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# Burn Injuries

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# Burns

## Lecture Outline

- Scene considerations & ABC aspects
- Smoke inhalation injury
- Carbon monoxide poisoning
- Estimating extent & depth of the burn
- Fluid resuscitation
- Severity categorization
- Outpatient burn care
- Followup & prevention



# Burns : Incidence

- 2,000,000 per year in U.S.
- Over 100,000 hospitalizations per year
- ? 8,000 to 10,000 deaths annually
- Lesser incidence in Europe due to better enforcement of fire codes & less arson

# Burns : Etiology

- Stupidity is the major factor
- Therefore, at least 75 % are preventable
- Usual type distribution :
  - Flame : 75 %
  - Scald : 15 %
  - Chemical : 5 %
  - Electrical : 3 to 5 %
  - Radiation : < 1 %

## Inflicted scald burn







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Source Undetermined

**Chemical burns from wet concrete**





**Another example  
of a chemical burn**



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Source Undetermined

# Residential Fires : Etiology

- Smoking : 19 %
- Heating : 14 %
- Incendiary : 16 %
- Electrical : 12 %
- Cooking : 7 %
- Appliances : 4 %
- Children playing : 4 %
- Spark : 4 %
- Flammable liquids : 1 %
- Unknown or misc. : 19 %

# **Physiologic Functions of Skin Disrupted By Burns**

- **Barrier to microorganisms**
- **Temperature regulation**
- **Fluid retention**
- **Sensory**
- **Cosmesis**

# Burns : Suspect Associated Injuries

- Explosion
- Falls
- Motor vehicle crash with fire
- High voltage electrical

Note : Treat the associated injuries first : *Do not focus on just the burn !*



# Suspect Associated Injuries

- The burn patient initially should be treated as a trauma patient (not a dermatology patient)
- A major burn causes multi-organ dysfunction and is not just a skin injury ; these patients can be the most sick & complex you may ever care for

# Burns : History

- Type of burn (flame, chemical, electrical, flash)
- Substances involved
- Associated trauma
- If in closed space
- Time of injury
- Duration of contact with smoke
- "AMPLE"
  - Allergies
  - Medications
  - Prior illnesses
  - Last meal (time)
  - Events preceding the injury

# Burns : Primary Scene Care

- Most important : *Do not become a victim yourself !*
- Turn off gas / pump / electric power, etc. if possible
- Remove patient from heat source (push with dry nonconductive material if in contact with electricity)
- Immediately move patient from vicinity if danger of explosion
- Keep low to avoid smoke ; use protective breathing apparatus if available
- Put fire out ; extinguish burning clothing (H<sub>2</sub>O or CO<sub>2</sub> extinguisher)

# Burns : Secondary Scene Care

- Position airway ; start O2 and / or CPR if needed
- Get off all potentially affected clothing
- Soak clothing or burn area if heat transfer still possible ; continue to copiously irrigate if chemical burn
- Ventilate area if smoke present
- Arrange transport
- Immobilize neck & back, etc., if needed

# Burns : Physical Exam

- ABC's same as for any other trauma patient
- Burn wound extent
- Burn wound depth
- Do not debride or dress burns until exam complete
- Get patient's weight

# Burns : Airway Management

- If early respiratory distress despite O2 : consider endotracheal intubation quickly
- 100 % O2 for everybody initially
- Place nasal airway early for deep facial burn (will hold open nose against edema swelling)
- Airway evaluation steps same as for other trauma patients (remember C-spine precautions and immobilization)

# Burns : Smoke Inhalation Injury

- 80 % of fire deaths
- Main problems :
  - Carbon monoxide poisoning
  - Chemical tracheobronchitis (true smoke inhalation injury)
  - Asphyxia (air O<sub>2</sub> content may go to only 5 % in a flash fire ; one cannot maintain consciousness at O<sub>2</sub> content of only 5 %)

# Smoke Inhalation Injury

- A chemical tracheobronchitis
- Not due to direct heat transfer (except for live steam and impacting hot particles)
- Incidence : 15 to 33 % of serious burns
- Survival > 90 % if no associated burn
- Doubles the mortality that would be calculated based on burn size area
- Is a major contributor to mortality in the elderly



# Toxic Gases in Smoke

- Carbon monoxide
- Acrolein (10 ppm causes pulmonary edema)
- Hydrochloric acid
- Ammonia
- Chlorine
- Aldehydes
- Sulfur & nitrogen oxides
- Hydrocyanic acid
- Phosgene

# **Smoke Inhalation Injury : Pathophysiology**

- **Mucosal edema**
- **Mucus and ash plugs**
- **Loss of surfactant**
- **Bronchospasm**
- **Pulmonary capillary leakage**
- **Mucosal cilia paralysis**
- **May progress to mucosal slough**
- **Predisposes to bacterial pneumonia**

# Smoke Inhalation Injury

- **Suspect from history if :**
  - Burns from explosions
  - Burns indoors or in "closed space"
  - Clothing fires
  - Unconscious after the burn

# **Smoke Inhalation Injury :**

## **Symptoms**

- **Hoarseness, sore throat**
- **Cough**
- **Dyspnea**
- **Hyperventilation**

# **Smoke Inhalation Injury :**

## **Physical Signs**

- Burns of the face, mouth , or anterior neck
- Singed nasal hairs or mustache
- Carbon deposits on lips, nose, oropharynx
- Carbonaceous sputum
- Rales, rhonchi or wheezes
- Stridor



**A patient  
obviously at  
risk for smoke  
inhalation  
injury**

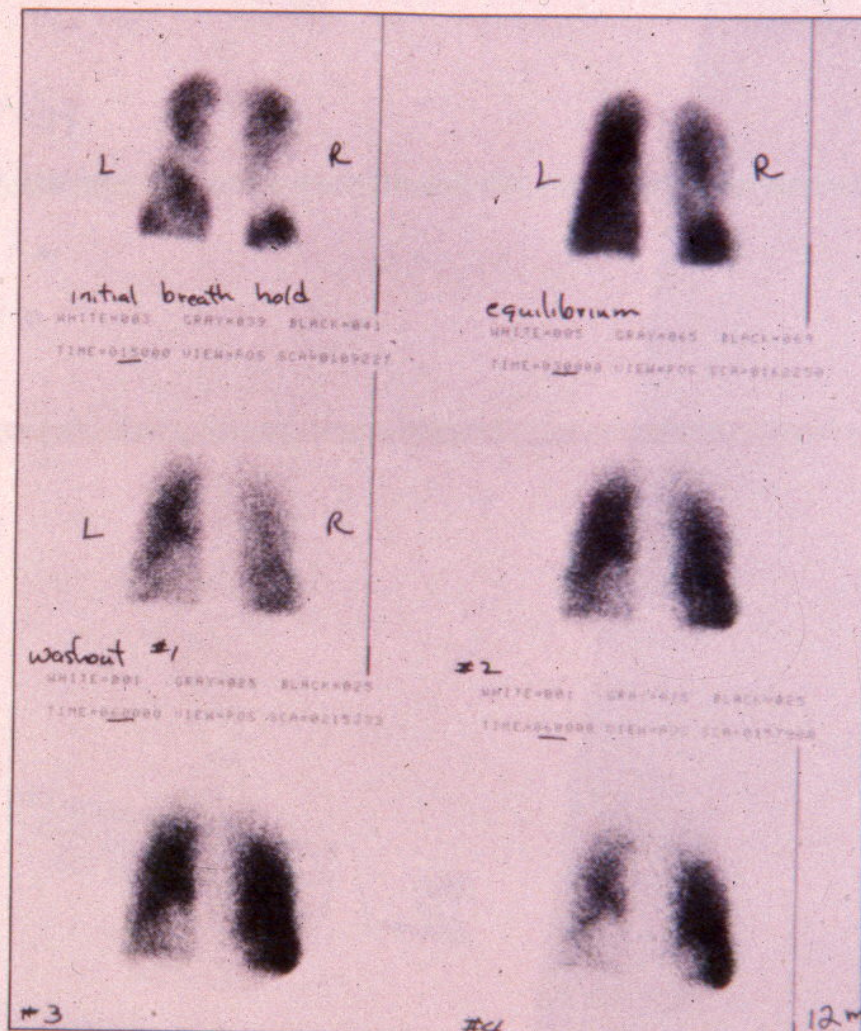
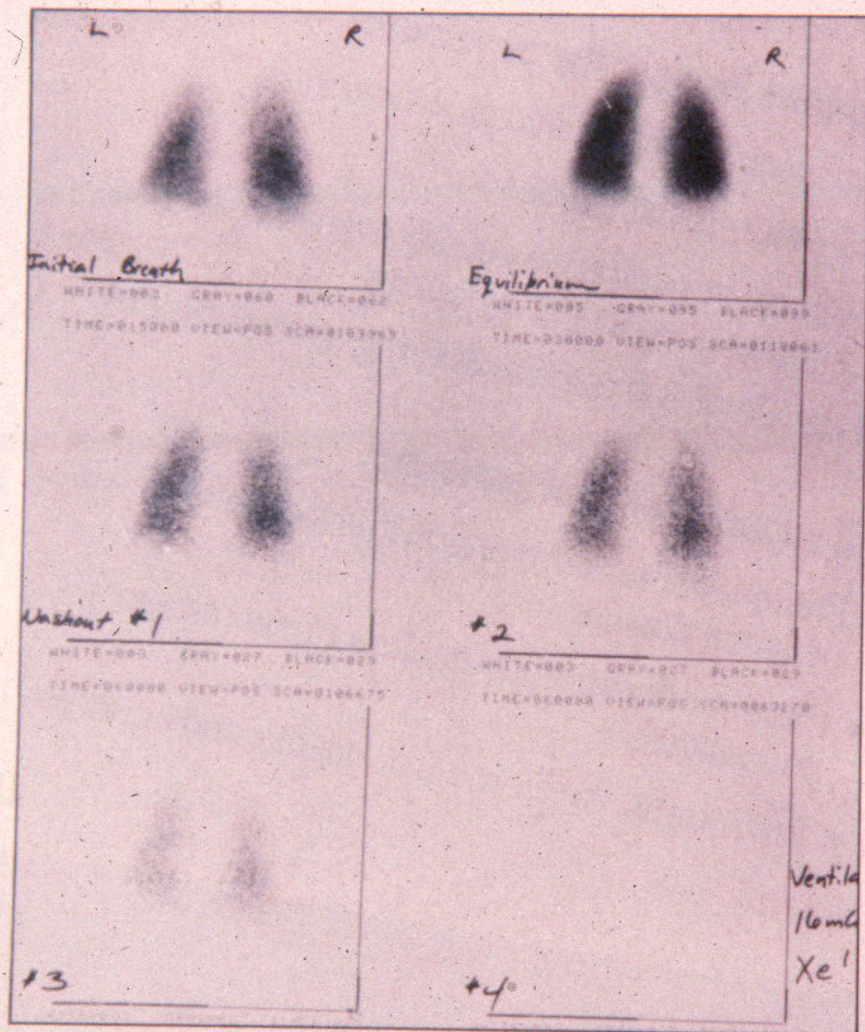
# **Smoke Inhalation Injury :**

## **Other Studies**

- **ABG's : often normal, but may show resp. alkalosis**
  - **If hypoxemia or hypercapnia, consider early intubation**
- **CXR : often normal**
  - **May show fluffy infiltrates at 24 hrs.**
- **PFT's : (not necessary to obtain on most cases)**  
**decreased FRC, decreased compliance, increased shunt**
- **Sputum exam : sloughed cells and carbon deposits**
- **Bronchoscopy : very accurate but invasive**
- **Xenon 133 ventilation scan : if radionuclide retention > 90 seconds : indicates abnormal ; very accurate**



# The xenon washout scan





# **Smoke Inhalation Injury :**

## **Criteria for Extubation**

- **When eyelid edema resolved (usually at 2 to 4 days postburn)**
- **No profuse bronchial secretions**
- **No respiratory failure by ABG's**

# Smoke Inhalation Injury :

## Treatment

- Moist O2
- Pulmonary toilet (incentive spirometry, suction, chest physical therapy & postural drainage)
- Intubation : oral or nasal, if upper airway edema or respiratory failure
- Mechanical ventilation ; may need PEEP if severe respiratory failure
- Bronchodilators : useful only for wheezing if present
- Antibiotics : not useful prophylactically
- Steroids or tracheostomy : NO ! (*increase mortality*)

# Burns : Carbon Monoxide Poisoning

- Probably commonest cause of death from fires
- Interferes with O<sub>2</sub> delivery by binding reversibly to hemoglobin and by leftward shifting of O<sub>2</sub> dissociation curve
- Also restricts cellular respiration by binding to cytochromes
- Should measure directly the carboxyhemoglobin level on all flame burn patients (venous is just as accurate or useful as arterial)

# Carboxyhemoglobin Level : Half-life

- Room air : 4 hours
- 100 % O<sub>2</sub> : 40 minutes
- 2 atmospheres pressure hyperbaric O<sub>2</sub> : 25 minutes

Should always “back-calculate” the carboxyhemoglobin level to what the level was at the time of injury in determining treatment (each 40 minute period the patient has been on oxygen counts as one half life)

# Carbon Monoxide Poisoning

- If patient requires resuscitative care for burns or other injuries, DO NOT send to non-walk-in hyperbaric chamber
- Large walk-in chamber required so resuscitation can continue during hyperbaric treatment
- Efficacy of hyperbaric Rx has never actually been proven in a randomized trial against face mask O2 given for an extended period

# Carboxyhemoglobin Levels and Usual Symptoms

- **< 10 % : Usually asymptomatic (same as smoker's)**
- **10 to 20 % : Headache, nausea, irritability, dyspnea**
- **20 to 40 % : Arrhythmias, CNS depression, vomiting**
- **40 to 50 % : Seizures, coma, cardiovascular collapse**
- **> 60 % : Often fatal (but certainly can have neurologically intact survival)**

# Treatment of Elevated Carboxyhemoglobin Levels

- < 10 % : 100 % O<sub>2</sub> for one hour or until symptoms (cough, headache, etc.) resolve
- 10 to 20 % : 100 % O<sub>2</sub> until symptoms resolve (usually 2 hours)
- 20 to 40 % : 100 % O<sub>2</sub> ; recheck levels ; consider hyperbaric O<sub>2</sub>
- > 40 % : 100 % O<sub>2</sub> ; most should probably get hyperbaric O<sub>2</sub>\* (?)

If pregnant or any neuro symptoms, should get hyperbaric treatment regardless of level\* (?)

\*There is debate about these indications ; some say just use prolonged facemask O<sub>2</sub>

# **Carbon Monoxide Poisoning : Complications**

- **Cerebral edema**
- **Cerebral infarcts**
- **Acute MI**
- **Persistent learning deficit**
- **Personality changes**
- **Memory impairment**
- **Death from progressive encephalopathy**



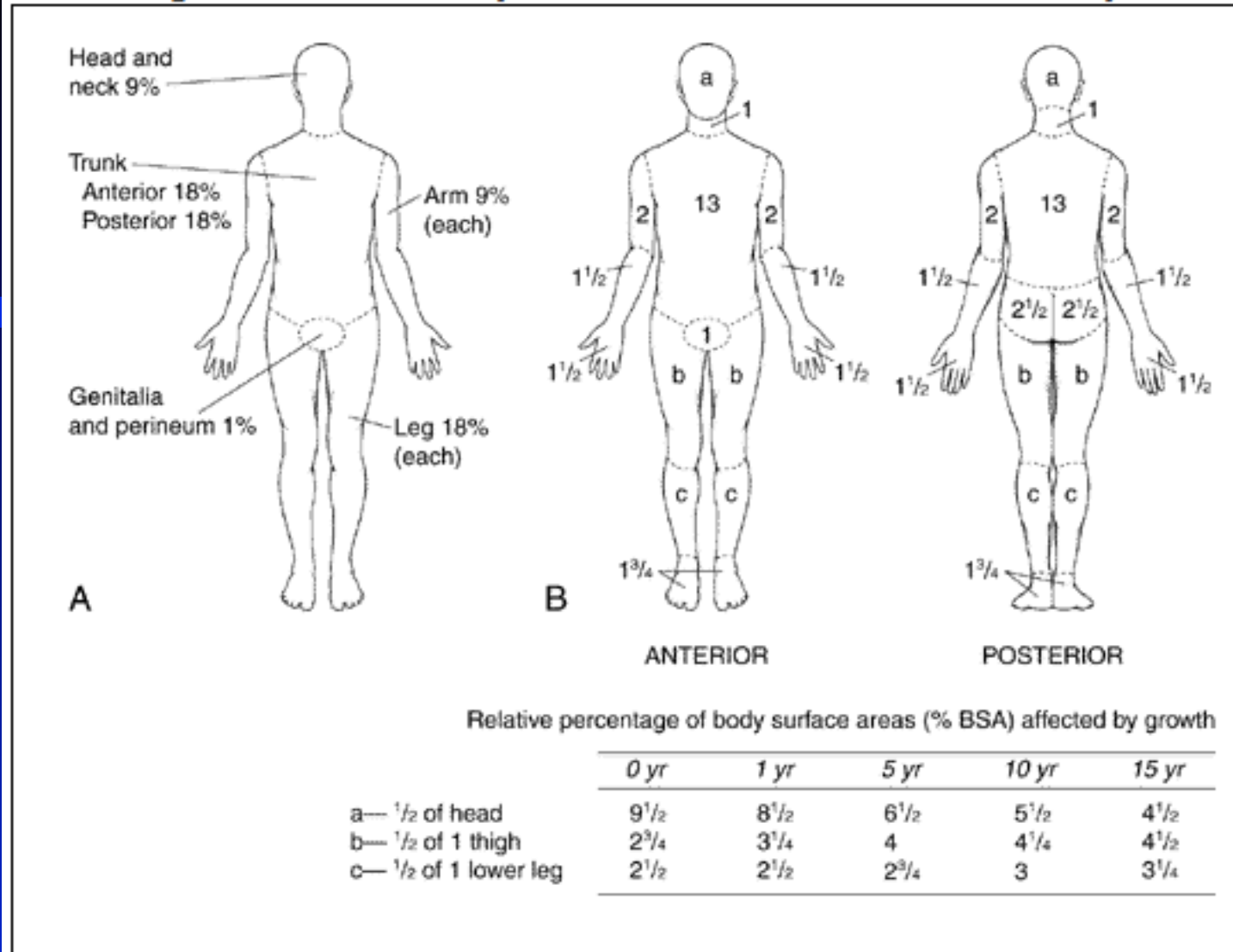
# Burns : Burn Wound Extent

- Expressed as percent of total body surface area (% TBSA)
- Rough guidelines :
  - Area of patient's hand = 1 % TBSA
  - Rule of 9's

# Burn Wound Extent : Rule of Nines

- Head : 9 % adult (18 % in babies)
- Arm : 9 % each
- Anterior trunk : 18 %
- Posterior trunk : 18 %
- Leg : 18 % each (14 % each in babies)
- Genitalia : 1 % (greater if the patient is from Texas or is a surgeon ; at least they say so)

## Estimating Percent Total Body Surface Area in Children Affected by Burns



(A) Rule of "nines"

(B) Lund-Browder diagram for estimating extent of burns



US Department of Health and Human Services, [Wikimedia Commons](#)

# Lund and Browder chart for estimation of burn wound extent

# Burn Wound Depth

- Initial depth determination often unreliable (especially in children)
- May need 2 weeks observation to accurately determine depth of injury
- First degree : Only outer epidermis damaged
- Second degree Shallow partial thickness : only epidermis damaged
- Second degree Deep partial thickness : damage extends into dermis but can heal by regrowth from cells of sweat glands and hair follicles
- Third degree : All of dermis destroyed ; requires grafting unless  $< 2.5$  cm in diameter

# **Burn Wound Depth**

- **First degree : like sunburn**
  - **Red, painful, no blisters**
  - **Do not count when determining burn surface area to calculate fluids**
  - **Heals in 3 to 7 days without scarring**
  - **Only cases which need admission would be babies with associated dehydration or heat illness**
  - **Rx with any soothing cream, NSAID's**
  - **Steroids shown not to be helpful**

# Burn Wound Depth

- **Second degree (or partial thickness)**
  - Usually red but can be white
  - Usually painful
  - Usually blisters
  - Heals in 7 to 28 days
  - May scar
  - May need skin grafting (because of its tendency to cause deforming or hypertrophic scarring)



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Source Undetermined

**Deep second degree burn of hand best treated by surgical excision and skin grafting**





**Case  
demonstrating that  
some blackened  
skin areas are just  
due to soot, but  
other blackened  
areas have partial  
or full thickness  
burns**



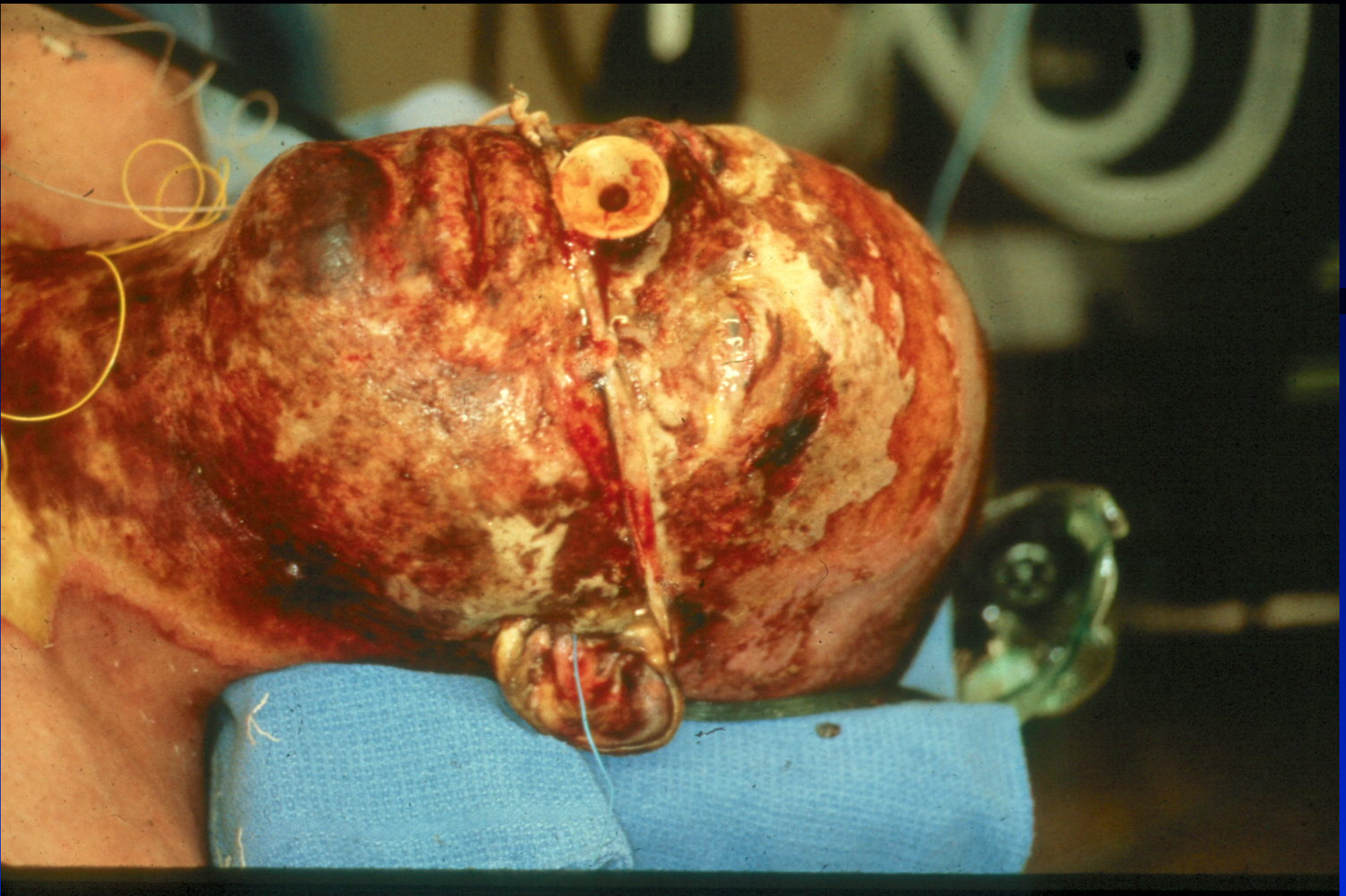
# Burn Wound Depth

- **Third degree (full thickness)**
  - Usually white (may be red)
  - Leathery
  - Insensate
  - Usually no blisters
  - Thrombosed subcutaneous vessels
  - Will heal from edges if  $< 2.5$  to 3 cm in diameter (otherwise needs skin grafting)



**Thrombosed  
subcutaneous  
veins in third  
degree burns**





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Source Undetermined

**Deep third degree burns of face (note need for nasal trumpet to hold nasal passage open & inability to close eyelids necessitating ophthalmic ointment protection of the cornea)**

# Burn Shock

- "Burn shock" due to loss of capillary seal throughout body with  $> 25\%$  TBSA burn
- Local loss of capillary seal occurs in vicinity of smaller burns
- "Burn shock" lasts 18 to 48 hours, then spontaneously resolves
- Etiology of "burn shock" uncertain but probably due to vasoactive mediators

# Burns : IV Placement

- **Peripheral lines OK ; seldom need central line**
- **OK to place IV through burned tissue**
- **Femoral lines OK**
- **Arterial line may facilitate monitoring**
- **Should change all IV catheters every 48 to 72 hours (to prevent line infections)**

# Burns : Fluid Resuscitation

- Aim of early fluid resuscitation is to maintain intravascular volume despite the body-wide loss of capillary seal
- Isotonic crystalloid best (colloid just leaks into lung in first 24 hours)
- Sodium at 0.5 meq / Kg / % TBSA burn is key factor
- Different resuscitation formulas used ; most provide the above similar amount of Na<sup>+</sup>

# Parkland Formula

- 4 cc Lactated Ringers times # of kg body weight times # of % TBSA burn
- Give one-half in first 8 hrs. (from time of burn)
- Then give one-half over the next 16 hrs.
- Example : 50 % TBSA burn in a 70 kg. man : 4 times 70 times 50 equals 14,000 cc ; give 7000 cc over first 8 hours, or about 1 liter per hour

# Parkland Formula for Children

- Add 4 cc / Kg / % burn to maintenance fluid requirement :
  - 100 cc / Kg for < 10 Kg
  - 1000 cc + 50 cc / Kg for 10 to 20 Kg
  - 1500 cc + 20 cc / Kg for 20 to 30 Kg



# **Shriner's Formula**

## **(More Accurate for Children)**

- **2000 ml / M<sup>2</sup> TBSA maintenance plus 5000 ml / M<sup>2</sup> BSA burned per 24 hours**
- **Requires access to a body surface area nomogram**

# Burns : Monitoring Fluid Resuscitation

- Urine output is key criterion
  - 30 cc / hr in adults
  - 1 cc / Kg / hr in children
  - 2 cc / Kg / hr for electrical burns
- Mental status & sensorium
- Pulse & BP : less useful
- Skin perfusion in non-burned areas
- Use the formula only as a guide ;  
adjust up or down as needed

# Importance of Monitoring Fluid Resuscitation Volumes

- If patient requires much higher than expected (calculated) fluid volumes for resuscitation:
  - Search for additional undiagnosed injury
  - Check serum electrolytes or hematocrit
  - Consider use of bicarb (extra  $\text{Na}^+$ )
  - Consider hypertonic resuscitation
  - Consider transfusion with packed cells
  - Consider plasmapheresis (can be life-saving)

# Escharotomy

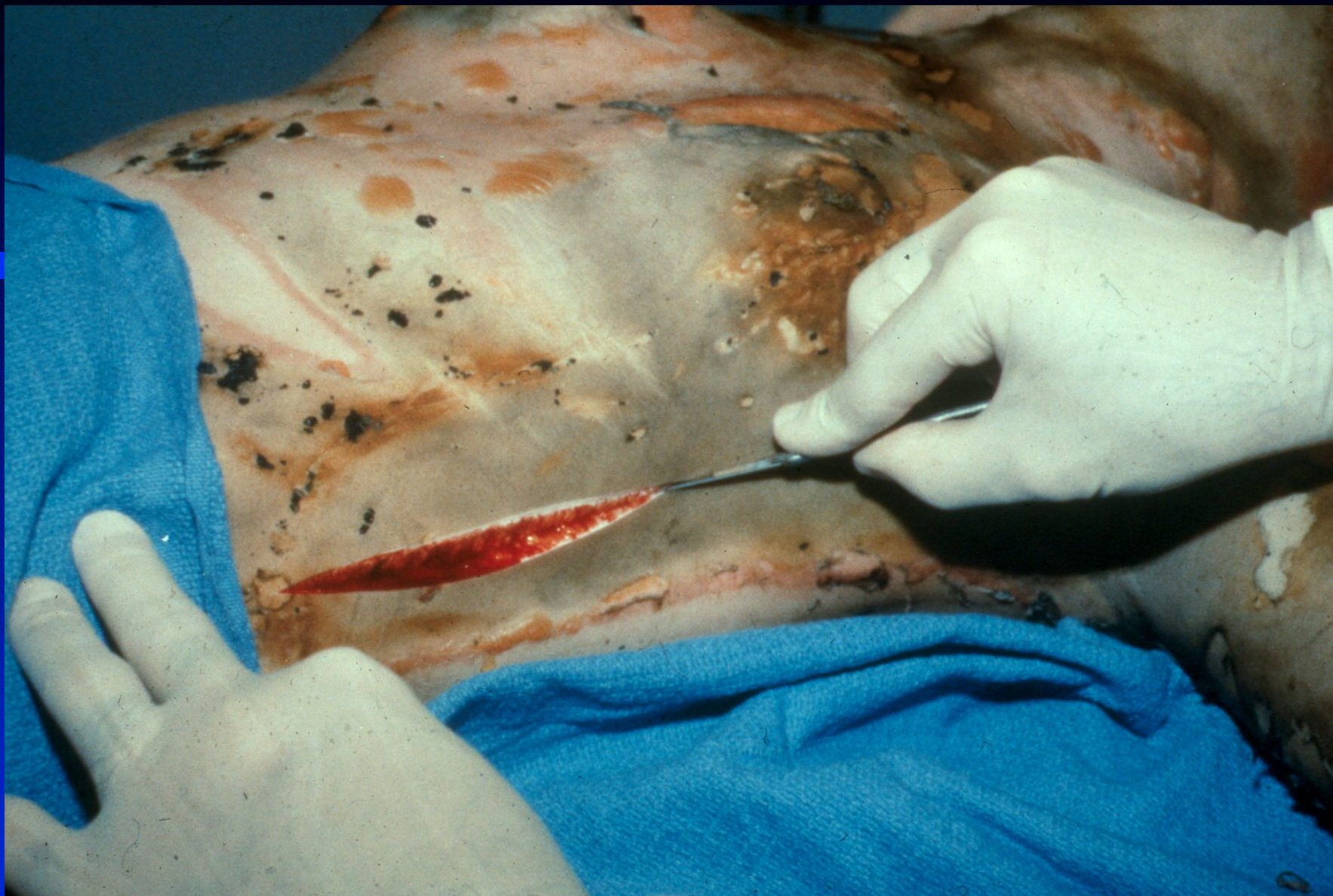
- Circumferencial full thickness burns of limb may cause ischemia of distal limb
- Anterolateral full thickness burn of thorax may cause restrictive ventilation defect
- Dx by distal paresthesias, pain, pallor
- Decreased pulse by Doppler or palpation is very late sign
- Most accurate dx by direct measurement of compartment pressure ( $> 30$  mm Hg is abnormal)

# Escharotomy

- Measure pressure in distal compartments with needle and manometer or wick catheter
- If pressure  $< 30$  mm Hg then repeat measurement in 2 hours
- If pressure  $> 30$  mm Hg, perform escharotomy
- Need for thoracic escharotomy dictated by clinical (ventilatory effort) status, not pressure measurements

# **Escharotomy Technique**

- **Incise through burned tissue till deeper tissue gapes**
- **No anesthesia needed**
- **May delay procedure only up to 4 hours after onset of restricted circulation**
- **Have ointment and bandaging material ready**
- **Incise along medial and lateral limb**
- **Incise along anterior axillary line and transverse subcostal for thoracic**



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Source Undetermined

## Escharotomy



# Burns : Admission Criteria Based on Categorization

- Severe : Transfer to burn center
- Moderate : Admit to local hospital
- Minor : Treat as outpatient

# Minor Burns

- Second degree < 15 % in adults
- Second degree < 10 % in children
- Third degree < 2 %
- No involvement of face, hands, feet, genitalia (technically difficult areas to graft)
- No smoke inhalation
- No complicating factors
- No possible child abuse

# Moderate Burns

- Second degree of 15 to 25 % TBSA in adults
- Second degree of 10 to 20 % TBSA in children
- Third degree of 2 to 10 % (not involving hands, feet, face, genitalia)
- Circumferencial limb burns
- Household current (110 or 220 volt) electrical injuries
- Smoke inhalation with minor (< 2 % TBSA) burns
- Possible child abuse
- Patient not intelligent enough to care for burns as outpatient

# Severe Burns

- Second degree > 25 % in adults
- Second degree > 25 % in children
- Third degree > 10 %
- High voltage electrical burns
- Deep second or third degree burns of face, hands, feet, genitalia
- Smoke inhalation with > 2 % burn
- Burns with major trunk, head or orthopedic injury
- Burns in poor risk patients (elderly, diabetic, COPD, obese, etc.)

# Burns : Additional Interventions

- NPO until evaluation complete
- NG tube (burns > 25 % TBSA cause an ileus)
- Foley
- IV narcotics (morphine) : low dose
  - No IM narcotics !
- Tetanus toxoid +/- tetanus immune globulin (TIG) prn
- Parenteral or oral antibiotics : usually not needed

# Inpatient Burn Care

- Resuscitation phase : First 24 to 48 hours postburn
- Post Resuscitation phase : day 2 to 5 postburn
  - Determine capillary seal time ( when IV fluid can be decreased to calculated maintenance rate and patient remains stable)
  - Give plasma and change IV to D5W
  - Extubate
  - Discontinue NG ; Start PO feeding & supplemental tube feedings
  - Start physical therapy
- Surgical phase : excision and skin grafting procedures
- Rehabilitation phase : after all skin grafts take
  - Secondary surgeries, attempts to decrease hypertrophic scarring, scar revision & cosmetic surgeries, rehabilitation

# **Major Burns :**

## **Additional Considerations**

- **Elevated body temperature**
  - **Usually persists until all burns closed by skin grafts**
  - **Not a reliable sign of infection**
- **Elevated metabolic rate**
  - **All patients require 2 to 4 times more calories & protein for nutritional support**
  - **This extra nutritional support can be the key factor in surviving the burn**



# Burns : Wound Care

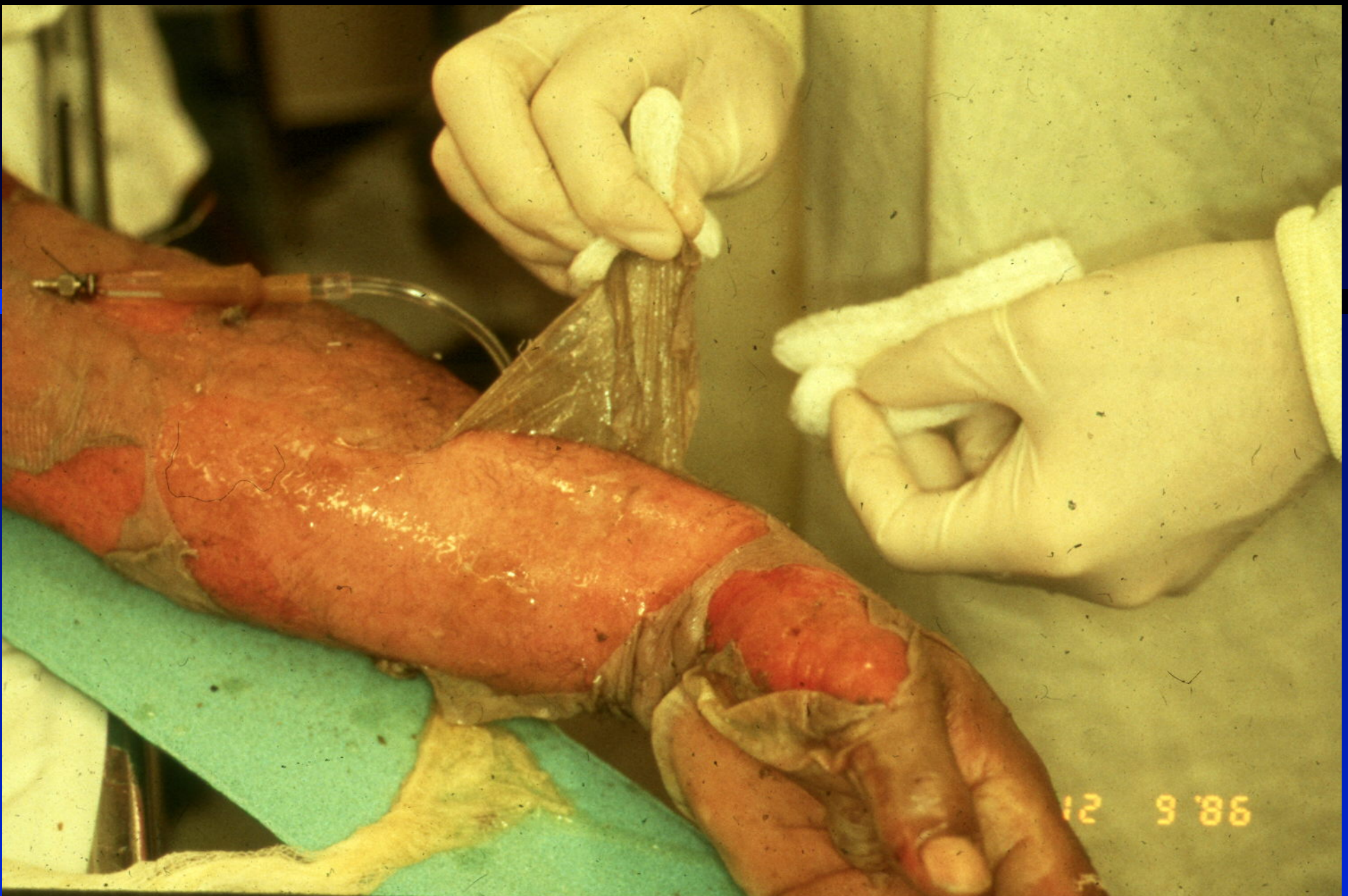
- **Blisters : "to debride or not to debride, that is the question "**
- **Probably should debride :**
  - **Large blisters**
  - **Ones already broken**
  - **If already infected**
  - **If unsure of depth of underlying burn**
- **Do not debride thick palmar or plantar blisters**

# Blister Debridement

- **Advantages :**
  - Eliminates dead tissue
  - Less risk of infection
  - Allows better assessment of burn depth
  - May permit better limb mobility
- **Disadvantages :**
  - More painful
  - ? delays wound healing

# **Blister Debridement : Method**

- **Have ointment & bandaging material ready**
- **Perform as quickly as possible ; limit exposure time to air**
- **Wipe tissue loose with dry 4 x 4 inch gauze**
- **Do not usually need to use scissors or knife**
- **Only debride what comes off easily ; should not stir up bleeding**
- **Be sure to "test wipe" all sooty areas to make sure they do not represent second degree burns**



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Source Undetermined

**Blister debridement (note sutured intravenous line)**

# Burns : Topical Agents

- **Silver sulfadiazine (Silvadene) :** painless, soothing on application, bacteriostatic, allergic sensitivity rare ; probably agent of choice
- **Sulfamylon :** penetrates eschar best, stings on application, causes metabolic acidosis by inhibition of carbonic anhydrase; probably best for pinnae burns
- **Povidone iodine (Betadine) :** painful on application, may sensitize to iodine, can cause iodine toxicity in large amounts
- **Gentamicin ointment :** can be absorbed and cause renal failure if used in large amounts

# Management of Tar Burns

- Immediately cool the tar with cold water to prevent further heat transfer
- Don't attempt to force peel off
- Use Orange-Sol, Neosporin ointment, other petrolatum-based ointment, or mineral oil to dissolve the tar
- Treat underlying burns same as other flame burns once the tar is removed







# Outpatient Burn Care

- Carefully instruct patient and family in dressing change procedure
- Change the ointment and dressing at least once a day (Preferably twice a day)
- See patient for recheck in 24 hours (after one dressing change at home) if you think he is not intelligent enough to do the burn care correctly
- See patient for recheck in 2 to 3 days if he seems reliable

# **Outpatient Burn Care :**

## **Patient Instructions**

- **Remove bandage and dressing**
- **Wash off the old Silvadene ointment with warm soapy water (may soak area first)**
- **Peel off any loose or broken blisters & pat area dry**
- **Reapply new Silvadene ointment 1/16" to 1/8" (3 to 6 mm) thick**
- **Reapply new bandage**
- **May take pain medicine 30 minutes before changing the ointment and bandage**

# **Outpatient Burn Care :**

## **What to Look for at Recheck Visits**

- **If patient is performing burn care satisfactorily**
- **If burn is developing signs of infection**
  - **Erythema and tenderness outside the original burned area**
  - **Thick drainage from the burn is usually just proteinaceous exudate and not a sign of infection**
- **If patient is maintaining satisfactory range of motion of the affected area**
- **If healing is progressing ; if not, the burn may be full thickness and referral for skin grafting may be needed**

# **Outpatient Burn Care :**

## **Advice to Patient After the Burn Heals**

- **Keep the area moist with cold cream**
- **Use Benadryl (diphenhydramine) for pruritis**
- **Keep the area out of the sun for 6 months (to prevent unpredictable lightening or darkening of the affected skin)**
- **Encourage extra active Range of Motion (ROM) exercises**
- **Assess for hypertrophic scarring (usually at 6 weeks)**



## Hypertrophic scarring

# **Outpatient Burn Care : Hypertrophic Scarring Treatment**

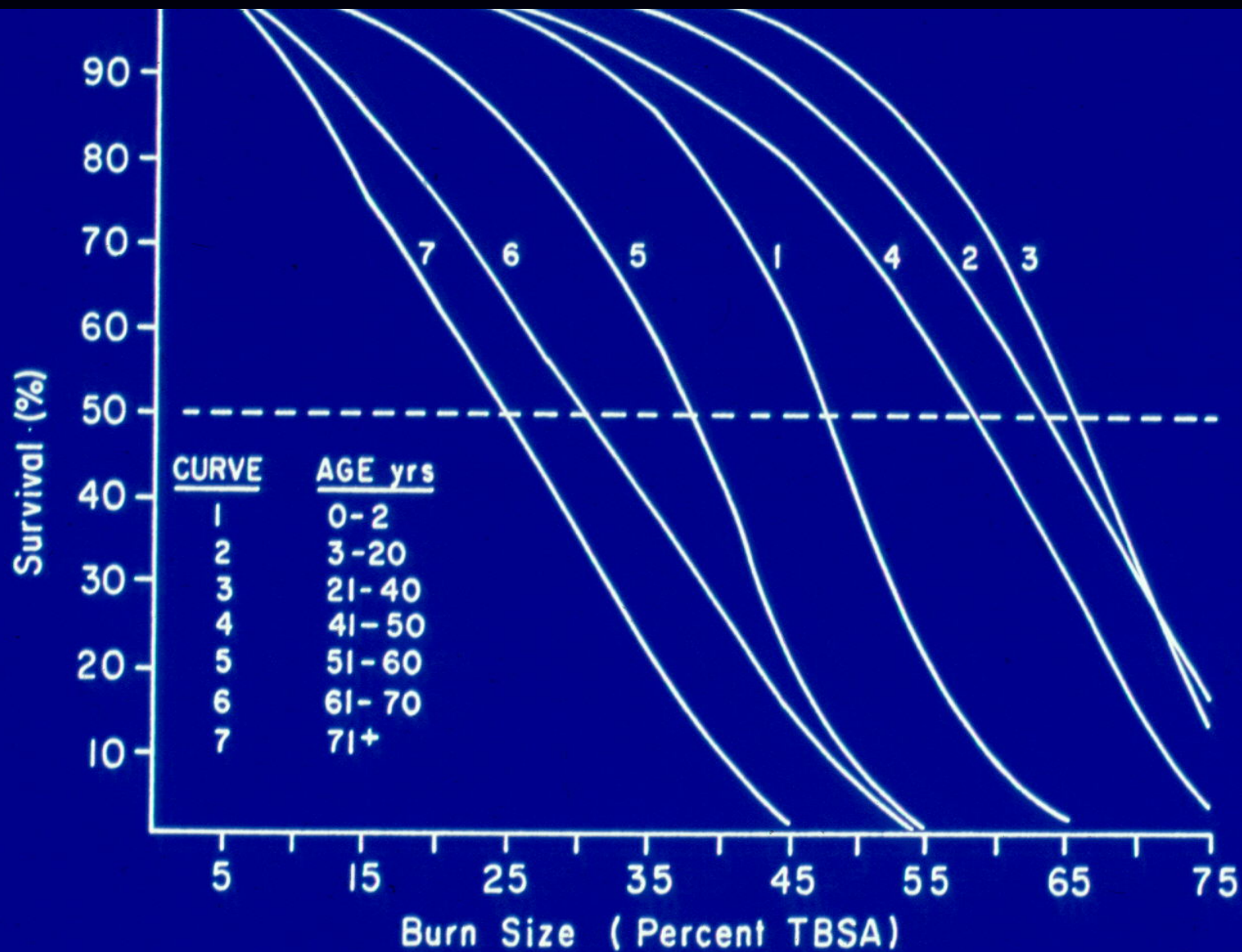
- **Intensive physical therapy & active ROM exercises**
- **Measure for Jobst garment ; wear the garment all the time for 1 year**
- **Early scar surgical revision only if major functional limitation**
- **Usually best to postpone surgical scar excision or revision until one year (time of full maturity for scar)**

# **Major Burns :**

## **Delayed Complications**

- **Infection**
  - **Burn wound sepsis**
  - **Pulmonary infection**
  - **Line infections**
  - **Fungal infections**
- **Pulmonary emboli or DVT**
- **Multiple organ failure**
- **Anemia**
- **Hypothermia**
- **Graft failure or non-take**





**Survival versus burn size for different age groups**

# Burns : Prevention

- Don't be stupid !
- Turn water heaters down to 120 to 130 degrees F (50 to 55 degrees C)
- Don't use open frying pan if young children present
- Dress children with flame-retardant clothing
- Use smoke detectors & sprinkler systems
- Educate children about fires & matches
- Stay low in a burning building to avoid smoke inhalation
- Familiarize yourself with building exits when on trips or in new buildings

# Burns

## Lecture Summary

- Treat major burns by same principles as for other major trauma
- Identify smoke inhalation early
- Monitor fluid resuscitation
- Categorize severity to decide on disposition
- Anticipate complications
- If Rx as outpatient, verify close followup thru healing & hypertrophic scarring phases
- Assist in prevention efforts