Disclosure

I have nothing to disclose…
Objectives

➢ Understand the significance of inhalation injury
➢ Explore the pathophysiology of inhalation injury
➢ Describe the initial assessment and management of the patient with inhalation injury, including indications for early airway intervention
➢ Identify treatments for inhalation injury
➢ List special considerations for children with inhalation injury
Historical Perspective

Cocoanut Grove – Boston, Massachusetts - 1942

492 fatalities with most occurring in the first 30 minutes
Primary cause of death = smoke inhalation

Image credit – radioboston.legacy.wbur.org/2012/10/31/cocoanut-grove-transcripts
Approximately 5% of inpatient burns have a concomitant inhalation injury.

Deaths from burn injury increase with advancing age and burn size, as well as the presence of inhalation injury.

Patients with inhalation injury have a higher case fatality for a given BAUX score than those with no inhalation injury.

- Fatality with low BAUX score attributed to inhalation injury.

Predicted mortality is 20% greater in the presence of inhalation injury.
<table>
<thead>
<tr>
<th>TBSA Category</th>
<th>Age</th>
<th>Inhalation Injury</th>
<th>Lived</th>
<th>Died</th>
<th>Mortality Rate</th>
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**TOTAL**  
164,235  
5,202    
3.1

Total N = 169,437 (Excluding 35,506 Unknown/Missing)
Clinical Significance

- Mortality: Immediate and late
- Airway closure secondary to edema
- Hemodynamic instability
  - Increased fluid resuscitation requirements
- Impaired gas exchange
  - Pneumonia, ARDS, etc.
- Multiple organ dysfunction syndrome
  - Systemic inflammatory syndrome
- Chronic pulmonary dysfunction
  - Laryngeal damage
Case Study

45 year old male
Explosion in oil field
8% TBSA
Partial thickness
Face & hands
PMH – asthma
No soot in mouth
No obvious airway swelling
Questions to consider…

- Does this person have an inhalation injury?
- Is supplemental oxygen indicated?
- Would you intubate prior to transfer?
- Are there any interventions/labs to consider?
- Is this person at risk for deterioration?
Differential Diagnosis

➢ Determined by history and exam
  • Mechanism of injury
  • Duration of exposure
  • Location

➢ Supported with interventional adjuncts
  • Bronchoscopy
  • Carboxyhemoglobin
  • Imaging
Pathophysiology

➢ Direct thermal damage
  • Irritation and inflammation
  • Mucosal slough
  • Bronchospasm

➢ Secondary inflammation
  • Local cytokine inflammatory response
  • Bronchorrhea, alveolar flooding, cast formation

➢ Anoxia

➢ Systemic toxicity
Supraglottic Injury

- Consequence of direct thermal injury to the upper airway
- Glottal reflex often spares the lower airway
- Obstruction is the biggest threat
Supraglottic Injury

- Burns of face and/or neck
- Singed nasal and/or facial hair
- Hoarseness
- Difficulty swallowing
- Dyspnea
- Stridor
- Signs of hypoxia
  - Agitation in the presence of inhalation injury is most likely related to hypoxia
Supraglottic Injury

➢ Maintain open airway
  • Intubate, if indicated
➢ Provide supplemental oxygen
➢ Close monitoring
➢ Appropriate fluid resuscitation
  • Inadequate resuscitation exaggerates local cytokine inflammatory response
  • Over-resuscitation exaggerates edema
Intubation

➢ Clinical judgment
  • Feel free to discuss with Burn Center

➢ Weigh the risks and benefits
  • Laryngeal injury, tube misplacement, stenosis, fistula, swallowing impairment

➢ Err on the side of safety
  • Loss of airway in the presence of upper airway edema is catastrophic

➢ Special considerations for end of life
Intubation

➢ Rapid Sequence Intubation
  • By the most experienced person

➢ Route
  • Orotracheal vs. nasotracheal

➢ Size of endotracheal tube
  • Use standard sizes for age/body type
  • Place the largest recommended size possible

➢ Secure the tube

➢ Cuff leak test prior to extubation
Would you intubate?
Would you intubate?
Would this change your mind?
Subglottic Injury

- Consequence of smoke, chemicals, or pressurized steam
- Lower airway injury
  - Glottal reflex not triggered
- Difficult to mitigate complications as effects are more diffuse
- Smaller particles are deposited distally
Subglottic Injury

- Sloughing of epithelial lining
- Impaired ciliary action
- Mucus hypersecretion
- Surfactant inactivation
- Inflammation
- Pulmonary edema
- Fibrin cast formation
Subglottic Injury

- Burns of face and/or neck
- Singed nasal and/or facial hair
- Hoarseness, sore throat, cough, difficulty swallowing
- Carbonaceous sputum
- Shortness of breath, dyspnea
- Wheezing, stridor
- Signs of hypoxia
  - Disoriented, restless, confused, agitated
Carbonaceous Material
Subglottic Injury

➤ Protect airway & support pulmonary function
  • Mechanical ventilation
  • Aggressive rotation

➤ Appropriate fluid resuscitation

➤ Suction, CPT, bronchoscopy

➤ Monitor for signs of pulmonary edema/ARDS

➤ Targeted therapy medications
  • Bronchodilators
  • Mucolytic agents
  • Anticoagulants
Fibrin Casts

Image credit – plasticsurgerykey.com/the-pathophysiology-of-inhalation-injury/
Systemic Toxicity

- Occurs with or without cutaneous injury
- Destruction at the cellular level
- Interferes with oxygen utilization
- Carbon monoxide
- Hydrogen cyanide
- Chemical warfare
Carbon Monoxide

- Carbon binds to receptors on hemoglobin
- Affinity 220 times greater than oxygen
- Hemoglobin continues to circulate through the vascular system creating ischemia
- SpO2 reading unreliable
- Carboxyhemoglobin
  - Goal < 5%
  - Smokers range from 3-15%
Carbon Monoxide

➢ Lower levels
  • Headache, fatigue, flu-like symptoms, weakness, dizziness, nausea, blurred vision, may appear intoxicated

➢ Higher levels
  • Vomiting, confusion, palpitations, seizures

➢ Levels >60 associated with cardiopulmonary arrest and death
Carbon monoxide

- 100% oxygen
- Flood receptors
- Half-life of CO
  - RA = 4 hours
  - 100% = < 1 hour

Reduction of Carboxyhemoglobin
Hydrogen Cyanide

➢ Less common than carbon monoxide
➢ Blocks oxygen utilization in mitochondria
➢ “Cherry-red” skin is the hallmark
➢ Metabolic acidosis
➢ Lactate > 10
  • Both sensitive and specific
➢ High venous pO2
  • Cells are not utilizing oxygen
Hydrogen Cyanide

- Lab for cyanide exists – not timely
- Low levels
  - Faint, flushing, anxiety, perspiration, vertigo, headache, drowsiness, tachypnea, tachycardia
- High levels
  - Hypotension, tremors, arrhythmia, convulsions, stupor, paralysis, coma, respiratory depression and arrest
- Levels > 100 - significant mortality
Hydrogen Cyanide

- Treatment via intravenous medication
- Hydroxocobalamin
  - detoxification
- Nitrates
  - neutralizing
- Sodium Thiosulfate
  - Converts cyanide to less toxic form
- Monitor closely during treatment for severe side effects
Common Complications

➢ Pneumonia
➢ Airway Obstruction
➢ Subglottic stenosis
➢ Chronic respiratory disease
Bronchoscopy

- Supports clinical diagnosis
- Allows for therapeutic removal of debris
- Allows for direct sampling
- Unable to assess distal airway and respiratory bronchioles
- Not sensitive to clinical outcomes
- Helpful, but not essential
  - Defer related to patient stability
### Bronchoscopic criteria used to grade inhalation injury

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0 (no injury)</td>
<td>absence of carbonaceous deposits, erythema, edema bronchorrhea, or obstruction (any or combination)</td>
</tr>
<tr>
<td>Grade 1 (mild injury)</td>
<td>minor or patchy areas of erythema, carbonaceous deposits in proximal or distal bronchi (any or combination)</td>
</tr>
<tr>
<td>Grade 2 (moderate injury)</td>
<td>moderate degree of erythema, carbonaceous deposits, bronchorrhea, with or without compromise of the bronchi (any or combination)</td>
</tr>
<tr>
<td>Grade 3 (severe injury)</td>
<td>severe inflammation with friability, copious carbonaceous deposits, bronchorrhea, bronchial obstruction (any or combination)</td>
</tr>
<tr>
<td>Grade 4 (massive injury)</td>
<td>evidence of mucosual sloughing, necrosis, endoluminal obliteration (any or combination)</td>
</tr>
</tbody>
</table>
Bronchoscopy
Burn compartment syndrome

- Circumferential chest/torso burns
- Compromises chest wall excursion and ventilation
- Increased peak pressures as airway compliance decreases
Escharotomy
Hyperbaric Oxygen

➢ Treats CO poisoning

➢ Indications
  • COHgb >25, or >20 in pregnant patients
  • + LOC
  • Metabolic acidosis, pH <7.1
  • End organ ischemia

➢ No evidence of superiority to standard oxygen therapy
Case Study
Case Study

➢ Respiratory failure within one day of admission with emergent intubation

➢ Bronchoscopy
  • Edematous trachea, friable tissue, bronchorrhea

➢ Significant pulmonary edema with frequent, sustained desaturations on maximum support
  • High-frequency ventilation (VDR-4), rotoprone

➢ Spontaneous pneumothoraces – CT x4

➢ Cardiac arrest without ROSC
Pediatric Considerations

Cause: Flame/Inhalation
Pediatric Considerations

- Airway obstructs easily
- Avoid hyperextension
- Smaller oxygen reservoirs
- Limited compensatory mechanisms
- Weaker accessory muscles
- Intubate
  - Be proactive
  - Use the appropriate, but largest size
  - Cuffed endotracheal tube
  - Secure
Final Thoughts

➢ Do not underestimate the significance of inhalation injury
➢ Mortality significantly increases with the presence of inhalation injury
➢ When in doubt - intubate
➢ Consult with the Burn Center
➢ Cares provided prior to arrival in the Burn Center significantly influence outcomes
References

• American Burn Association. (2016). *Advanced burn life support*.


