
- ▶ Based on the TBSA, body weight and whether patient is adult/child
- ▶ Fluid overload should be avoided – difficult to retrieve settled fluid in tissues and may facilitate organ hypoperfusion

# Fluid resuscitation

- ▶ Lactated Ringers - preferred solution
- ▶ Contains  $\text{Na}^+$  - restoration of  $\text{Na}^+$  loss is essential
- ▶ Free of glucose – high levels of circulating stress hormones may cause glucose intolerance

# Fluid resuscitation

- ▶ Burned patients have large insensible fluid losses
- ▶ Fluid volumes may increase in patients with co-existing trauma
- ▶ Vascular access: Two large bore peripheral lines (if possible) or central line.

# Fluid resuscitation

- ▶ Fluid requirement calculations for infusion rates are based on the *time from injury*, not from the time fluid resuscitation is initiated.

# Assessing adequacy of resuscitation

- ▶ **Peripheral blood pressure:** may be difficult to obtain – often misleading
- ▶ **Urine Output:** Best indicator unless ARF occurs
- ▶ **A-line:** May be inaccurate due to vasospasm
- ▶ **CVP:** Better indicator of fluid status
- ▶ **Heart rate:** Valuable in early post burn period – should be around 120/min.
- ▶ > HR indicates need for > fluids or pain control
- ▶ **Invasive cardiac monitoring:** Indicated in a minority of patients (elderly or pre-existing cardiac disease)

# Parkland Formula

- ▶  $4 \text{ cc R/L} \times \% \text{ burn} \times \text{body wt. In kg.}$
- ▶ ARF may result from myoglobinuria
- ▶  $\frac{1}{2}$  of calculated fluid is administered in the first 8 hours
- ▶ Increased fluid volume, mannitol bolus and  $\text{NaHCO}_3$  into each liter of LR to alkalinize the urine may be indicated
- ▶ Balance is given over the remaining 16 hours.
- ▶ Maintain urine output at  $0.5 \text{ cc/kg/hr.}$

# Galveston Formula

- ▶ Used for pediatric patients
- ▶ Based on body surface area rather than weight
- ▶ More time consuming
- ▶ L/R is used at  $5000\text{cc}/\text{m}^2 \times \% \text{BSA}$  burn plus  $2000\text{cc}/\text{M}^2/24$  hours maintenance.
- ▶  $\frac{1}{2}$  of total fluid is given in the first 8 hrs and balance over 16 hrs.
- ▶ Urine output in pediatric patients should be maintained at  $1\text{cc}/\text{kg}/\text{hr}$ .

# Effects of hypothermia

- ▶ Hypothermia may lead to acidosis/coagulopathy
- ▶ Hypothermia causes peripheral vasoconstriction and impairs oxygen delivery to the tissues
- ▶ Metabolism changes from aerobic to anaerobic

serum lactate 

serum pH 



# Prevention of hypothermia

- ▶ Cover patients with a dry sheet – keep head covered
- ▶ Pre-warm trauma room
- ▶ Administer warmed IV solutions
- ▶ Avoid application of saline-soaked dressings
- ▶ Avoid prolonged irrigation
- ▶ Remove wet / bloody clothing and sheets
- ▶ Paralytics – unable to shiver and generate heat
- ▶ Avoid application of antimicrobial creams
- ▶ Continual monitoring of core temperature via foley or SCG temperature probe

# Pain management

**Adequate analgesia imperative!**

**DOC: Morphine Sulfate**

Dose: Adults: 0.1 – 0.2 mg/kg IVP

Children: 0.1 – 0.2 mg/kg/dose IVP  
/ IO

Other pain medications commonly  
used:

- ▶ Demerol
- ▶ Vicodin ES
- ▶ NSAIDs

# GI considerations

- ▶ Burns > 25% TBSA subject to GI complications secondary to hypovolemia and endocrine responses to injury
- ▶ NGT insertion to reduce potential for aspiration and paralytic ileus.
- ▶ Early administration of H2 histamine receptor recommended

# Antibiotics

- ▶ Prophylactic antibiotics are not indicated in the early postburn period.



# Other considerations

- ▶ Check tetanus status – administer Td as appropriate
- ▶ Debride and treat open blisters or blisters located in areas that are likely to rupture
- ▶ Debridement of intact blisters is controversial

**The most important function of the skin is to act as a barrier against infection. The skin prevents loss of body fluids, thus preventing dehydration. The skin also regulates the body temperature by controlling the amount of evaporation of fluids from the sweat glands. The skin serves a cosmetic effect by giving the body shape.**

**When the skin is burned, these functions are impaired or lost completely. The severity of the skin injury depends upon the size of the injury, depth of the wound, part of the body injured, age of the patient, and past medical history. Because of the importance of the skin, it becomes clear that injury can be traumatic and life threatening. Recovery from burn injury involves four major aspects: burn wound management, physical therapy, nutrition, and emotional support.**

# Treatment

1. Treatment should begin immediately to cool the area of the burn. This will help alleviate pain.
2. For deep partial-thickness burns or full-thickness burns, begin immediate plans to transport the victim to competent medical care. For any burn involving the face, hands, feet, or completely around an extremity, or deep burns; immediate medical care should be sought. Not all burns require immediate physician care but should be evaluated within 3-5 days.
3. Remove any hot or burned clothing.

# Treatment

4. Use cool (54 degree F.) saline solution to cool the area for 15-30 minutes. Avoid ice or freezing the injured tissue. Be certain to maintain the victim's body temperature while treating the burn.
5. Wash the area thoroughly with plain soap and water. Dry the area with a clean towel. Ruptured blisters should be removed, but the management of clean, intact blisters is controversial. You should not attempt to manage blisters but should seek competent medical help.
6. If immediate medical care is unavailable or unnecessary, antibiotic ointment may be applied after thorough cleaning and before the clean gauze dressing is applied.



# Special considerations

**Scalding**-typically result from hot water, grease, oil or tar. Immersion scalds tend to be worse than spills, because the contact with the hot solution is longer. They tend to be deep and severe and should be evaluated by a physician. Cooking oil or tar (especially from the “mother pot”) tends to be full-thickness requiring prolonged medical care.

- a. Remove the person from the heat source.
- b. Remove any wet clothing which is retaining heat.
- c. With tar burns, after cooling, the tar should be removed by repeated applications of petroleum ointment and dressing every 2 hours.

# Special considerations

## Flame

- a. Remove the person from the source of the heat.
- b. If clothes are burning, make the person lie down to keep smoke away from their face.
- c. Use water, blanket or roll the person on the ground to smother the flames.
- d. Once the burning has stopped, remove the clothing.
- e. Manage the persons airway, as anyone with a flame burn should be considered to have an inhalation injury.

# Special considerations

**Electrical burns**: are thermal injuries resulting from high intensity heat. The skin injury area may appear small, but the underlying tissue damage may be extensive. Additionally, there may be brain or heart damage or musculoskeletal injuries associated with the electrical injuries.

- a. Safely remove the person from the source of the electricity. Do not become a victim.

# Special considerations

- b. Check their Airway, Breathing and Circulation and if necessary begin CPR using an AED (Automatic External Defibrillator) if available and EMS is not present. If the victim is breathing, place them on their side to prevent airway obstruction.
- c. Due to the possibility of vertebrae injury secondary to intense muscle contraction, you should use spinal injury precautions during resuscitation.
- d. Elevate legs to 45 degrees if possible.
- e. Keep the victim warm until EMS arrives.

# Special considerations

**Chemical burns-** Most often caused by strong acids or alkalis. Unlike thermal burns, they can cause progressive injury until the agent is inactivated.

- a. Flush the injured area with a copious amount of water while at the scene of the incident. Don't delay or waste time looking for or using a neutralizing agent. These may in fact worsen the injury by producing heat or causing direct injury themselves.

# Pathophysiology: Summary

- ▶ Increased capillary leak, with protein and intravascular volume loss
- ▶ Hypermetabolic response, similar to SIRS
  - ▶ loss of lean body mass, protein catabolism
- ▶ Cardiac output decreased initially, then normalizes
  - ▶ depressed contractility/increased SVR/afterload
  - ▶ anticipate, identify, & treat low ionized calcium

# Pathophysiology: Summary

- ▶ Usual indices (BP, CVP) of volume status unreliable in burn patients; urine output best surrogate marker of volume resuscitation
  - ▶ ADH secretion may be confounding variable
- ▶ ARF rare unless prolonged hypotension
  - ▶ exception: soft tissue injury with pigmenturia
  - ▶ kaliuresis may require brisk K<sup>+</sup> replacement
  - ▶ hypertension (with encephalopathy) may occur

# Pathophysiology: Summary

- ▶ Pulmonary dysfunction results from multiple etiologies
  - ▶ shock, aspiration, trauma, thoracic restriction
  - ▶ inhalation injury; increases mortality 35-60%
  - ▶ diffuse capillary leak reflected at alveolar level
- ▶ CNS dysfunction may result from hypovolemia/hypoperfusion, hypoxia, or CO exposure



# Pathophysiology: Summary

- ▶ High risk of gastric “stress” ulceration
- ▶ Increased gut permeability, with increased potential for bacterial translocation
  - ▶ protective role of early enteral feeding
- ▶ Gut dysmotility due to drugs, or disuse
- ▶ Early, mild hepatic dysfunction common; late or severe dysfunction heralds increased morbidity

# Pathophysiology: Summary

- ▶ Anemia is common
  - ▶ initially due to increased hemolytic tendency
  - ▶ later due to depressed erythropoietin levels, and ongoing acute phase iron sequestration
  - ▶ may be exacerbated by occult bleeding, or iatrogenicity related to fluid management
- ▶ Thrombocytopenia early; thrombocytosis then supervenes as acute phase response

# Pathophysiology: Summary

- ▶ Immunologic dysfunction is pleiotropic
  - ▶ normal barrier, immune functions of skin lost
  - ▶ immunoglobulin levels depressed, B-cell response to new antigens blunted
  - ▶ complement components activated, consumed
  - ▶ normal T4/T8 ratios inverted
  - ▶ impaired phagocyte function
  - ▶ “immunologic dissonance”

# Initial Management: ABCDEs

- ▶ Airway
- ▶ Breathing
- ▶ Circulation
- ▶ Depth of Burn
- ▶ Extent of Injury(s)
  
- ▶ Pediatric (special) issues

# Initial Airway Management

- ▶ Evaluate, and ensure airway patency
- ▶ Determine the need for an artificial airway
  - ▶ intact airway reflexes?
  - ▶ risk factors for airway burns/edema?
    - ▶ Perioral burns, carbonaceous sputum subjective dysphagia, hoarseness or changes in phonation
  - ▶ erythema to edema transition may be rapid
- ▶ Ensure adequate air exchange, thoracic excursion with tidal breaths

# Breathing

## Assessment/Support

- ▶ Ensure adequate oxygenation
  - ▶ ABG with carboxyhemoglobin level preferred
  - ▶ humidified 100% FiO<sub>2</sub> empirically
- ▶ Assess for possible inhalation injury
  - ▶ history of an enclosed space, carbonaceous sputum, respiratory symptoms, altered LOC
  - ▶ younger children at greater risk
- ▶ NMB for intubation: avoid succinylcholine

# Breathing

## Assessment/Support

- ▶ NG tube placement
  - ▶ thoracic decompression; reduce aspiration risk
- ▶ Ventilatory support recommended for circulatory insufficiency, or GCS<8
  - ▶ decreased airway protective reflexes
  - ▶ risk of inhalation injury/CO exposure
  - ▶ risk of concomitant injury/trauma requiring evaluation/support

# Initial Management: Circulatory

- ▶ Assess capillary refill, pulses, hydration
- ▶ Evaluate sensorium
- ▶ Place foley to assess urine output
- ▶ Achieve hemostasis at sites of bleeding
- ▶ Venous access, depending upon BSA involvement; avoid burn sites if possible
- ▶ Begin empiric volume resuscitation



# Initial Depth Assessment

- ▶ Assess depth of injuries:
  - ▶ First degree burn
    - ▶ restricted to superficial epithelium
    - ▶ pain, erythema, blistering
    - ▶ treatment rarely required (IV hydration)
  - ▶ Second degree (partial thickness, dermal) burn
    - ▶ through epidermis into a variable portion of dermis
    - ▶ infection, malnutrition, hypoperfusion may cause conversion to full thickness (3rd degree) burn

# Degree of Burn Wound Depth

- ▶ Refer to handouts:
  - ▶ figure 2 in outline
  - ▶ back of last page, power point transcript

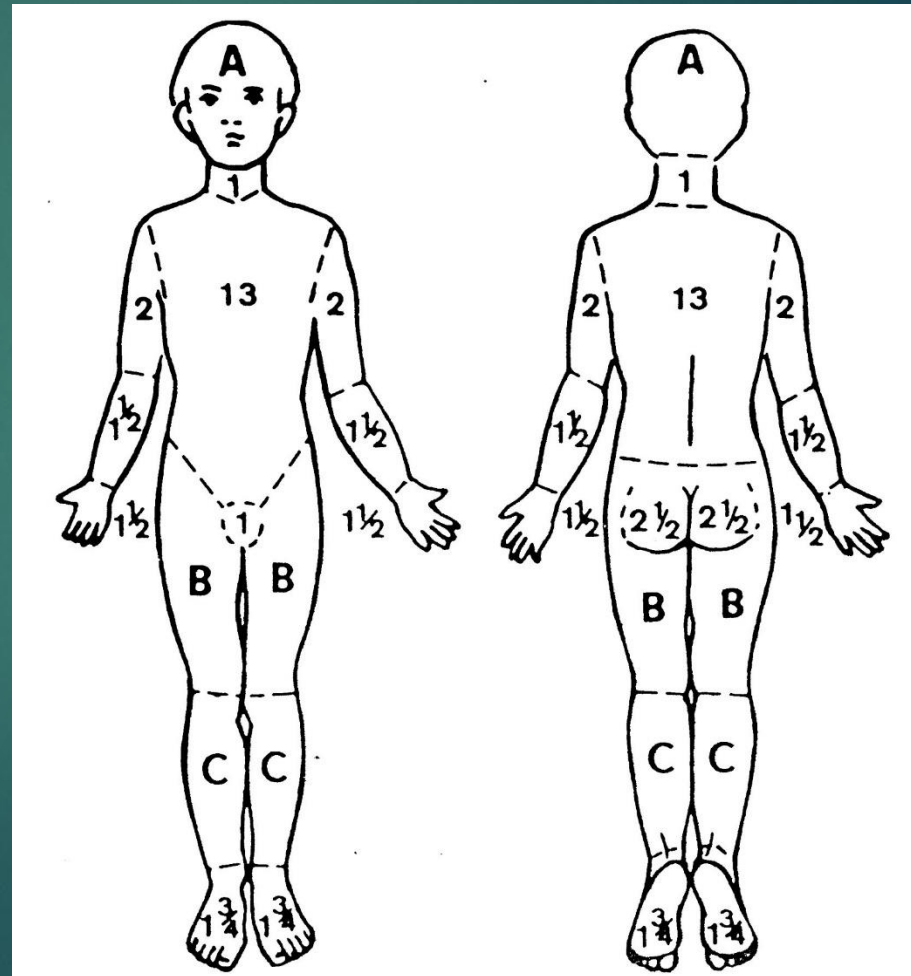
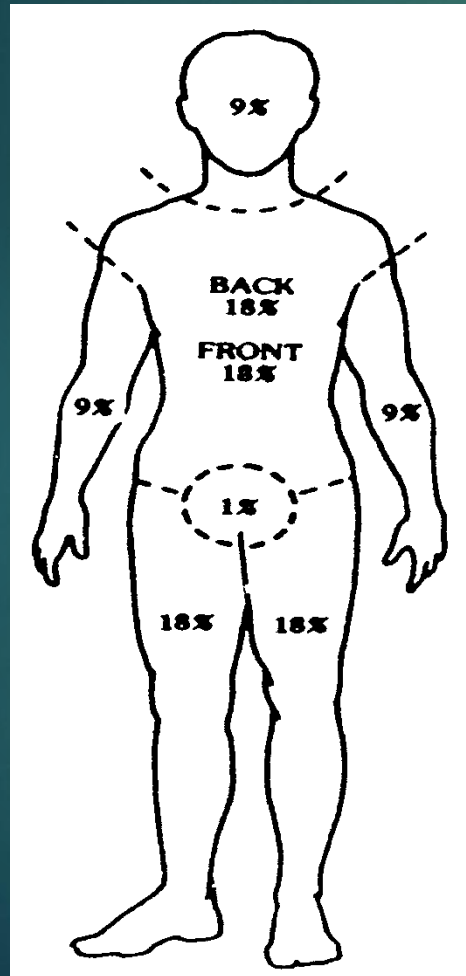
# Initial Depth Assessment

- ▶ Assess depth of injuries:
  - ▶ Third degree (full thickness)
    - ▶ full thickness injury extending through all layers into subcutaneous fat
    - ▶ typically requires some degree of surgical closure
  - ▶ Fourth degree
    - ▶ third degree with extension into bone/joint/muscle
- ▶ Note circumferential burns, compartment syndrome risk; consider escharotomy need

# Initial Management: Extent

- ▶ Expressed as percentage of total BSA
  - ▶ Only 2<sup>nd</sup> & 3<sup>rd</sup> degree burns mapped
- ▶ Once adult proportions attained (~15 yo), “rule of nines” may be used
- ▶ For children less than 15 years of age, age adjusted proportions must be used
  - ▶ fluid replacement is based upon BSA estimates
- ▶ Must rule out concomitant other injuries

# BSA estimation: “Rule of 9s”



# Management: Pediatric Issues

- ▶ Hypothermia
  - ▶ increased insensible fluid loss from burn
- ▶ Hypoglycemia
  - ▶ stress response; smaller glycogen stores
- ▶ Vaccination
  - ▶ adequate tetanus prophylaxis mandatory
- ▶ If injury pattern not consistent with history, consider possibility of child abuse

# Burn Injury Classification:

## Minor Burns

- ▶ Total involved BSA < 5%
- ▶ No significant involvement of hands, feet, face, perineum
- ▶ No full thickness component
- ▶ No other complications
- ▶ May typically be treated as outpatients

# Burn Injury Classification:

## Moderate Burns

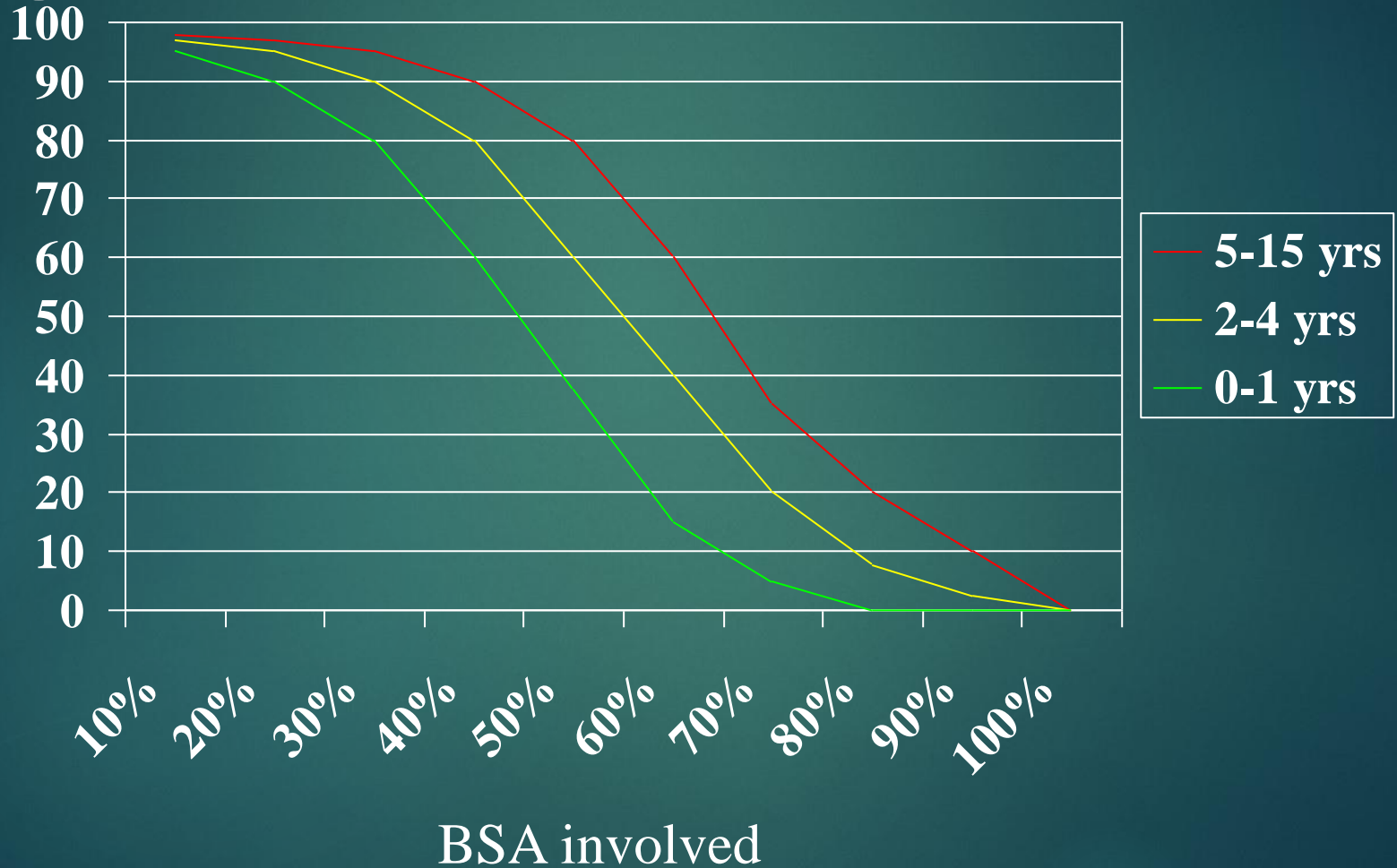
- ▶ Involvement of 5-15% BSA, OR any full thickness component
- ▶ Involvement of hands, feet, face, or perineum
- ▶ Any complicating features (e.g., electrical or chemical injury)
- ▶ Should be admitted to the hospital



# Burn Injury Classification: Severe Burns

- ▶ Total burn size >15% BSA
- ▶ Full thickness component >5% BSA
- ▶ Hypovolemia requiring central venous access for resuscitation
- ▶ Presence of smoke inhalation or CO poisoning
- ▶ Should be admitted to an ICU

# Survival Data: BSA and age



Airway compromise?  
Respiratory distress?  
Circulatory compromise?

Yes

No

Intubation, 100% O<sub>2</sub>  
IV access, fluids

Multiple trauma?

Yes

No

Evaluate &  
treat injuries

Burns >15%, or  
complicated burns?

No

Yes

Circumferential full  
thickness burns?

IV access; fluid  
replacement

Yes

No

Escharotomy

Burn care, tetanus prophylaxis, analgesia

# Burn Injury: Fluid Resuscitation

- ▶ Oral/enteral fluid replacement an option in unextensive, uncomplicated burns
- ▶ Multiple formulas/approaches available
  - ▶ Baxter/Parkland formula, Carvajal formula, Muir Barclay formula, University of Wisconsin formula
- ▶ In the field/pre-transfer, reasonable to begin IV fluids (LR), at 20cc/kg/hour (for 1-2 hrs)

# Burn Injury: Fluid Resuscitation

- ▶ HMC approach: modified Parkland formula
  - ▶ Deficit:  $(3 \text{ cc/kg}) \times (\text{wt in kg}) \times (\% \text{ BSA})$  as LR
    - ▶ 50% over 1st 8 hours, 50% over ensuing 16 hours
    - ▶ Subtract documented fluids given en route or in ER
  - ▶ Maintenance:  $D_5.25NS$ , customarily calculated
- ▶ Overaggressive volume resuscitation may result in iatrogenic complication
  - ▶ pulmonary edema, compartment syndrome

# Fluid Resuscitation

## Reminders:

- ▶ Titrate IV fluids to achieve desired rehydration,  
quantified mainly by urine output
  - ▶ mucous membranes, skin turgor, fontanelle, tears,  
pulse rate, sensorium, capillary refill
- ▶ Kaliuresis can be profound; IV replacement may  
be required
- ▶ Increased ADH release (pain/anxiety) may  
confuse picture

# Burn Injury: Nutritional Support

- ▶ Essential for wound healing, graft survival; prevents “at risk” partial thickness injury from converting to full thickness injury
- ▶ Enteral feeds preferred over TPN
  - ▶ may prevent gut→bacterial translocation
  - ▶ early (within 4 hours) institution of enteral feeds may achieve early positive N<sub>2</sub> balance
  - ▶ may be precluded by paralytic ileus

# Burn Injury: Nutritional Support

- ▶ Hypermetabolic state favors breakdown/use of fat and protein; rate of loss of lean body mass can be slowed by approximating positive nitrogen balance; high protein content of enteral formula therefore favored
- ▶ Enteral formulas should be lactose free, and less than 400 mOsm/L
- ▶ Multiple formulas for caloric requirements



# Burn Injury: Nutritional Support

- ▶ Curreri Formula:
  - ▶  $\text{calories/day} = (\text{wt in kg}) (25) + (40) (\% \text{BSA})$
  - ▶ needs periodic recalculation as healing occurs
  - ▶ probably overestimates caloric needs
- ▶ Weight loss of more than 1% of baseline wt per day should not be tolerated for more than ~5 days before progressing to the next level of nutritional support

# Burn Injury: Wound Management

- ▶ Escharotomy/fasciotomy may be necessary within hours
  - ▶ neurovascular compression; chest wall motion
- ▶ Surgery for wound closure is necessary for full thickness injury, or areas of deep partial thickness that would heal with delay or scar
- ▶ In life threatening burns, urgency to graft before substantial colonization occurs

# Burn Injury: Wound Management

- ▶ Integra
  - ▶ inert material mimicking the structure of dermis
  - ▶ collagen strands provide ordered matrix for fibroblast infiltration/native collagen deposition
  - ▶ allows harvesting of thin epidermal layer for graft, with more rapid healing at donor sites
- ▶ Appropriate tetanus prophylaxis mandatory
- ▶ Consider relative risk of DVT, prophylaxis

# Burn Injury: Pain Management

- ▶ Treatment, dosing titrated to achieve effect
- ▶ IV morphine remains the gold standard
  - ▶ tolerance may occur if therapy is prolonged
  - ▶ discontinuation of opiates should be anticipated and tapered as wound healing occurs
- ▶ Use opiates cautiously in infants who are not mechanically ventilated
- ▶ Consider role of anxiolytics

# Burn Injury: Pain Management

- ▶ PCA may be an option in older patients
- ▶ Ketamine may be useful during procedures
  - ▶ profound analgesia, respiratory reflexes intact
  - ▶ HTN, emergence delirium, hallucinations
    - ▶ midazolam 0.1 mg/kg to reduce ketamine “edge”
- ▶ Propofol, other modalities
- ▶ Do not overlook analgesia/sedative needs of patients receiving neuromuscular blockade

# Burn Injury: Topical Antibiosis

- ▶ Colonization via airborne &/or endogenous gram+ flora within the 1st week is the rule; subsequent colonization tends to be gram-
- ▶ Complications of topical agents
  - ▶ hyponatremia, hyperosmolarity, metabolic acidosis, methemoglobinemia
- ▶ Silvadene resistance universal for *E. cloacae*
  - ▶ *S. aureus* common, *Pseudomonas* occasional

# Burn Injury: Infection

- ▶ Types of infections in burn patients
  - ▶ burn wound invasion/sepsis, cellulitis, pneumonia, suppurative thrombophlebitis, miscellaneous nosocomial infections
- ▶ Organisms causing burn wound invasion
  - ▶ pseudomonas-45%, mycotic 19%
  - ▶ other gram negatives-16%, mixed bacterial-8%
  - ▶ mixed bacterial/mycotic-10%, Staph-1-3%

# Burn Injury: Wound Sepsis

- ▶ Characterized by gray or dark appearance, purulent discharge, systemic signs of sepsis
- ▶ If true burn wound sepsis, wound culture should yield  $>10^5$  organisms/gram of tissue
- ▶ Gram negative bacteremia/sepsis
  - ▶ think wound, lungs
- ▶ Gram positive bacteremia/sepsis
  - ▶ think indwelling lines, wound



# Burn Injury: Prevention

- ▶ Pre-emptive counseling of families essential
- ▶ ↓ water heater temperature from 54°C to 49°C (130→120°F) ↑es time for full thick-ness scald from <30 seconds to 10 minutes
- ▶ Cigarette misuse responsible for >30% of house fires
- ▶ Smoke detector installation/maintenance

# Burn Injury: Prevention

- ▶ Burn prevention has far greater impact on public health than refinements in burn care
- ▶ Burn risks related to age:
  - ▶ infancy: bathing related scalds; child abuse
  - ▶ toddlers: hot liquid spills
  - ▶ school age children: flame injury from matches
  - ▶ teenagers: volatile agents, electricity, cigarettes
  - ▶ introduction of flame retardant pajamas

# Burn Injury: Summary

- ▶ Many risk factors age dependent
- ▶ Pediatricians primary role: prevention
- ▶ High risk of multiple organ system effects, prolonged hospitalization
- ▶ Initial care: ABCs, then surgical issues
  - ▶ special attention to airway, hemodynamics
- ▶ Chronic care issues: scarring, lean mass loss