AIRWAY BURNS: MORE THAN IN THE HEAT OF THE MOMENT

PAT DELANEY, RN, CCRN
UVM MEDICAL CENTER
APRIL 4, 2019
Objectives

• Describe several mechanisms of causing airway burns

• Identify 3 types of inhalation injuries

• Explain early management of airway burns

• List criteria for transfer of airway burns to a burn center
Disclosures

• None... other than a love for this topic!
Data

• Each year in the United States 450,000 people receive medical attention for burn injuries.

• Approximately 45,000 people are hospitalized for burn injuries each year

• The leading cause of fire death in the United States is fire due to smoking materials, especially cigarettes.
Smoking on O’s
Types of Burns

- Thermal injury (hot and/or cold)
- Inhalation injury
- Electrical injury
- Chemical burns
- Radiation injury
- Blast injury
Severity of Burns

- Superficial/1st degree
- Partial thickness/2nd degree
- Deep partial thickness/Deep 2nd degree
- Full thickness/3rd degree
- 4th degree
Superficial/1st Degree
Partial Thickness/2\textsuperscript{nd} Degree
Deep Partial Thickness/Deep 2\textsuperscript{nd} Degree
Full Thickness/3\textsuperscript{rd} Degree

THIRD DEGREE BURN
4th Degree
So Why Do We Care About the Depth of Burn?

Lund and Browder

Relative percentage of body surface area (% BSA) affected by growth

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Age (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>a = 1/2 of head</td>
<td>9 1/2</td>
</tr>
<tr>
<td>b = 1/2 of 1 thigh</td>
<td>2 3/4</td>
</tr>
<tr>
<td>c = 1/2 of 1 lower leg</td>
<td>2 1/2</td>
</tr>
</tbody>
</table>

How Do These Other Burns Affect the Airway??

• Burns greater than 20% TBSA are associated with increased capillary permeability and intravascular volume deficits that are most severe in the first 24 hours post injury. Optimal fluid resuscitation aims to support organ perfusion with the least amount of fluid.

• Large fluid volumes shift...into places such as the lungs, leading to pulmonary edema, respiratory collapse, etc.

• Large partial thickness burns can be so painful that high doses of pain meds will be required, leading to respiratory insufficiency.
Let’s Focus on the Respiratory Stuff!!
Inhalation Injury

• Definition: Inhalation and/or aspiration of superheated gases, steam, hot liquids or products of incomplete combustion

• Common cause of fire-related deaths at the scene

• Present in 2-14% of burn center admissions
Distinct Types of Inhalation Injury

• Systemic poisons: carbon monoxide & cyanide (non-inflammatory)

• Upper airway (inflammatory)
  • Supraglottic (above the vocal cords)
  • Direct heat or chemicals – edema

• Lower airway (inflammatory)
  • Subglottic (below the cords)
  • Parenchymal pulmonary edema
Carbon Monoxide (CO) Poisoning

• Odorless gas
• Binds hemoglobin with an affinity 200 X greater than oxygen
• Plasma carboxyhemoglobin level essential to diagnose CO poisoning
## CO Poisoning

<table>
<thead>
<tr>
<th>CO level (%)</th>
<th>Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>None</td>
</tr>
<tr>
<td>10-20</td>
<td>Tension in forehead, dilation of skin vessels</td>
</tr>
<tr>
<td>20-30</td>
<td>Headache, pulsating temples</td>
</tr>
<tr>
<td>30-40</td>
<td>Severe headache, nausea, vomiting, collapse</td>
</tr>
<tr>
<td>40-50</td>
<td>As above plus syncope, increased respiratory/heart rate</td>
</tr>
<tr>
<td>50-60</td>
<td>As above, plus coma, seizure, Cheynes-Stokes respirations</td>
</tr>
<tr>
<td>&gt;60</td>
<td>Coma, seizures, weak respirations and pulse, possible death</td>
</tr>
</tbody>
</table>
CO and HCN Poisoning Treatment

• CO
  – Treat with 100% Oxygen
  – Decrease CO half life from 4 hours to 1 hour
  – Goal: carboxyhemoglobin < 10%
  – Hyperbaric oxygen: likely not beneficial

• HCN
  – Empiric treatment based on index of suspicion
  – Antidote: hydroxycobalamin... Vitamin B12!!
**Hyperbaric Oxygen Therapy**

<table>
<thead>
<tr>
<th>Therapeutic roles for hyperbaric oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air or gas embolism</td>
</tr>
<tr>
<td>Carbon monoxide poisoning</td>
</tr>
<tr>
<td>Decompression sickness</td>
</tr>
<tr>
<td>Clostridial myonecrosis</td>
</tr>
<tr>
<td>Crush injury and other forms of traumatic ischemia</td>
</tr>
<tr>
<td>Enhanced healing of problematic wounds, including diabetic wounds</td>
</tr>
<tr>
<td>Severe anemia</td>
</tr>
<tr>
<td>Actinomycotic brain abscess</td>
</tr>
<tr>
<td>Necrotizing soft tissue infections</td>
</tr>
<tr>
<td>Refractory osteomyelitis</td>
</tr>
<tr>
<td>Radiation necrosis of soft tissue and bone</td>
</tr>
<tr>
<td>Compromised skin grafts and flaps</td>
</tr>
</tbody>
</table>

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Graphic 75304 Version 2.0
How Helpful is Hyperbaric Treatment?

Carboxyhemoglobin half-life during hyperbaric oxygen in a patient with lung dysfunction: a case report.

Weaver LK¹, Deru K¹.

Author information

Abstract

INTRODUCTION: The carboxyhemoglobin half-life (COHb t1/2) during hyperbaric oxygen (HBO₂) is often quoted as 23 minutes, derived from the average of two adult male volunteers breathing HBO₂ at 3 atmospheres absolute (ATA). However, the mean COHb t1/2 of 12 male volunteer smokers was 26.3 minutes at 1.58 ATA and in 12 non-intubated carbon monoxide (CO) poisoned patients treated at 3 ATA, was 43 minutes.

CASE REPORT: An 81-year old male, poisoned by an improperly ventilated natural gas heater, was intubated for coma, then treated with HBO₂. His PaO₂/FiO₂ = 283 from aspiration. His initial COHb was 34.4%, and 18 minutes before HBO₂, 5.9%. After a compression interval of 17 minutes, the COHb measured after 22 minutes at 3 ATA was 3.3%.

RESULTS: By exponential decay, his COHb t1/2 before HBO₂ was 95 minutes. We estimate the range for COHb t1/2 during compression as 62-81 minutes and for the 3-ATA interval, 58 to 49 minutes, respectively. The mid-point estimate of COHb t1/2 at 3 ATA was 53 minutes.

CONCLUSIONS: The COHb t1/2 we calculated is greater than previously reported, but longer in our patient possibly because of concomitant respiratory failure, lung dysfunction, and mechanical ventilation. The often-cited COHb t1/2 of 23 minutes, likely underestimates the actual COHb t1/2 in CO-poisoned patients, especially those with cardiopulmonary dysfunction.
Cyanide Treatment

Clinical features

History
- Ascertain if patient has access to cyanide, or if patient was part of a high-risk event (e.g., fire, industrial exposure)
- Initial symptoms are nonspecific: headache, anxiety, confusion, abdominal pain

Physical examination
- Vital signs: Initial hypertension/tachycardia/tachypnea progresses to respiratory and circulatory collapse
- Skin: may be flushed with "cherry red" color
- Neurologic: seizures and coma as poisoning progresses

Laboratory evaluation
- Obtain the following:
  - Fingerstick glucose, acetaminophen and salicylate levels, electrocardiogram, and pregnancy test (when appropriate)
  - Basic chemistries and serum lactate
    - Elevated anion gap acidosis, with elevated lactate, expected in cyanide poisoning
    - Venous blood appears bright red
  - Central venous blood gas with concomitant arterial blood gas
    - Narrowed venous-arterial PO2 gradient supports cyanide toxicity
    - Carboxyhemoglobin and methemoglobin levels
  - Rule out dyshemoglobinemias
  - Use nitrates (see below) cautiously or not at all in presence of dyshemoglobinemias

Cyanide poisoning can cause: renal failure, hepatic failure, rhabdomyolysis, pulmonary edema; obtain relevant studies as indicated

General treatment

Secure airway, breathing, and circulation. Intubation is usually required. Administer high-flow oxygen by nonrebreather face mask regardless of pulse oximetry reading.

Do NOT perform mouth to mouth resuscitation in cases of suspected cyanide toxicity. Patients with dermal exposure must be decontaminated using proper precautions.

Give a single dose of activated charcoal if the airway is adequately protected (50 g in adults; 1 g/kg in children with maximum dose of 50 g)

Treat hypotension with rapid IV boluses of isotonic fluid and vasopressors as needed. Treat seizures with a benzodiazepine (e.g., diazepam 5 mg IV).

Obtain assistance from medical toxicologist or poison control center

Antidotal treatment

Administer cyanide antidote when cyanide poisoning is clinically suspected. Hydroxocobalamin is the preferred antidote.

If hydroxocobalamin is available, give the following:
- Hydroxocobalamin 70 mg/kg up to 5 g IV (5 g is standard adult dose)
- Sodium thiosulfate (25 percent) 1.65 mL/kg up to 50 mL IV; may repeat once (maximum dose 12.5 g)

If hydroxocobalamin is not available, cyanide toxicity is known or strongly suspected, and there are no contraindications to nitrates, give the following:
- Sodium nitrite 10 mg/kg - up to 300 mg - by slow IV infusion; may repeat once
- Sodium thiosulfate (25 percent) 1.65 mL/kg up to 50 mL IV; may repeat once

If hydroxocobalamin is not available and cyanide toxicity is possible but not certain, or the patient has contraindications to nitrates, give the following:

Sodium thiosulfate (25 percent) 1.65 mL/kg up to 50 mL IV; may repeat once

*Up-to-Date 02/21/2019
Supraglottic Injury

• Most damage above the cords
• Edema may be severe
• Intubate early if concern for airway swelling
Subglottic Injury

• Chemical injury
• Multiple chemical agents in smoke particles
• Direct epithelial damage
• Bronchoscopy findings: edema, carbon deposits, erythema, ulceration
Subglottic Injury

- Severity: unpredictable based on initial history and physical
- Initial chest x-ray: often normal
- Markedly worsens prognosis
Subglottic Injury

- Sloughing of epithelial lining
- Impaired ciliary action
- Mucus hypersecretion
- V/Q mismatch
- Surfactant inactivation
- Inflammation
- Pulmonary edema
Risk Factors: History

• Enclosed space fire (house fire, car crash and fire)
• Prolonged smoke exposure
• Loss of consciousness
Risk Factors: Physical Exam

- Deep facial burns
- Soot in throat
- Carbonaceous sputum
- Agitation (hypoxia)
- Hoarseness
Airway Management

Stridor, retraction, respiratory distress and/or deep facial burn

Yes

Intubate immediately
Humidified oxygen
Call burn center

No

100% oxygen
Monitor and reassess frequently
Other Indications for Intubation

• Suspected lower airway inhalation injury
• Impaired oxygenation and/or ventilation
• Anticipated large volume resuscitation
• When in doubt, consult the burn center
Endotracheal Intubation

- By most experienced person
- Oral intubation if possible
- Use appropriate size endotracheal tube
- Secure the tube well
How Do We Manage??

• **SECURE AIRWAY** (no airway = no patient!!)

• Aggressive O2 and ventilatory support
• Chest X-ray
• Labs, including carboxyhemoglobin
• Monitor for need for escharotomy
Ventilator Management
Potential Studies of Mode of Ventilation in Inhalation Injury

Michael D. Peck, MD, David Harrington, MD, Ronald P. Micak, PhD, Robert Cartotto, MD, FRCS(C)

Journal of Burn Care & Research, Volume 30, Issue 1, 1 January 2009, Pages 181–183, https://doi.org/10.1097/BCR.0b013e3181923c7a
Published: 01 January 2009

Future studies of modes of ventilation after inhalation injury fall into two categories: 1) optimizing a specific ventilator mode's use in inhalation injury followed by 2) comparison of the different ventilator modes in inhalation injury. The key to determining optimal ventilator strategies is the use of well-defined hypotheses in conjunction with meticulous study design. Studies assessing modes of ventilation after smoke inhalation injury should include attention to several issues that arose during the trials of low tidal volume therapy. Ventilatory goals need to be clarified, and protocols for ventilator adjustments need to be developed. For example, during permissive hypercapnia, how low can the pH descend without needing treatment, and when respiratory acidosis does need treatment, should it be done with sodium bicarbonate, increased ventilation rate, or larger tidal volumes need to be clarified prior to study initiation. When tidal volumes are calculated...
Volumetric Diffusive Ventilator

David Harrington, MD, FACS

Journal of Burn Care & Research, Volume 30, Issue 1, 1 January 2009, Pages 175–176,
https://doi.org/10.1097/BCR.0b013e3181923c44
Published: 01 January 2009

Following an airway and parenchymal injury such as inhalation injury, an ideal ventilator would apply low peak airway pressures, facilitate clearance of soot, sloughed mucosa and secretions, and recruit collapsed airways. The Volume Diffusive Respirator (VDR), which has been utilized for the management of burn patients with inhalation injury since the mid 1980s, has these abilities. It is a pneumatically powered, pressure limited ventilator that stacks oscillatory breaths to a selected peak airway pressure by means of a sliding venturi called a phasitron. After inspiration, exhalation is passive and ends at a selected level of oscillatory CPAP. A retrospective analysis comparing the VDR ventilator to conventional volume ventilation, in patients with similar distribution of age and burn sizes, revealed a decreased rate of pneumonia and mortality in those patients ventilated with the VDR. The beneficial
Use of High Frequency Oscillatory Ventilation in Inhalation Injury

Robert Cartotto, MD, FRCS(C)

*Journal of Burn Care & Research*, Volume 30, Issue 1, 1 January 2009, Pages 178–181,
https://doi.org/10.1097/BCR.0b013e3181923c6a

Published: 01 January 2009

High frequency oscillatory ventilation (HFOV) is an unconventional form of mechanical ventilation which has been used for the past two decades in the neonatal intensive care unit for respiratory distress syndrome. Recognition of HFOV’s lung protective properties combined with sound physiologic evidence of its ability to open and recruit the lung, have led to translation of HFOV to the adult ICU, for patients with the Acute Respiratory Distress Syndrome (ARDS). Initially HFOV was employed as a rescue therapy for severe ARDS cases with end-stage oxygenation failure. More recently, however, HFOV has been successfully employed as a ventilation approach earlier and earlier in the course of ARDS among diverse patient populations including burn patients.

Currently, very little has been reported on the use of HFOV after inhalation injury, aside from one animal experiment,¹ a pediatric case report,² and data (unpublished) from...
Airway Pressure Release Ventilation

Ronald P. Mlcak, PhD, RRT, FAARC

*Journal of Burn Care & Research*, Volume 30, Issue 1, 1 January 2009, Pages 176–177, https://doi.org/10.1097/BCR.0b013e3181923c58

**Published:** 01 January 2009

Airway pressure release ventilation (APRV) is a relatively new approach to ventilation that was first described by Stock et al. APRV can be classified as a time–triggered, pressure–limited and time–cycled ventilation mode. Basically, APRV provides two levels of airway pressure, Pressure high (P high) and Pressure low (P low) during two time periods, Time high (T high) and Time low (T low). APRV usually involves a long T high (4–7 seconds) and a short T low (0.5–0.8 seconds). Because of this APRV has been referred to as a ventilation mode that basically sets a continuous positive airway pressure that intermittently time–cycles to a lower airway pressure. Additionally, APRV uses an active exhalation valve that allows spontaneous breathing during both T high and T low. APRV generates a higher mean airway pressure with a lower tidal volume and lower end–expiratory pressure when...
HFOV

CMV vs HFOV
ECMO

Centrimag-ECMO
Special Situations...
Special Situation: Pediatric Patients

- Airways are relatively small
- Upper airway obstructs easily
- Select tube carefully
- Position properly
- Small uncuffed tubes dislodge easily
- Use cuffed tubes, preferably
- Secure tube and head position
Special Situation: Escharotomy

• Definition: surgical release of tight skin burn eschar

• Indications:
  • Circumferential torso full-thickness burns AND
  • Restriction of ventilation
Stabilization

• Monitor vital signs
• Insert NGT
• Assess extremity perfusion
• Administer pain medication
• Cover burns with clean linens
• Maintain body temperature
• Documentation
CAN We Manage This Patient??
Referral Criteria

- >10% TBSA partial thickness burns
- Any full-thickness burns in any age
- Burns to face, feet, hands, genitalia, perineum, or over major joints
- Electrical burns including lightning
- Chemical burns
- Inhalation injury
Referral Criteria

• Patients with preexisting medical disorders
• Patients with concomitant trauma
• Pediatric burns in hospitals without qualified personnel or equipment to care for children
• Patients who require special social, emotional or rehabilitative intervention
Summary

- Nearly a half million burns per year, many with airway injuries
- Airway burns comprise the upper airway, lower airway and/or systemic poisonings
- Management is ASAP, and be assertive—NO AIRWAY=NO PATIENT!!
- Get help early and often
Any **Burning** Questions??