

# **BURN INJURY**

## Initial Management of the Burn Patient



BRIGHAM AND  
WOMEN'S HOSPITAL

**BURN CENTER**  
ACS/ABA verified

Burn Center Outpatient Appointments: 617-732-7715

24-Hour Transfer Arrangements: 617-732-5034



## Message from the Burn Director, Bohdan Pomahac, MD

*I am pleased to provide you with this resource manual for pre-hospital burn care. Burn patients can be one of the most challenging, but also the most rewarding to take care of. At Brigham & Women's Hospital, we are committed to providing our patients with the best possible functional and aesthetic outcome following their burn injury.*



*I am personally attracted to burn care because of my background in plastic surgery, but also the perceived need for more innovation in this field. Burn care is a true team effort and you are a critical part of that team. I am excited that together we can serve our patients and the community-at-large.*

*Please feel free to contact my office if we can answer any questions or be of any assistance to you.*

*Sincerely,*

Bohdan Pomahac, M.D.  
Medical Director, Burn Service  
Department of Surgery

---

The Brigham and Women's Hospital Burn Center is an accredited American Burn Association (ABA) burn center. Our team is always available to assist you in the management of the burn patient and is willing to provide expert assistance in the transfer process as outlined by the ABA.

24-Hour Burn/Trauma Patient Transfer Number: 617-732-5034



### Burn/Trauma Program Contacts:

Out-patient Burn Clinic	617-732-7715
Dr. Pomahac Main Office	617-732-7796
Burn/Trauma Program Manager	617-732-7734

<https://www.brighamandwomens.org/burntrauma>

## Table of Contents

---

<b>Section</b>	<b>Title</b>	<b>Page</b>
	Introduction	4
I.	Managing the ABC's in the Burn Patient: ❖ Airway ❖ Breathing ❖ Circulation	5
II.	Burn Center Transfer Criteria	15
III.	Initial Assessment and Management of Burn Injury ❖ Skin functions ❖ Burn assessment ❖ Initial management ❖ Burn severity and outcome	16
IV.	Chemical Burns ❖ General principles and management ❖ Eye injury ❖ Specific chemical injury	29
V.	Electrical Burns ❖ Terminology ❖ Initial assessment and management ❖ High voltage injury ❖ Low voltage injury	36
VI.	Burns to High Risk Areas: ❖ Hands, feet, perineum, face, ears	46
VII.	Cold injuries: Hypothermia and Frostbite	49

---

## Introduction

A number of advances in the early management of major, moderate, and minor burns have substantially reduced the mortality and morbidity associated with burn injury events. These advances include application of the most current science and evidence directly related to pain management, infection rates, and wound coverage.

The focus of this resource manual is the provision of care for burn patients during two critical periods:

- ❖ Initial assessment and treatment of life threatening conditions, specifically related to Airway, Breathing and Circulation.
- ❖ Early recognition of the burn severity, depth, size.

Current treatments will be discussed to round off the complete picture of early management of burn injury.

Sequences of Events and Priorities in Management:

- ❖ Stop the Burning Process
- ❖ Management of Airway and Pulmonary Problems
- ❖ Restoration of hemodynamic stability
- ❖ The Burn Wound:
  - Assessment
  - Initial management
  - Determine disposition
- ❖ Transfer Criteria to Burn Center

### ABA CRITERIA FOR PATIENT TRANSFER TO BURN CENTER

- Partial thickness burns greater than 10% of total body surface area (TBSA);
- Burns involving the face, hands, feet, genitalia, perineum, or major joints;
- Third degree burns in any age group;
- Electric burns, including lightning injury;
- Chemical burns;
- Inhalation injury;
- Burn injury in patients with pre-existing medical disorders that could complicate management, prolong recovery or affect mortality;
- Any patients with burns and concomitant trauma (such as fractures) in which the burn poses the greatest risk of morbidity or mortality;
- Burned children in hospitals without qualified personnel or equipment for the care of children;
- Burn injury in patients who will require special social, emotional or long-term rehabilitative intervention.

## I. Managing the ABC's in the Burn Patient



Caption1: House or home dwelling fires continue to be the number one source of burn injuries.

Caption 2: Burn patient suffering facial and inhalation injuries.

Module components:

- Stop the Burning Process
- Carbon monoxide toxicity
- Airway injury from smoke
- Pulmonary problems from smoke
- Chest wall restriction
- Burn-induced plasma shift
- Fluid resuscitation
- Blood flow restriction from compression

### ***Stop the Burning Process***

#### a. Flame Source

-Eliminate any ongoing burning, (i.e. from burning clothes).

-Synthetics in clothes can retain heat which needs to be neutralized.



-Cover the patient with DRY CLEAN sheets.



#### b. Chemical Source

-Chemicals continue to burn if in contact with skin.

-Remove chemically contaminated clothing.

Continuous flushing with water



## **Management of Airway and Pulmonary Conditions**

Smoke inhalation is a major cause of morbidity and mortality in the immediate post burn period. These, often life threatening, effects of smoke inhalation must be recognized and aggressively managed. The degree of lung damage is usually not evident for several hours.



Early transfer to a Burn Center is highly recommended, if smoke injury is suspected.

The three injury processes, resulting from smoke exposure, are presented in the order in which peak symptoms occur:

- \* Carbon Monoxide Toxicity
  - Immediate
- \*Upper Airway Injury with Potential Obstruction
  - Can be delayed for an hour or more
- \*Lower Airway Injury with Impaired Gas Exchange
  - Can be delayed for hours

### ***Carbon Monoxide Toxicity Pathophysiology***

Carbon Monoxide binds to the hemoglobin molecule displacing oxygen thereby decreasing the oxygen delivery to tissue. Over 99% of tissue oxygen is provided by the oxygen carried on hemoglobin.

#### **-Risk Factors**

- ♦ Any exposure to smoke
- ♦ Any exposure to fumes

#### **-Diagnosis**

Have a high index of suspicion in any fire victim with a history of smoke exposure. A carboxyhemoglobin level exceeding 10% total (morbidity is related to the peak level at the scene--not the first value obtained). Be especially concerned of cases in which there is an unexplained metabolic acidosis. See the table below for hemoglobin levels as related to the degree of CO intoxication.

Carbon Monoxide Intoxication	
<i>*CO Hgb Level</i>	<i>Symptoms</i>
0-5	Normal value
15-20	Headache, Confusion
20-40	Disorientation, fatigue, nausea, visual changes
40-60	Hallucination, combativeness, coma, shock, shock state
60 or above	Cardio-pulmonary arrest, Death

\*CO HgB = Carboxyhemoglobin

Endpoints of level of consciousness (LOC) in relation to treatments:

AWAKE	OBTUNDED
High flow by mask oxygen (FiO <sub>2</sub> 100%) until COHgb < 5%	Intubate and provide 100% oxygen via positive pressure ventilation. Hyperbaric oxygen therapy (HBO) is used if the patient does not respond to 100% oxygen (specific indications for HBO remain undefined).

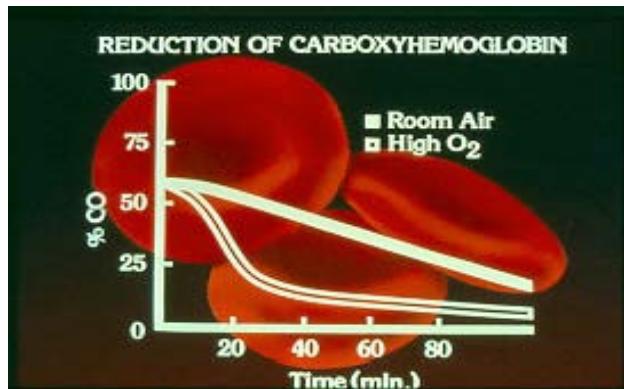
\*COHgb - carboxyhemoglobin

-Treatment of Carbon Monoxide Exposure



Immediate use of high flow 100% oxygen to remove the carbon monoxide from the hemoglobin and replacing with oxygen.

Effect of Oxygen on Carboxyhemoglobin Levels:



Caption: The carbon monoxide is rapidly displaced by breathing oxygen compared to breathing room air.

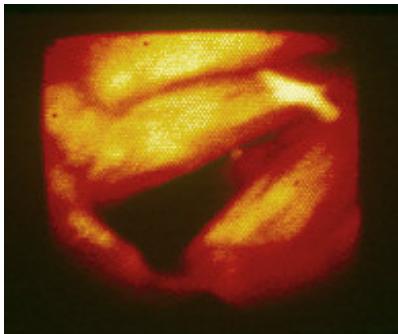
NOTES:

### -Cyanide Toxicity

Cyanide is also found in smoke, especially from burning polyurethane. Plasma cyanide levels are difficult to obtain so treatment is usually based on a high index of suspicion, usually due to an unexplained severe metabolic acidosis not corrected by oxygen and fluids. In general, for cyanide poisoning, cardiopulmonary support is usually sufficient treatment since the liver, via the enzyme rhodanase, will clear cyanide from the circulation. Sodium nitrite is used (300mg IV over 5-10 minutes) in severe cases, especially in those patients in which the diagnosis is made by blood cyanide levels. The nitrite, in turn, binds with the cyanide. Ordinarily, thiosulfate is also given, which in turn binds the cyanide to form thiocyanate. One must be reasonably sure of the diagnosis of cyanide toxicity before giving sodium nitrite as a side effect is the production of methhemoglobin.

### *Airway Injury from Smoke*

RISK FACTORS
<b>Oral Burn:</b> Rapid swelling of tongue and mucosa compromising airway patency.
<b>Supraglottic Edema:</b> Progression to obstruction.
<b>Cord and Infraglottic Edema:</b> Progression to obstruction.



Techniques to determine risk factors include laryngoscopic assessment for smoke inhalation:

#### -Diagnosis

History of smoke exposure (or exposure to high temperature e.g. explosion).

Direct laryngoscopic evidence of injury.

Symptoms of stridor, dyspnea (often delayed in onset).

Edema and erythema with decreasing airway lumen is noted on initial assessment.

#### -Treatment:

- ◆ 100% oxygen
- ◆ Airway Support
- ◆ Early intubation maybe required
- ◆ Transfer to Burn Center if smoke inhalation injury suspected

NOTES:

## Initial Assessment and Management of the Airway

Key signs and symptoms:



→ Stridor Retraction

→ Respiratory Distress present

→ Deep Burns: Face, Neck

If key signs or symptoms Present	If key signs or symptoms Absent
<ul style="list-style-type: none"> <li>*Intubate now!</li> <li>*Use adequate size tube</li> <li>*Humidified oxygen</li> <li>*Elevate head</li> <li>*Transport to Burn Center</li> </ul>	<ul style="list-style-type: none"> <li>*Provide 100% oxygen</li> <li>*Look for signs of airway injury: <ul style="list-style-type: none"> <li>◆ Oropharyngeal erythema</li> <li>◆ Hoarseness</li> <li>◆ Pulmonary status</li> </ul> </li> <li>*Can perform laryngoscopy</li> <li>*If edema present, intubate now</li> <li>*Transfer to Burn Center if history or findings are positive for smoke inhalation injury</li> <li>REMEMBER: Deterioration is often delayed in onset.</li> </ul>

### Pulmonary Problems from Smoke

Onset of symptoms is often delayed

Early transfer to Burn Center if suspect of smoke injury

Table: Lung Injury from Toxins in Smoke

Compounds	Source	Effect	Timing
Ammonia Sulfur Dioxide Chlorine	Clothing, Furniture, Wool,Silk	Mucous membrane irritation, Bronchospasm, Bronchorrhea	Early onset (first several hours)
Hydrogen Chloride Phosgene	Polyvinyl Chloride, Furniture, (wall floor coverings)	Severe mucosal damage; Ulcers, Mucous plugging, Mucosal slough, Pulmonary edema	Delayed often 1-2 days
Acetylaldehyde Formaldehyde Acrolein	Wallpaper, Lacquered wood, Cotton, Acrylic	Severe mucosal damage; Ulcers, Mucous plugging, Mucosal slough, Pulmonary edema	Delayed often 1-2 days
Cyanide	Polyurethane upholstery,	Tissue Hypoxia	IMMEDIATE
Carbon Monoxide	Any combustible substance	Tissue Hypoxia	IMMEDIATE

### ***Chest Wall Restriction***

A full thickness burn of the anterior and lateral chest wall can lead to severe restriction of chest wall motion, especially as edema develops beneath the nonviable tissue (eschar), even in the absence of a completely circumferential burn. Chest wall escharotomy maybe required to relieve the restriction.

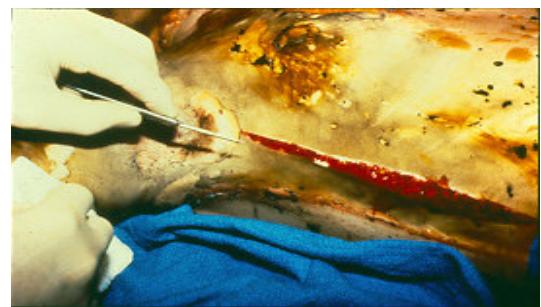


Escharotomy is best done in a Burn Center unless ventilation is severely impaired.

Caption: Impaired breathing from deep chest wall burn.



The restriction to ventilation is further compromised by the abdominal burn diminishing the movement of the diaphragm. The escharotomy incisions are placed along the anterior axillary lines with bilateral incisions connected by a subcostal incision (see next photo). The incisions must extend completely through the eschar so that the sub-eschar space can expand and decrease tissue pressure. In a full thickness burn, nerve endings are destroyed along with the entire epidermis and dermis. As a result, analgesics are usually not necessary for escharotomy.



Caption: Escharotomy incisions along anterior axillary line.

## Burn Induced Plasma Shift

### 1. Restoring loss of Plasma Volume (*Hypovolemia*)

Loss of plasma volume is rapid after a burn injury as fluid collects in the burn tissue. The magnitude of loss can be easily underestimated as plasma is not visibly lost from the surface but rather is hidden beneath the burn.

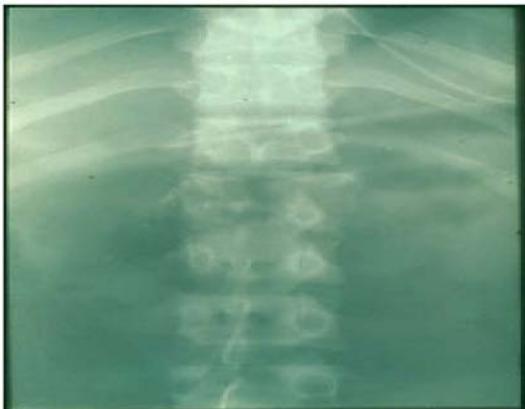
Early fluid resuscitation is required for burns exceeding 20% of body surface area.

#### -Assessment

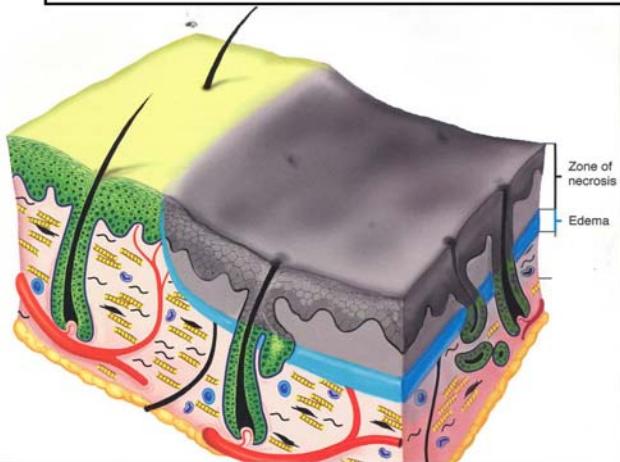


- ◆ Look for other traumatic injuries (falls, explosions, blunt trauma)
- ◆ Estimate percent of body surface burned in order to estimate isotonic fluid requirements – “Rule of Nines.”
- ◆ Use burn resuscitation formula remembering to add more fluid or blood for other traumatic injuries

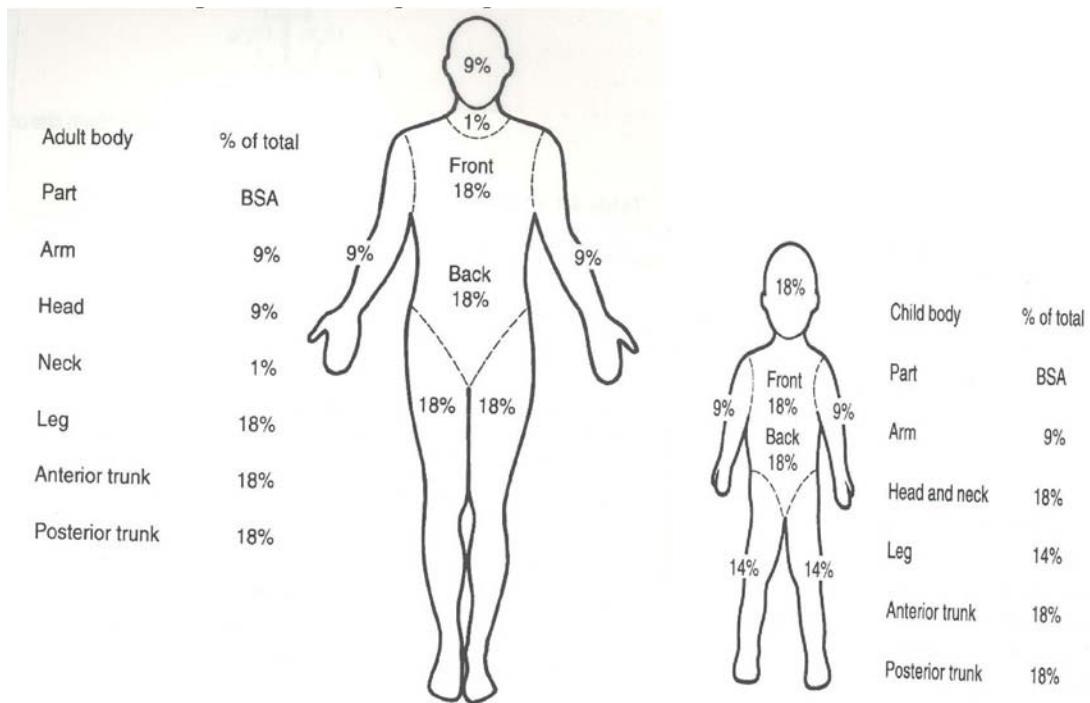
Thoracic Vertebral Fracture in burn patient after a two story fall.



Fluid loss beneath the burn surface can be massive.



## Estimating the size of the Burn as a percentage of the Total Body Surface Area (TBSA)



Caption: This formula divides the body into parts considered to be 9% (arms, head) to 18% (legs, front, back) of total body skin surface in adults. The small child has a different surface area breakdown. The burn size (as % of total) can then be used in the resuscitation formula. **Remember that a formula is only an estimate and adjustments need to be made based on patient's status.**

### Fluid Resuscitation Protocol

\* Establish and maintain adequate circulation



\* Burns >20% TBSA require initial fluid resuscitation



\* Use at least one large bore intravenous catheter. Begin Ringer's Lactate. Estimate initial rate according to the estimated percent total body skin surface area burned(%TBSA).





Estimated bodyweight (4cc/kg/% TBSA in 24 hours giving half of the estimate within 1-8 hours.)

\* Other interventions to monitor intake and output:

- Foley catheter
- Nasogastric tube

Parameters to maintain:



- ◆ Systolic Blood Pressure > 90 mm
- ◆ Urine output 0.5-1.0ml/kg/hr
- ◆ Pulse < 130 bpm
- ◆ Temperature > 37°C

Modify your protocol in the presence of massive burns, inhalation injury, shock, and in elderly patients applying the following strategies:

- Fluid requirements are greater to prevent burn shock.
- Include colloid (either Hespan or Albumin) in these patients from the start.
- Transfer to Burn Center if a major burn or moderate burn level exceeds local resources.

NOTES:

### ***Blood Flow Restriction from Tissue Compression***

As subeschar edema develops under the burn tissue, tissue pressure increases. This is of particular concern in extremities with a circumferential burn. Increasing pressure cannot be dissipated by normal expansion into neighboring tissue. This increased pressure initially impedes venous return, which markedly accentuates further edema production, raising pressure to a level that compromises arterial blood flow.

Perfusion to the distal extremity must be closely monitored.



Pain and color will be unreliable indicators of perfusion in the presence of a burn to the area.

A warm extremity invariably indicates good flow during the period, but cool skin does not always indicate that the problem is due to proximal burn constriction. Hypovolemia may well be the problem.



Caption1: Circumferential burn impairing circulation to hand. Caption 2: Release of tissue pressure and restoration of perfusion (Preferable performed in a Burn Center).

### Steps for the prevention and treatment of impaired distal perfusion



- ◆ Remove constricting objects, such as jewelry.
- ◆ Immediate elevation of burned extremities.
- ◆ Monitor peripheral circulation by pulse palpation and Doppler.
- ◆ Escharotomies planned for circumferential third or fourth degree burns, if **perfusion is impaired** (preferably performed in a Burn Center).

The monitoring of distal pulsatile flow by palpation and then by the use of a Doppler flowmeter is the most practical method of assessment. Pulsatile flow must be present.

## **II. Criteria for Referral to a Specialty Burn Center**

The American Burn Association (ABA) has identified those injuries that should be treated in a specialized burn center. Patients with these burns should be treated in a specialized burn facility after initial assessment and treatment at an appropriate hospital emergency department. Sometimes major burns are directly transferred to a burn center from scene if the center is within a safe transport time.



A large burn



A deep burn



High risk due to location

### **Transfer Criteria**

The American Burn Association (ABA) has identified those injuries that should be treated in a specialized burn center. Patients with these burns should be treated in a specialized burn facility after initial assessment and treatment at an appropriate hospital emergency department. Sometimes major burns are directly transferred to a burn center from scene if the center is within a safe transport time.

Burn Injuries that should be referred to a burn unit include the following:

- 1. Partial thickness burns greater than 10% total body surface area (TBSA)**
- 2. Burns that involve the face, hands, feet, genitalia, perineum or major joints (see High Risk section)**
- 3. Third degree burns in any age group**
- 4. Electrical burns, including lightning injury (see Electrical Burn section)**
- 5. Chemical burns (see Chemical Burn section)**
- 6. Inhalation injury**
- 7. Children with any of the above burn injuries**
- 8. Burn injury in patients with preexisting medical disorders that could complicate management**
- 9. Any patients with traumatic injury (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality. If the trauma poses the greater immediate risk, the patient must be initially stabilized in the nearest appropriate facility before being transferred to a burn unit.**
- 10. Any burned children if the hospital initially receiving the patient does not have qualified personnel or equipment for children.**

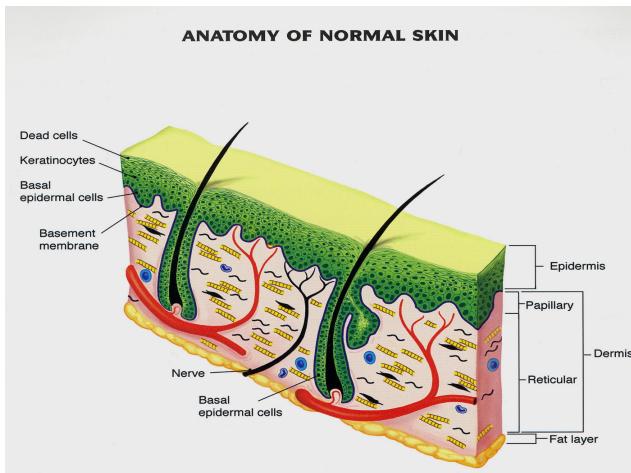
### **III. Burn Injury: Initial Assessment and Management**



- The Normal Structure and Barrier Properties of the Skin
- Burn Injured Skin
- Initial Burn Management
- Burn Severity and Outcomes (for Burn Size see Section 1)

#### **1. The Normal Properties of Skin**

Normal skin is a very complex organ with a wide variety of properties mainly protective barriers, which are critical to survival. Loss of these barrier functions occur with a skin burn. Understanding of these alterations in skin function will greatly assist in initial management.



#### **Skin Barrier Function**

### **Skin Barrier Functions: Epidermis (outer layer)**

- Protection from drying
- Protection from bacterial entry (infection)
- Protection from toxin absorption , like chemicals on the skin
- Fluid balance: avoiding excess evaporative water loss that would cause dehydration
- Neurosensory (touch, pain, pressure, sensation)
- Social-interactive (visible portion of the body covering)

### **Skin Barrier Functions: Dermis (inner layer)**

- Regulation of body temperature to avoid hypothermia with cold air exposure or high body T° with exercise and a hot environment
- Prevention of excess loss of body heat
- Protection from injury because of the properties of elasticity and durability

## **Skin Structure**

**Epidermis:** The outer thinner layer known as the epidermis is composed mainly of epithelial cells. The deepest epidermal cells are immature cells which are continually dividing and migrating toward the surface, to replace lost surface cells; e.g. after an injury. The same types of regenerating epidermal cells are found in hair follicles and other skin appendages, which are anchored in the dermis. As the cells mature and migrate to the surface, they form keratin, which becomes an effective barrier to environmental hazards such as infection and excess water evaporation.

**Stratum Corneum:** is the “outer most” layer of the epidermis consisting of several flattened layers of dead keratinocytes as well as keratin. This layer protects against entry of bacteria and toxins. The epidermal layer regenerates every 2-3 weeks but regeneration requires the presence of the dermis.

**Dermis:** The dermis is the deeper layer responsible for skin durability and flexibility. The nerves for touch and pain, blood vessels and hair follicles are present in the dermis. The dermis is responsible for reforming the outer epidermis. So, if the outer layer is burned, the wound can heal as long as there is dermis. If the dermis is totally destroyed, the burn cannot heal.

## **2. Burn Injury**

A skin burn is the damage to the skin caused by heat or other caustic materials like chemicals. The most immediate and obvious injury is one due to heat. Excess heat causes rapid protein denaturation and cell damage. The depth of heat injury is dependent on the depth of heat penetration. Wet heat (scald) travels much more rapidly into tissue than dry heat (flame). A surface temperature of over 156°F (68°C) by wet heat produces immediate tissue death as well as vessel clotting. A higher temperature would be required with dry heat (flames). The dead tissue on the surface is known as eschar. The depth of the burn is dependent on the temperature of the heat insult, the contact time, and the medium (air-water). In addition, the thickness of the skin layer is critical as the thinner the skin, the deeper the burn. Children and the elderly have very thin skin. Chemicals destroy skin by chemically killing the tissue. It is now clear that toxic agents released by inflammation, which are activated with the burn, cause much of the tissue damage after the burn, especially in the deeper burns.

It is important to know that a burn can become deeper than that present initially, due to any continued exposure to the heat source, any degree of shock or later infection.

### **Reasons for Burn Worsening:**

- continued contact with the heat or chemical source
- decrease in burn blood flow: shock or constriction
- infection

### **Burn Severity is determined by:**

- **burn depth**
- **burn size**
- **burn location**

### **Burn with loss of barrier protection**



#### **Deep hand burn:**

- \*Increased risk of infection
- \*Increased pain and risk of scar formation
- \*Increased risk of loss of skin elasticity leading to disability
- \*Increased risk of desiccation
- \*Increased surface fluid and heat loss

### 3. Burn Assessment

#### Burn Depth: How deep is the burn?

Burn depth is defined by how much of the two skin layers is destroyed by the heat source. Burns can be categorized by degree:

**1st degree:** confined to the outer layer only

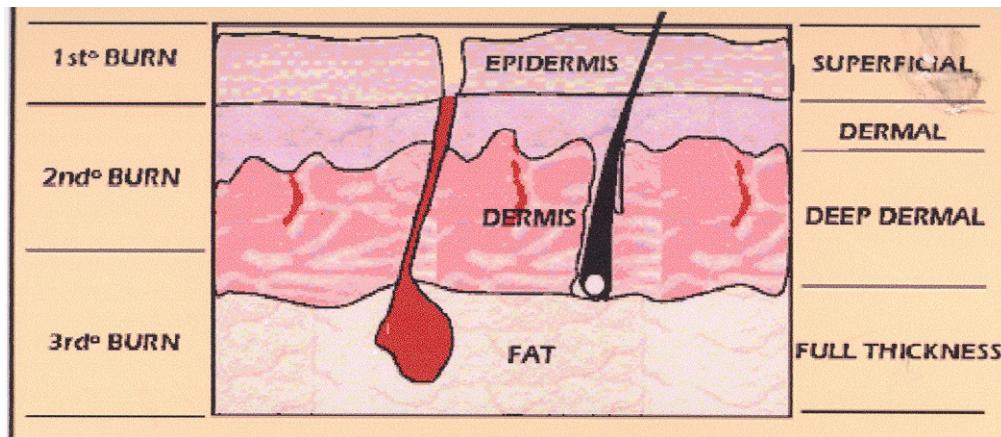
**2nd degree:** also involves part of the dermis

**3rd degree:** destruction of both layers  
or

**Partial thickness:** is a second degree burn consisting of injury to part of the dermis

**Full thickness:** is a third degree burn consisting of injury to both layers

Only burns extending into the second layer (the dermis) are considered significant.



#### A. First-degree burn

A first-degree burn is confined exclusively to the outer surface and is not considered a significant burn. No barrier functions are altered. The most common form is a **Sunburn** which heals by itself in less than a week without scar.

#### B. Second-Degree or Partial Thickness Burn

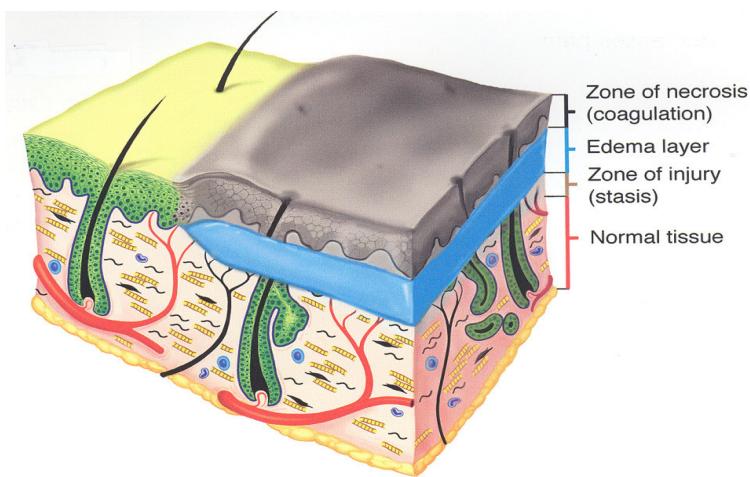
This degree burn destroys the epidermal layer and portions of the dermis. Since it does not extend through both layers, it is termed a **partial thickness burn**.

There are a number of depths of a second-degree or partial thickness burn typically used to characterize the burn. Each corresponds with a predictable healing time, treatment modalities and outcomes. However, it is not necessary to make these distinctions with initial assessment but more knowledge is always better.

**Superficial Second-Degree:** Involves the entire epidermis and no more than the upper third of the dermis is heat destroyed. Rapid healing occurs in 1-2 weeks, because of the large amount of remaining skin and good blood supply. Scar is uncommon. Initial pain is the most severe of any burn, as the nerve endings of the skin are now exposed to the air.

**Characteristics:**

- Confined to upper third of dermis
- usually caused by hot liquids
- Blisters, wet pink, painful
- low risk of infection
- Heals in 10-12 days without scar



**Superficial 2° burn caused by hot water: a scald burn**



**Superficial burn with plasma leaking into wound (note blisters)**



### **Mid Second Degree (mid-partial thickness) burn:**

Destruction to about half of the dermis occurs. Healing is slower (2-4 weeks) due to the fact that there is less remaining dermis and less blood supply. Pain can be severe but is less intense than superficial 2°. The reason is that part of the nerve is now heat destroyed. Some scar can result.

The most common approach is to use a topical antibacterial cream with fine mesh gauze covered with a dry occlusive dressing, changed once or twice daily. This approach does not produce the optimum moist healing environment especially with the risk of surface dessication, but remains the standard of care because of infection concerns. Newer temporary skin substitutes can also be used.



#### **Characteristics of Mid to Deep Dermal:**

- Residual non-viable tissue firmly adherent to wound
- Usually managed with topical antibacterial agent
- Increased risk of infection compared to more superficial burn

### **Deep Second Degree (Deep Partial Thickness) Burn:**

Most of skin is destroyed except for small amount of remaining dermis. The wound looks white or charred indicating dead tissue. Pain is much less as the nerves are actually destroyed by the heat. Usually, one cannot distinguish a deep dermal from a full thickness (third degree) by visualization. The presence of sensation to touch usually indicates the burn is a deep partial injury.

#### **Characteristics:**

- Involves majority of the inner dermal layer
- Cause is usually flames
- Dry, white or charred skin
- Pain is minimal
- High risk for infection
- May heal in 2-3 months
- If heals: scar is severe
- Readily converts to a full thickness burn

## Deep Partial Thickness Burn



**Flame Burn:** Patches of white are the deep dermal burn surrounded by a more superficial burn.



Deep dermal burn to forearm. Note patches of white indicating a deeper burn. Less pain is usually present in the deeper burn.

## General Treatment Principles: Deep Partial Thickness Burn

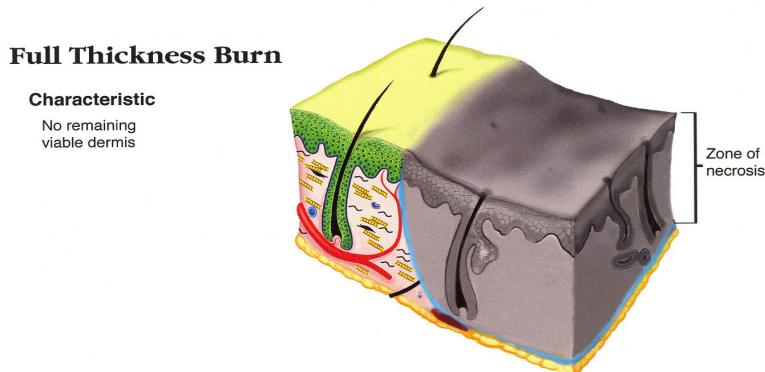
1. Admit if over 2% due to need for early grafting
2. Transfer to Burn Center based on Transfer Criteria  
(no need to perform burn care if transfer is immediate)
3. Gentle washing with antibacterial soap
4. Silversulfadiazine using a closed dressing twice a day
5. Or siver impregnated dressing
6. Cold is not beneficial once the burning has stopped as pain is minimal

### C. Third degree (Full Thickness) Burn:

Both layers of skin are completely destroyed leaving no cells to heal. Any significant burn will require skin grafting. Small burns will heal with scar.

#### Characteristics:

- Complete destruction of both layers
- Cause is usually flames
- White, char, dry, painless
- High risk for infection
- Needs to be excised and skin grafted



Full Thickness (3<sup>rd</sup> degree) burn of the hand. The burn is hard, dry, non pliable and painless. Veins are clotted. Long-term disability is inevitable. (Meets transfer criteria due to depth.)

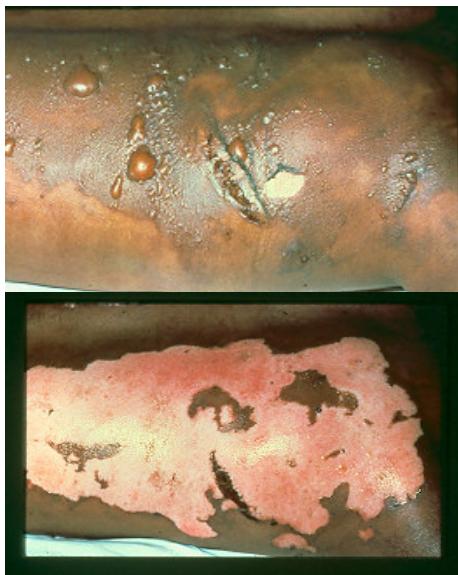
Full Thickness (3<sup>rd</sup> degree) burn of the arm and chest. Note presence of char. The area is painless due to loss of nerve endings. (Meets transfer criteria based on size, depth and patients age.)

### **General Treatment Principles: Full Thickness Burn**

1. Transfer to Burn Center based on Transfer Criteria  
(no need to perform burn care if transfer is immediate)
2. Gentle washing with antibacterial soap.
3. Siversulfadiazine using a closed dressing twice a day.
4. Or use of a silver impregnated dressing
5. Cold is not beneficial once the burning has stopped as pain is minimal.

### **D. Visually Deceiving Burns**

Some burns usually caused by contact with flames or extremely hot temperatures like explosions have destroyed epidermis still present in the wound. The depth can be underestimated unless the wound is gently washed and debrided after which the size and depth is more clearly defined.



Flame Burn (direct contact) looks superficial with blisters but mechanism suggest a deep burn.

When gently cleansed, the wound is noted to be a combination of deep second and third degree burn.

#### **Treatment:**

1. Gently wash, removing all loose epidermis
2. Application of silver cream or dressing

### E. Immersion Scalds

Scald burns in which a part or all of the body is immersed in hot water. Hot water contact can be prolonged, producing a deep burn. This process is characteristically seen in the elderly or in young children who cannot escape hot water. Forced immersion or abuse must be considered. The water vehicle transmits heat to tissues 20 times greater than air, therefore the tissue is injured deeper than with a flash flame of short exposure. However, the water T° is usually not hot enough to immediately coagulate vessels, so the wound looks red like a superficial burn but soft tissue injury including nerves can be severe and the burn can be very deep.

**Appearance:** The major characteristic is a dark red color due to myoglobin and hemoglobin pigment released in the tissues, which can be mistaken for viable tissue. The depth of a long term scald exposure is invariably underestimated.

**Outcome:** Since the burn is usually deeper with this form of scald and the area is often buttocks and/or feet, morbidity both short term and long term is high.



Typical appearance: looks red, like a Mid Second burn but is not wet and is less painful. The burn is actually a Full Thickness.



Note the sharp borders of the burn indicating the child was unable to move.

#### Treatment:

1. Burn size and area are indicators that patient needs care in a Burn Center
2. Notification of Social Service

## 4. Burn Severity and Outcome

### Burn Depth and Outcome Relative to Cause

<b>Second Degree (Partial Thickness)</b>	<b>Cause</b>	<b>Appearance</b>	<b>Pain</b>	<b>Healing</b>	<b>Scar</b>
<b>Superficial</b>	Hot liquid, short exposure	Wet, pink blisters	Severe	10-14 days	Minimal
<b>Mid-Dermal</b>	Hot liquid, hot grease, or flash flame with longer exposure	Less wet, red ± blisters	Moderate	2-4 weeks	Moderate
<b>Deep Dermal</b>	Chemicals, direct contact with flames	Dry, white	Minimal	3-8 weeks	Severe, usually needs skin graft
<b>Third Degree (Full Thickness)</b>	Chemicals, flames, explosion with very high temperature	Dry, white or char	None	Needs skin graft	Mild to severe, depending on timing and type of graft

### Factors Affecting Burn Severity and Outcome

- Burn depth
- Amount of skin burned (measured as percent of total skin)
- Age (very young and very old are high risk)
- Chronic illness and overall health
- Part of the body burned
- Presence of smoke inhalation injury

Burn survival has markedly improved in recent years when optimum care is provided from the injury scene to discharge. The burn size, as percent of total body, is shown with the comparison to age. This chart does not consider the presence of smoke inhalation injury.

## **Survival Rate from Burn Centers**

(Data obtained from Specialized Center for Mean Survival Rate (%) Comparing Age and Burn Size)

Burn Size (%) of total skin	Age (years)						
	0-1	2-4	5-34	35-49	50-59	60-74	>75
0-10	>95	>95	>95	>95	>95	>95	90
10-20	>95	>90	>95	>90	>90	>70	>60
20-30	>90	>90	>90	>90	>75	50	35
30-40	75	80	90	80	70	40	<20
40-50	50	65	80	60	40	10	<10
50-60	50	60	70	60	40	<25	<10
60-70	40	50	60	40	25	<10	0
70-80	35	40	45	30	25	0	0
80-90	30	35	30	30	<20	0	0
90-100	20	20	20	15	0	0	0

\* The body surface burn, combined second and third degree

Note that survival is very high for even massive burns (over ¾ of the body) in older children and young adult. Survival decreases in the elderly due to the presence of pre-existing disease and inability to withstand severe stress. Survival is also less for babies and toddlers for the same size.

## **Survival Statistics**



Burn of 15% of body in a 12 year old.  
Over 95% chance of survival.



Burn of 20% of the body in a 40 year old.  
Over a 90% survival.



Burn of 60% of the body in a 20 year old.  
About a 70% chance of survival.



Burn of 25% of the body in an 80 year  
old. About a 25% chance of survival.

## IV. Chemical Burns



- General Characteristics, Assessment and Treatment
- Eye Injury
- Specific Chemical Injuries

Chemical burns are commonly seen in the home but especially in the workplace.

**The most common categories of toxic chemicals will be described. These chemicals can produce local tissue injury and some have potential to be absorbed resulting in body poisoning.**

Toxic chemicals can be in the form of gases, liquids or solids. The gas form typically causes injury through breathing like smoke exposure.

The liquid and solid forms are more likely to cause damage to the skin, with the exception of fuming sulfuric acid, heat or thermal injury play a minor role in chemical burn.

## **A. Characteristics of Chemical burns**

- Usually deeper than it looks as the skin is destroyed mainly by chemicals.
- Appearance is often brown to gray as opposed to the typical white or char with a flame burn.
- Continue to get deeper and later appearance is usually worse.
- Severe persistent pain is often present indicative of ongoing skin damage.
- Chemical toxins like phenol or hydrocarbons like gasoline may cause only skin irritations, but absorption can lead to systemic poisoning.

## **B. Treatment and Assessment**

### **Airway**

- Support airway as fumes can cause swelling

### **Breathing**

- Fumes or absorption of toxins cause injury to lungs
- Chemical explosions can cause chest damage
- Assess and assist breathing

### **Circulation**

- Assess adequacy of circulation with vital signs, skin color and temperature  
(Hypovolemic shock is usually not present in the immediate post burn period)
- Intravenous catheter indicated mainly for administration of medications
- Local circulation
  - removal of constricting objects, like jewelry
  - deep chemical burn can produce constriction of local blood flow similar to thermal burn

### **Disability**

- Absorption of some chemicals can lead to impaired brain function
  - seizures
  - unconscious state
- Altered consciousness can also be due to head injury (if explosion)
- Assess and document level of consciousness A-V-P-U
- Management based on protocol

### **Expose and Examine**

- Remove clothing and constricting objects

### **History**

Once the ABC's and initial removal of the chemical have been initiated, further details as to history of the event must be obtained

- Place of exposure (was it enclosed?)
- Nature of exposure (spill, fall, explosion?)
- Duration of exposure (how long was the chemical exposure before initial treatment)
- What is the chemical/chemicals?
  - acid, alkali, hydrocarbon
  - specific toxic properties (information usually available if industrial accident)
- Relevant patient history
  - health status
  - current symptoms

### **Wound Management**

- Initial management of the chemical burn has a major impact on outcome
- Continuous water irrigation if the area should be initiated
  - use of showers in the workplace is optimum
  - use tepid water if possible, to avoid long exposure to cold or hot water
  - irrigation for strong acid or alkali exposure is 30-60 minutes
  - continuous irrigation if eye is exposed to chemicals
  - do not attempt to neutralized acids with alkali or vice versa, just use copious water
- Solid chemicals should be brushed off first prior to irrigation using safety gloves
- Continue irrigation through transport while maintaining body T°
- Cover the patient with clean dry sheet or blanket after irrigation stopped (per protocol)

### **CHEM-TREC - Chemical Transport Emergency Center**

This 24-hour service established in 1971 provides information to rescue teams responding to chemical emergencies and can provide direct contact with the chemical company. The phone number for **CHEM- TREC is 1-800-424-9300**

### **Pain Management**

- Water irrigation should begin to decrease pain
- Pain medications (Intravenous administration in small amounts)

### **Transfer**

- Significant chemical burns meet criteria for transfer to a Burn Center

### **Eye Injury (Prevention and Treatment)**

- Permanent eye damage can be prevented if copious, continuous irrigation with water, saline or Ringer's Lactate
- Remove contact lenses
- Hold eyelids apart and begin gentle, continuous irrigation
- Use if IV bag and tubing provides continuous controlled irrigation

**Eye injury from splattered alkali**



Treatment is continuous water irrigation

**Alkali burn to eye**



Delayed treatment resulted in permanent corneal damage

## C. Specific Chemical Burns

### Strong Acid Burn from Sulfuric Acid



Note the brownish-gray appearance. Characteristic of a deep skin burn from a strong acid or alkali. Persistent pain is present. Wound usually looks deeper at 24 hours. Treatment is removal of clothing and water irrigation. Burn is Full Thickness.

### Chemical Burn by Nitric Acid



Burn is caused by a nitric acid spray. A brown discoloration is characteristic. Persistent pain is present. Treatment is water irrigation.

### Deep Lime powder burn to lower leg



Lime powder at a construction site entered the patient's boot. The deep burn was noted when pain developed. Initial treatment is water irrigation.

### **Full Thickness Sodium hydroxide burn to the back (at 24 hours)**



Brownish dry appearance indicates the burn is full thickness. Patient did not seek medical attention for 24 hours.

### **Other Chemical Injuries: Petroleum (Hydrocarbon) Exposure**

These agents carry the risk of not only a skin injury from exposure but the exposed patient is highly flammable. In addition these chemicals can be rapidly absorbed leading to a life threatening poisoning.

- Agents include: gasoline, fuel, solvents, phenol
- Protection from any sparks or flame source as these agents make clothes and skin highly flammable
- Absorption of these toxins can lead to poisoning
- Initial skin burn from chemical is often superficial

Early removal of clothing and copious irrigation needed - A small exposure to water can actually spread the agent and lead to further damage

### **Hot Tar Burns**

Tar in its liquid form is superheated and therefore any direct contact e.g. roofers, will usually lead to a **deep** burn. Pain may be minimal as the burn is deep, and under estimation of the degree of burn is common. The tar typically remains adherent to the skin.

A secondary exposure, e.g. stepping on already poured but still sticky tar, will likely produce a more superficial but still significant burn.

Initially cool the tar to decrease retained heat

- use of copious water
- Do not attempt to remove the tar in the pre-hospital setting
  - careful removal will further damage the skin burn
- Cover area with clean, dry sheet or cloth
- Removal in definitive care can be done using fat emulsifiers
  - Neosporin ointment
  - mineral oil
  - not flammable solvents

### **Deep Hot Tar Burn to Hand**



Note the white area in the exposed wound, indicating the burn to be very deep. Pain is minimal and injury can be easily underestimated.

### **Skateboarder versus Poured Asphalt**



The asphalt was still hot upon contact. The burn was partial thickness. Initial management is cooling the tar with water then transport to Burn Center due to facial burn. An eye assessment will be needed.

<b>Agent</b>	<b>Pathophysiology</b>	<b>Treatment</b>
<b>General Category of Acids</b>	Deep skin burn caused by tissue desiccation and protein denaturation. Injury may extend well below skin with concentrated acids. Acids such as sulfuric, nitric, hypochloric cause local damage. Appearance is tan to gray discoloration with extreme pain, a common finding.	Vigorous water irrigation up to 60 minutes after injury using warm water with extensive exposure to avoid hypothermia. Treatment should be based on the assumption that the burn will be much deeper than initial appearance indicates. Standard fluid resuscitation principles.
<b>Hydrofluoric Acid</b>	Deep skin burn usually on the fingers can be extensive. Systemic effects are due to hypocalcaemia as a result of removal of tissue calcium by the fluoride.	Vigorous water lavage along with local injection of calcium gluconate as well as topical use of 2.5% calcium gluconate gel. Topical zephrin solution is also helpful. Endpoint of local wound calcium is relief of pain.
<b>General Category of Alkali</b>	Deep skin burn caused again by tissue and protein desiccation and protein denaturation from chemical reaction of alkali exposed to hydrated tissue. Alkali burns tend to be worse than acid burns, but systemic effects from absorption are not common. Appearance is tan to gray surface discoloration with characteristic extreme pain.	Vigorous water lavage for at least 60 minutes after injury and longer for lye burns, avoiding hypothermia during the lavage. Treatment should be based on the assumption that the burn will progress in depth. Standard fluid resuscitation principles.
<b>General Category Organic Components Gasoline immersion</b>	Superficial skin injury: erythema Systemic poisoning from absorbed hydrocarbons	Water irrigation plus aggressive maintenance of hydration and pulmonary support
<b>Phenol</b>	Partial thickness burn: dull tan to gray color Systemic injury from absorption, which is usually rapid with the rate and amount being directly proportional to surface area of exposure	Spray or pour large volumes of water on surface. Do not swab or use small amounts of water, which will only increase surface area exposure. After lavage, use a quick skin wipe with polyethylene or propylene glycol
<b>Tar</b>	Superficial to deep skin burn, depends on T° of tar once skin contact occurs. No systemic absorption is present	Removal of tar to allow wound care. Neosporin contains the emulsifier Tween-80 which is useful in dissolving the tar

## V. Electrical Burns



- Terminology and Types of Electrical Burns
- Initial Assessment and Management
- High Voltage Electrical Injury: Diagnosis and Treatment
- Low Voltage Electrical Injury: Diagnosis and Treatment

## A. Overview and Terminology

An electrical current will produce an array of injuries if the current passes through the body. Most of the damage is beneath the skin surface and therefore the actual injury can easily be underestimated. There are often several possible components to the injury.

- The **first component** is the injury caused by the electrical current itself. The current (the current of injury) generates intense heat often in excess of 2000°F along its path through the body, which can lead to severe muscle, nerve and blood vessel damage.

### Typical Injuries

- \* damage from sun
- \* skin burn from an "arc" or flash
- \* clothes on fire
- \* blunt trauma

In addition the electricity itself damages tissues especially nerves. The major of the damage is beneath the skin leading to a "hidden" injury.

- The **second component** is the injury from "arcing". Ionization of air particles associated with a voltage drop is called arcing. The heat generated in the arc can be as high as 4,000°C and can vaporize metal. This process frequently causes a patient's clothing to ignite and cause flame burns. A form of explosion dissipates excess energy from the arc.
- The **third component** is the skin burn caused by a flash. A flash can result from the power source or from the ignition of clothing or surroundings. A flame burn can occur without underlying tissue injury.
- The **fourth component** is traumatic injury caused by the intense muscle spasm with the current or from a fall. There is also a variety of cardiac, lung muscle, nerve and internal organ injuries which can occur, some being immediately life threatening.

## High Voltage Injury

High Voltage Injury defined as exposure to a voltage of 1000 volts or greater (damage beneath the surface should be suspected).

- **injury is caused by passage of current**
- **arc or flash from electrical source can cause severe skin burns**
- **explosive force and falls can cause blunt trauma**
- **cardiac, neurological and other injuries occur.**

A high-tension source is usually required to produce the tissue destruction characteristically seen along the path of the current. High-voltage injuries characteristically occur in an outdoor environment near power sources and lines. Electrical current can arc (jump) 1 inch from a power source or line for every 10,000 volts being carried, so that a person does not actually have to touch the source to sustain injury.

## **Low Voltage Injury**

Low Voltage is defined as less than 500 volts (local heat damage is usually evident e.g. at the edge of the mouth in kids biting electric cords)

- current not sufficient to cause tissue damage along its course except at contact site
- cardiac problems are common e.g. ventricular fibrillation

**Low-voltage injuries occur characteristically in a home or residential environment. Electrocutions in bathtubs and by electric hair dryers are the most common causes of low-voltage deaths.**

### **Contact Points of Injury**

The term "entrance and exit" sites are commonly used to describe the damage at a contact point with the electricity. These terms are really a misnomer when describing a high voltage AC current injury as the current is actually passing back and forth between contact with electricity and grounding site on the body. Low-voltage injuries usually only have a small burn (or no damage) at the point of contact.

#### **• Contact Point with Electrical Source**

Previously called the entrance site, the wound will be found anywhere on the body in contact with the source. A burn is present at the site due to the high temperature at the surface. The heat can evaporate the water on skin leading to a sunken or hollowed area.

#### **• Contact Point usually at grounding site**

This wound previously call an exit site is where the current comes to the surface. A small hole or large defect can be present depending on the size of the current and tissue resistance. The wound may look small but remember the damage is from the inside out and is therefore the damage is very deep.

## **Pathway of Current**

The pathway of current can be somewhat unpredictable, but, in general, current passes from a point of entry through the body to a grounded site, i.e. , a site of lower resistance to flow compared with air, which is a poor conductor. Extremely high voltage sources usually exit in multiple areas in an explosive fashion. Current passing from hand to hand or hand to thorax has a high risk of producing cardiac fibrillation compared to hand to foot passage. Passage through the head is likely to cause an initial respiratory arrest and subsequent severe neurologic impairment.

## B. Initial Assessment and Management

### **Stop the Burning Process**

- Neutralize the heat source
- Remove smoldering clothing

### **Airway**

- Assess patency of airway
  - consider the presence of smoke inhalation injury and carbon monoxide toxicity if smoke is present

### **Breathing**

- Assess adequacy of breathing efforts (is there labored breathing, wheezing?)
- Remember that the electrical current can impair the ability to breathe. Initiate respiratory assistance, if needed

### **Circulation**

- Electrical burn to muscle acts like a crush injury
- Assess adequacy of circulation
- Shock from heart damage could be seen within minutes)
- IV placement and fluid administration
- Cardiac monitoring is indicated with electrical injury
- CPR and defibrillation per diagnosis and protocol
- Remove potentially constricting object, like jewelry
- Monitor pulse in extremities with contact point burn or thermal injury; looking for muscle or skin swelling, impairment to local circulation (compartment syndrome)
- Diagnosis of High Voltage Injury
  - \*History of contact including voltage source and exposure time
  - \*Presence of contact point burns

### **Disability**

- Brain and nerve deficits are a common problem
- Determine status of consciousness and treat accordingly (AVPU)
- Are all four extremities moving?

### **Expose and Examine**

- Presence of contact point burns (if present then patient must be transported to a hospital, preferably a burn center due to the risk of the "hidden" injury)
- Assess for presence of arc or flash burns
- Assess for other traumatic injuries

### **History**

- Contact time and exposure
- Voltage of electrical injury
- History of other traumatic injury

### **Traumatic Injuries**

- Spine support
- Splinting for fractures
- Direct pressure for hemorrhage

### **Wound care**

- Do not apply ointments or other agents to burns
- Cover with clean, dry sheet

### **Body Temperature Maintenance**

### **Pain Management**

- No oral analgesics
- Intravenous medication in small doses

### **Transfer**

- To Burn Center after ABC's

## **C. High Voltage Electrical Injury**

### **1. Pathophysiology**

The extent of injury depends on the type of current, the pathway of flow, the local tissue resistance, and the duration of contact. The electric current entering the body follows along the path of least resistance. Since resistance is an integral part of the pathophysiology of the electrical injury, differences in tissue resistance to current flow help explain the observed changes following electrical trauma.

The degree of resistance to passage directly correlates with the heat produced by the current. The resistance of dry skin is high resulting in severe local injury, often mummification, at the entrance site followed by damage along the currents path. Temperatures of several thousand degrees can develop. A wet hand will allow passage of current with little resistance and the entrance site may look quite benign while the damage by the current may be worse, as more current passes.

Tissue resistance progressively increases from nerve to blood vessel, muscle, skin, tendon, fat and bone. Bone has high resistance because of its density. Consequently, more heat is generated to adjacent tissue in the area of the bone leading to greater muscle damage deep to the surface. The electrical current itself also destroys tissue along its course, especially muscle and nerves.

### **Common Complications**

Ventricular fibrillation	Muscle necrosis
Other rhythm abnormalities	Fractures
Respiratory arrest	Hemolysis
Seizures/Coma	Renal failure
Mental changes	Hemorrhage
Hypertension	Limb loss
Retinal detachment	Anemia
Cataract(delayed)	Paresis/paralysis and other neurologic (delayed)

## **2. Skin Injury (Contact Points)**

The determination that a current injury to underlying tissue may be present is the finding of contact point sites. Their presence is diagnostic of an electrical injury beneath the skin.

The heat generated at the skin surface is dependent on the local resistance, which in the dry hand can be sufficient to generate heat in excess of 1000°C with high-voltage sources. This will lead to local mummification at the entrance. The skin appearance at the site of contact is often that of a well-defined charred wound that is depressed due to loss of tissue bulk. The wound may sometimes appear like a typical deep flame burn, except in this case the injury extends deep into the surface.

The arc burn is basically a thermal burn caused by the intense heat generated from the high tension current arcing from the wire. Tissue appearance at the contact point of the ground varies considerably. With moderate exposures, the appearance is often that of small skin ulcerations with a depressed center and heaped up edges. With passage of a large current, multiple exit sites are frequently seen along the route of the current. The appearance is often that which would be expected from explosion, since pieces of cutaneous tissue are often absent, having been blown out by the immense energy of the exiting current.

### **Contact point with High Voltage source**



Typical site would be the hand. There is a burn to the hand from generated heat. The entrance site is the blackened area on the wrist where there appears to be a defect as the water, in the skin and beneath, has vaporized.

### **Contact point with High Voltage source**



Injury is from 10,000 volts. There is obvious mummification or total destruction of the hand and the wrist is fixed in flexion as the tendons and muscles of the forearm have been destroyed. The loss of tissue water shortens the now dead tissue. The wound at the elbow crease resulted from the heat of the current as it traveled up the arm.

### Contact Point at victim Grounding site



The site where the passing current reaches the surface can often look like holes and appear innocuous. However, these wounds are deep as the current is coming from the inside out. A wound such as this, commonly seen on the foot, clearly indicates passage of a high voltage current through the body.

### Contact Point with Surface



A more dramatic contact point “blowout” type wound is shown where the fourth and fifth toes are destroyed.

## 3. Body Burns

Burns from the heat of an electrical arc, flash or clothes catching fire, are common with high voltage injuries.

### Arc Burn to arm



Intensive heat is generated when the high voltage current jumps to the victim from the source. This heat will cause deep surface burn. Clothes often catch fire as well.

#### **4. Muscle Damage**

Electrical burns more closely resemble a crush injury than they do a thermal burn. The damage below the skin where the current passes is usually far greater than the appearance of the overlying skin would indicate. The immediate damage to muscle is caused by the heat, which is usually patchy in distribution along the course of the current, often most severe near the bones.

Within minute of injury the dead muscle releases its red pigment, myoglobin, into the blood stream. The muscle rapidly swells compressing local nerves and blood vessels. An incision through the overlying layers will be necessary to release the pressure (called a fasciotomy).

#### **Electrical Burn with dead muscle**



The pale looking dead muscle is beneath normal skin, near the mummified foot (contact point). An invasion has been made to avoid the pressure of swollen muscle from damaging nerves and remaining living muscle.

#### **Muscle Pigment in urine**



The dark nearly black urine on the left is caused by the muscle damage and pigment release. The urine gradually gets clearer over 24 to 48 hours with fluid resuscitation, however, kidney failure can result.

#### **5. Heart and Blood Vessel Injury**

Immediate cardiac arrest is the most common cause of death after electrical injury. The process is due to both the direct alteration of rhythm by the current, leading to fibrillation or to the depression of respiration and subsequent hypoxia. Hand to hand passage of a high voltage current has a reported immediate mortality of 60%. The initial heart problems are often reversible with CPR. High blood pressure is also quite common immediately after injury.

## **6. Lung Injury**

Impairment of the brain centers stimulation of breathing and severe central nervous system damage will lead to lack of breathing, which is frequently the cause of immediate death. Decreased muscle activity in the chest wall caused by a chest burn, muscle damage, or second-degree blunt traumatic injuries can markedly impair breathing.

## **7. Neurologic Injury**

Acute central nervous system damage with coma, seizures, motor and, to a lesser extent, sensory deficits are well described. Many of these abnormalities are permanent.

## **8. Orthopedic Injury**

Orthopedic injuries occur as a result of three processes:

- Muscle spasm-induced fractures and dislocations
- Heat-induced local bone destruction
- Devascularizaton of bone

The most common orthopedic injury occurs as a result of severe immediate muscle spasm, which is capable of producing long bone fractures and dislocation at major joints. Heat necrosis of local periosteum with subsequent production of non-viable bone and sequestrum formation is the next most common process. Devascularization of bone due to the same vascular injury affecting other tissues is less common.

### **Humerus fracture from initial muscle spasm**



Humerus fracture caused when the muscle went into intense spasm with contact with the current.

## **9. Eye and Ear Injuries**

Conjunctival and corneal burns as well as ruptured ear drums are well described early changes.

## **D. Low Voltage Electrical Injury (up to 500 volts)**

### **Pathophysiology**

- Tissue necrosis or severe burns are not present**

- Cardiac Problems**

**The most severe injury is electrocution as a household current applied to wet skin is sufficient to cause ventricular fibrillation and cardiac arrest (only 60 millamps is required). Other rhythm disturbances can also occur.**

- Muscle Spasm**

Tetany and spasm can also develop with contact with low voltage. The "can't let go" current is only 30 millamps. The spasm in the flexor muscles in the hand and forearm prevents the victim from letting go. Suffocation can also occur if the chest muscles go into spasm as the victim can't breathe. This problem is most commonly seen with immersion in water like a bath tub.

- Oral Burn**

Low-voltage electricity is the leading cause of electrical injury in children, especially 1 to 2 year olds. Sucking an extension cord is responsible for more than half of the injuries, and biting on an electric cord accounts for about 30%. The most common mechanism is the production of an electrical arc by the bared wires conducted by the child's saliva. Intense local heat is generated, producing severe local destruction of mouth tissues.

The local mouth burn is characteristically grayish-white in color and indented at the center due to tissue necrosis. Severe swelling then develops a venous thrombosis impedes blood return. The oral burn may involve lip, tongue or oral mucosa and underlying bone. The most frequent site is the lip, in particular the commissure area between upper and lower lip. The swelling of the lips may be intense, impairing control of saliva. Swelling subsides over the next 5 to 10 days and local necrotic tissue begins to slough. Bleeding from labial artery at the edge of the mouth is a common occurrence (20%) during the period of slough (7 to 21 days) and should be anticipated. Pressure control of bleeding will be necessary.

<b>Oral Burn</b>	
	Typical appearance of an electrical cord burn.

## VI. Burns to High Risk Areas



- Face Burns
- Foot Burns
- Perineal Burns
- Hand Burns
- Ear Burn

## **Face Burns**

Facial burns require considerable care to avoid progression and infection. Two to three times a day gentle washing followed by application of topical antibiotics as needed. Admission to a burn center is often required except for small superficial burns. The face burn is usually treated open with bacitracin or Neosporin for superficial burns, and silvadene(SSD) for deep burns. A temporary skin substitute can be used on superficial to mid – partial thickness burns.

## **Foot Burns**

Foot burns are at high risk for conversion to a deeper burn. Dependent edema due to walking or sitting will further decrease blood flow increasing the risk of conversion and infection. The ability to function, especially with bilateral burns is an issue that will determine disposition.

Deep foot burns are considered major burns and require admission for elevation and early surgery. Superficial burns, as with the face, may require admission for elevation, pain management and dressing changes, especially with bilateral burns.

## **Burns of the Perineum**

Perineal burns are at high risk for infection and require frequent cleaning and reapplication of antibiotics. Burn Center admission is always required for deep burns.

## **Hand Burns**

Hand burns are high risk for two reasons:

1. The risk for extension of the depth of burn edema from lack of elevation or infection is high risk. Often the discomfort of cleaning decreases the quality of cleaning at home.
2. Decrease in activity due to pain will result in a rapid decrease in strength and range of motion.

Deep hand burns require burn center admission and extensive superficial burns will benefit from short term admission.

## **Ear Burns**

Ear burns are notoriously undertreated. The risks of complications are extremely high as the cartilage blood supply is essentially negligible. The depth of the injury is underestimated because eschar is not commonly present even though the burn is deep. The risk of infection and chondritis is high. Any pressure on the burned ear by a dressing, a pillow, etc., will increase the risk of further damage and chondritis which can destroy the cartilage. Ear burns should be managed in a burn center.

## **Deep Ear Burn**



Note the white color and swelling indicating a deep burn.

### III. Cold Injuries: Hypothermia and Frostbite



- Classification of Hypothermia
- Initial Assessment and Management
  - The re-warming process
- Classification of Frostbite
- Initial Assessment and Management
  - The re-warming process

## **A. Overview**

Accidental hypothermia consists of an uncontrolled lowering of the body temperature below 95°F (35°C) by exposure to cold.

Cold exposure is magnified by moisture and wind. The chilling effects on the body are the same for exposure of 20°F air with a 40-mile per hour wind and zero degrees with a 2 mile per hour wind. Moisture or any wetness of the body will increase the rate of heat loss by 100 fold.

Hypothermia in cold water can occur in seconds compared to minutes to hours with cold air.

When the core (body) temperature drops below 89°F (32°C) the patient may appear dead, as pulse and respirations will be difficult to detect.

Frostbite often occurs in a hypothermia victim. In frostbite, skin and muscle freeze. However, frostbite can occur in the absence of hypothermia and vice versa. Therefore, the two processes will be described separately.

## **B. Hypothermia (Exposure)**

The initial body response to a dropping temperature is to produce more heat by shivering. As that fails and temperature falls further the need for oxygen decreases, as does the body's metabolism. Initially, this is a protective mechanism: heart rate fall, breathing decreases and brain function diminishes leading towards an unconscious state.

However, as body temperature continues to fall, tissue damage from freezing will occur and the heart will eventually stop and death will eventually result.

Shivering is the body's attempt to increase body heat by muscle activity. It is standard response when temperature starts to fall but fatigue will impair the process, especially if no food is available.

As body temperature falls further, shivering stops and heat production is decreased to preserve remaining body heat. Unconsciousness, drugs, alcohol, all suppress shivering and lead to a more rapid drop in temperature.

### **High Risk Factors for Hypothermia**

- elderly or small children due to thin skin
- cold environment
- wet skin in modest cold
- cool water exposure (heat is lost 100 times faster if skin is wet)
- alcohol or drug use increasing risk of exposure and decreasing shivering
- unexpected, prolonged exposure relative to protective clothing

Hypothermia may be classified by duration into acute (several minutes to a few hours) to subacute (several hours to a day), chronic (one to more days).

Acutely, there is a large difference between body core and outside temperatures. In subacute and chronic hypothermia, the differences between body core and outside temperature is decreased.

#### **Classification by the Environmental Cause**

1. **Immersion Hypothermia** is usually acute or subacute and results from immersion in cold water. A similar hypothermia can be due to exposure to cold rain and high winds
2. **Field Hypothermia** occurs in previously healthy individuals such as skiers, climbers, hunters, and hikers and may accompany injuries occurring outdoors in cold weather.
3. **Urban Hypothermia** occurs in individuals with a physical predisposition, disability or illness. Predisposing conditions include those which increase heat loss (in infants and newborns with relatively large surface areas), or interference with production, i.e., the elderly with impaired circulation.
4. **Hypothermia** occurs when the body core is accidentally cooled to below 95°F. It can be caused by exposure to cold, snow or ice.

#### **Classification by Health Status**

1. **Primary Hypothermia** is due to an overwhelming exposure to cold air or water in a previously healthy person (not common)
2. **Secondary Hypothermia** occurs when a milder cold exposure is combined with an impairment in the ability to generate body heat
  - injury, trauma, burn
  - pre-existing illness
  - elderly and small children
  - drugs, alcohol

#### **Clinical Classification**

**Mild Hypothermia** is defined as a body temperature between 90-95°F or 32-35°C.

Usual Characteristics:

- shivering
- anxious unless there is another factor altering consciousness
- pulse increased
- respiratory rate is normal to increased
- skin cool
- appearance overall may be normal

**Moderate Hypothermia** is defined as a body temperature between 86-90°F or 30-32°C

Usual characteristics

- shivering may be depressed
- somnolent, disoriented
- blood pressure may be normal
- respiratory rate lower than normal
- appearance pale to gray

**Severe Hypothermia** is defined as a bodily temperature below 86°F or 30°C

Usual Characteristics

- unconsciousness
- slow pulse, often less than 10bpm or non-palpable
- low or often no obtainable blood pressure
- breathing may appear absent
- appearance is gray to cyanotic
- skin is very cold, mottled

**Remember the range of a normal thermometer does not go below 90°F or 32°C**

### **Fatal Hypothermia**

It is very difficult to determine death in the hypothermic patient. Patients who appears to have suffered a cardiac arrest from a low body temperature should not be pronounced dead until they are re-warmed. The exception would be a pre-existing fatal event (i.e. massive head injury) with no functions prior to development of hypothermia.

### **Prevention of Hypothermia**

Heat loss occurs through conduction, convection, evaporation, radiation and respiration. Heat loss through conduction and convection can be minimized through the use of insulation and wind proof materials. Clothing should be worn in layers to trap several layers of still air warmed by body heat.

The best fabrics are wool, with polyester, acrylic and synthetics a close second. Cotton has poor insulating value, especially when wet. These fabrics are worn typically as the innermost two or three layers. Outer layers should be of "lofting" materials, such as polyester and nylon pile and fleece. The outermost layer should be windproof and water resistance fabric.

Heat loss by evaporation is avoided by wearing water-repellant outer garments by drying off quickly or changing into dry clothes when wet, and by removing layers to avoid perspiring.

Heat loss by radiation is avoided principally by wearing a hat. Circulation to the head is not reduced in the cold, and up to 70% of total body heat can be lost through an uncovered head. Body parts with a large surface area to volume ratio (nose, ears, toes and fingers) should be protected. Mittens are preferable to gloves. Tight boots and other garments which restrict circulation should be avoided. In cold windy weather, a face mask should be worn and in extreme conditions the individual should seek shelter. Alcohol and tobacco should be avoided during cold exposure.

### **Prevention of Further Hypothermia in the Patient**

- remove and replace the wet clothing with warm blankets
- recognize the risks of rapidly developing hypothermia in a compromised, ill or injured patient even in a mildly cool environment
- minimize time to re-warming

### **Diagnosis**

- Circumstances of the patients environment
  - cold air environment
  - cool water immersion
- History of exposure time
- Symptoms compatible with hypothermia ranging from shivering to an unconscious state
- Physical findings
  - low pulse
  - cool skin
  - gray to cyanotic appearance
  - disoriented to unconscious

### **Treatment**

The most critical phase of treatment is initiation of measures to avoid post rescue collapse during the first 30 minutes following rescue and during transport

## **C. Initial Assessment and Management of Hypothermia**

### **Airway**

- standard airway management

### **Breathing**

- assist if breathing is inadequate
- endotracheal intubation for severe hypothermia
- provide oxygen

### **Circulation**

- obtain vital signs
- often difficult to palpate pulse due to vasoconstriction
- do not assume victim is dead until re-warmed
- check EKG for presence of rhythm
- in presence of a stable rhythm, CPR is not necessary and may actually initiate ventricular fibrillation
- in absence of a stable or inadequate rhythm, initiate CPR
- continue CPR until patient is re-warmed
- initiate IV access and fluid therapy per protocol

### **Disability**

- note brain and nervous system function use A-V-P-U
- look for other causes for disability i.e. trauma, drugs, alcohol

### **Look for other traumatic injury or illness**

### **D. Actions for all Patients**

- Remove wet garments
- Protect against heat loss and wind chill (use blankets and insulating equipment)
- Maintain in horizontal position to protect against development of shock
- Avoid any rough handling or excess movement - the cold heart is very irritable and any jolting could initiate a cardiac arrest
- Avoid a further drop in body temperature during rescue (after-drop)
  - avoid muscle activity of the hypothermic victim as this can pump cold peripheral blood from the arms and legs into the main circulation further decreasing temperature
    - if ventilatory assist is required don't use cold ambient air if possible, as 10-30% of heat loss comes by way of an exchange in the lungs
    - best to first move to a warmer environment
- Monitor core temperature
  - rectal probe
  - esophageal probe
  - must use low range thermometer
- Monitor cardiac rhythm

Management of cardiac arrest due to hypothermia is quite different from management of normothermic arrest. The hypothermic heart may be unresponsive to cardioactive drugs, pacemaker stimulation, and defibrillation, and drug metabolism is reduced. Administered medications, including epinephrine, lidocaine, and procainamide, can accumulate to toxic levels if used repeatedly in the severely hypothermic victim.

### **E. Re-warming**

Passive re-warming is initiated in all patients to avoid any further heat loss. This approach is provided in the field and is effective for temperature above 92°F or 34°C if further heat loss is prevented. Active re-warming is added in definitive care.

#### **Passive Re-warming**

- Removing the patient from the cold environment
- Keep the patient dry
- Replace wet clothing
- Apply external heat to both sides of the patient using whatever heat is available. This can include the body heat of the rescuers
- Keep the patient in a warm environment
- Monitor core temperature, respiration and pulse

Active re-warming needs to be added for temperatures at or below 92°F or 32°C

### **Active External Re-warming**

- Re-warm in bath water of 105-110°F or 40-42°C water temperature

### **Active Internal Re-warming**

- Use of warmed IV fluids
- Warm humid oxygen (42-46°C)
- Heated inhaled air (42-46°C)
- Heart lung bypass re-warming (extra-corporeal re-warming)

### **Transport**

Transport to the nearest appropriate emergency facility

### **Prognosis**

Survival can be expected in 50% of patients whose core temperature drops below 32.2°C. Coexisting diseases (e.g. stroke, neoplasm, myocardial infarction) are common and increase the death rate to 75% or more. Survival does not correlate closely with the lowest absolute temperature reached. Death may result from pneumonitis, heart failure or renal insufficiency.

## **F. Frostbite and related cold injuries**

### **Overview**

Frostbite involves freezing of tissues. Ice crystals form leading to tissue damage. Skin and muscle are considerably more susceptible to freezing damage than tendons and bones, which explains why the patient may still be able to move severely frostbitten digits.

Frostbite is caused by cold exposure, whose effects can be magnified by moisture or wind. For example, the chilling effects on skin are the same with an air temperature of 20°F and a 30-mile per hour wind as with an air temperature of 0°F and only a 2-mile per hour wind. Skin contact with metal or any solvent like gasoline in very cold weather can cause virtually instantaneous freezing; skin will often stick to metal and be lost. The risk of frostbite is increased by generalized hypothermia, which decreases skin blood flow as part of the mechanism for preservation of core body temperature. Two related injuries, trench foot and immersion foot, involve prolonged exposure to wet cold above freezing (e.g. 10°C). The resulting tissue damage is produced by ischemia.

Children are at greater risk for frostbite than adults because their skin is thinner and less weathered. Also, children lose heat from the skin more rapidly.

### **Risk Factors**

- Extremes of age
- homelessness
- Immobilization
- Exposed skin in harsh conditions
- Exposure to water or dampness
- Working outdoors in the cold
- Outdoor winter activities
- Inadequate or tight fitting clothes
- Fatigue
- Altered mental status
- Use of nicotine or other vasoconstriction drugs
- Mountain climbing
- High altitude
- Previous cold injury

### **Diagnosis: Frostbite and related injury**

Frostbite of varying degrees looks quite similar when first seen. The magnitude of damage becomes evident with re-warming and time to demarcation.

### **Signs and Symptoms**

- reddened, blue or pale cold skin
- puckering and painful with superficial frostbite
- blistering
- painless, numb with white waxy appearance, with deep frostbite
- gangrene with prolonged exposure

### **Common Locations**

- hands
- feet
- skin
- cheeks
- nose
- ears
- corneas

### **Initial Classification**

#### **Superficial Frostbite**

- only the skin and fat below the skin are frozen
- tissues beneath are still compressible with pressure

#### **Deep Frostbite**

- skin, fat and underlying tissue like muscle are all frozen
- the extremity or body part has a hard "wood like" feeling
- likely a third or fourth degree injury

### **Frostnip**

A minor variant of this syndrome is a transient blanching and numbness of exposed parts that may progress to frostbite if not immediately detected and treated. It often appears on the tips of fingers, ears, nose, chin or cheeks and does not lead to skin loss if re-warmed.

### **Cold immersion foot (or hand)**

Describes a non freezing injury of the hands or feet, typically in soldiers, sailors or fishermen, resulting from chronic exposure to wet conditions and temperatures just above freezing, i.e. 35-50°F (1.6-10°C). Although the entire foot may appear black, deep tissue destruction may not be present. The damage may turn out to be skin alone after re-warming.

**Chilblain or pernio** is mainly a skin manifestation of chronic repetitive damp cold exposure, as might occur in fishermen, or chronic dry cold exposure, as might occur with mountain climbers. It typically occurs on the face, skin, or back of hands and feet, areas poorly protected or chronically exposed to the environment. It is characterized by itching, red-purple skin lesions. With continued exposure, skin ulcers appear and progress to scar with itching replaced by tenderness and pain.

## **Final Classification of Frostbite after Re-warming**

**First degree:** redness and swelling without skin breakdown

**Second degree:** large, clear blister formation accompanies the edema with partial thickness skin loss

**Third degree:** full thickness skin and fatty tissue destruction occurs commonly with hemorrhagic vesicle formation

**Fourth degree:** full thickness skin destruction including muscle and bone with gangrene

While the affected body part is initially nearly always hard, cold, white and anesthetic, the appearance of the lesion changes frequently during the course of treatment. Additionally, the initial treatment regimen is applicable for all degrees of insult and the initial classification is often not prognostically accurate. The degrees of damage are comparable to the degrees of burn injury, as opposed to a burn.

However, the final degrees of tissue destruction is usually less with cold injuries than initial findings indicate. Some of the initially damaged tissue recovers whereas with a burn, what you might see initially usually gets worse over time.

## **Second Degree Frostbite**



Blisters typically occur after re-warming.  
Initial appearance would be white and not blanching.

### **Treatment**

- Remove from cold environment
- Manage the ABC's
- Look for other injuries or illness
- Begin to treat any hypothermia
- Remove damp or constricting clothing and replace with loose garments
- **NO ATTEMPT SHOULD BE MADE TO RE-WARM THE FROSTBITTEN AREA IN A COLD ENVIRONMENT**
- Do not attempt any re-warming if there is a danger of re-freezing
- Avoid rubbing the affected area with warm hands or snow, as this can cause further injury
- Avoid applying pressure to the frostbitten area
- Cover blisters and injured area with a soft dressing
- If the affected body part is an extremity, wrap it in a blanket for mechanical protection during transport
- Avoid any medication which can enhance heat loss and impair shivering
- In the absence of a life threatening problem like severe hypothermia, it is better to walk with frozen feet to a safe environment than attempting to re-warm in a cold environment.
- Once removed from the cold: elevate the injured area to reduce any developing swelling
- During long transport in warm air environment (60 minutes)
  - can begin to re-warm by immersion of the frostbitten area in water 100-105°F
  - do not use dry heat as the risk of compounding the injury is great with any method of thawing other than immersion in warm water
  - process of re-warming may take 30-45 minutes
  - return of color and sensation indicates thawing
  - once thawed patient cannot walk on cold injured feet
  - elevate the injured area

### **In-Hospital Care**

The frostbitten part should be re-warmed (thawed) in a water bath or whirlpool at around 100F for 20-30 minutes. Thawing should not be attempted until the victim can be kept permanently warm and at rest. The risk of seriously compounding the injury is great with any method of thawing other than immersion in warm water. After thawing has been completed, the patient should be kept recumbent and the injured part left open to air, protected from direct contact with sheets, clothing, etc. Blisters should be left intact and the skin gently debrided by immersing the part in a whirlpool bath for about 20 minutes twice daily. No scrubbing or massaging of the injured part should be allowed, and topical ointments, antiseptics, etc., are of no value. Very conservative debridement is recommended as some tissue recovery is expected. Extreme care must be provided to prevent infection.

### **Prognosis**

Prognosis for a superficial frostbite is excellent, if appropriate treatment is provided. Some tissue loss is likely with deep frostbite.

- Favorable prognostic signs - Early sensation to pinprick - Healthy appearing skin color - Clear rather than blood filled blebs
- Poor prognostic signs - Cyanosis (blue-gray color) - Bloody blebs or blisters that do not extend to tips of digits - Frozen appearance
- Short Term: infection, soft tissue loss, gangrene, loss of nails
- Long Term: painful tingling sensations in the area, excessive sweating in the area, extreme cold sensitivity, abnormal skin color, muscle atrophy, joint stiffness, tremors.