Inhalation Injury and Toxic Industrial Chemical Exposure
Agenda

- Contributors
- Purpose
- Summary
- Key Principles of CPG
- Performance Improvement (PI) Monitoring
- References
- List of Appendices in CPG
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Key Principles of CPG

- Background
- Evaluation and Treatment
- General Inhalation Injury
- Specific Industrial Chemicals

- PI Monitoring
- References
- Appendices
Purpose

This CPG provides evidence–based guidelines for the management of the most common toxic industrial chemicals which lead to pulmonary injury.
Patients with both burn and inhalation injury have significantly increased morbidity and mortality compared to those with burn injury alone.

Care is often supportive.
Patients with both burn and inhalation injury have significantly increased morbidity and mortality compared to those with burn injury alone.

During smoke inhalation, thermal and chemical injury are the primary initial toxicities.
Chemicals come in a variety of irritants and asphyxiants

### Mechanisms of Lung Injury of Gaseous Respiratory Irritants

<table>
<thead>
<tr>
<th>Irritant Gas</th>
<th>Mechanism of Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia (NH$_2$)</td>
<td>Alkali burns</td>
</tr>
<tr>
<td>Source: Agriculture, rain, plastic, explosive</td>
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<tr>
<td>Hydrogen chloride (HCl)</td>
<td>Acid burns</td>
</tr>
<tr>
<td>Source: Dyes, fertilizers, textiles, rubber, thermal degradation of polyvinyl chloride</td>
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<tr>
<td>Sulfur dioxide (SO$_2$)</td>
<td>Acid burns</td>
</tr>
<tr>
<td>Source: Smelting, combustion of coal/oil, paper manufacturing, food preparation</td>
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<tr>
<td>Chlorine (Cl$_2$)</td>
<td>Acid burns, free radical</td>
</tr>
<tr>
<td>Source: Paper textile manufacturing, sewage treatment</td>
<td></td>
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<tr>
<td>Oxides of nitrogen (NO, NO$_2$, N$_2$O$_4$)</td>
<td>Acid burns, free radical</td>
</tr>
<tr>
<td>Source: Agriculture, mining, welding, manufacturing of dyes/lacquers</td>
<td></td>
</tr>
<tr>
<td>Phosgene (COCl$_2$)</td>
<td>Acid burns</td>
</tr>
<tr>
<td>Source: Firefighters, welders, paint strippers, chemical intermediates (isocyanate, pesticides, dyes, pharmaceuticals)</td>
<td></td>
</tr>
</tbody>
</table>

Colors indicate water solubility – Red: High; Yellow: Intermediate; Green: Low

*Source: Medical Aspects of Chemical Warfare – Borden Institute*
Toxic chemical inhalation injury treatment generally supportive, but some specific chemicals require **antidotes**.

- Most critically ill patients require unique ventilation techniques used for Acute Respiratory Distress Syndrome (ARDS).
- Patients are at a higher risk of developing ventilator-associated pneumonia.
Evaluation & Treatment

ARDS management focuses on:

- Airway management
- Lung-protective ventilation strategies
- Aggressive Pulmonary toilet
- Avoidance of volume overload to prevent worsening pulmonary edema
Chlorine Overview

- Yellow-green gas with irritating smell commonly used in industry – found in industrial/chemical accidents and sometimes in IEDs
  - Dissolves in water to form hydrochloric and hypochlorous acids.
  - Clinical effect: tearing, skin burning, drooling, cough, shortness of breath, chest pain, hypoxia, respiratory distress.
  - If pulmonary toxicity, may worsen over days.

Photo by US Army – Dugway Proving Ground Public Affairs

Chlorine gas release
Treatment: Skin decontamination, supplemental oxygen, beta agonists, and ARDS ventilatory techniques

- Inhaled Corticosteroids (Fluticasone 200 mcg BID) may improve secondary outcomes and should be done if the patient requires intubation.

- Consider IV steroids if unable to administer inhaled or has significant bronchoconstriction.
Phosgene Overview

- Sweet, pleasant, smell of mown hay – does not prompt escape

- Combustion of chlorinated hydrocarbons (welding, fires) and synthesis of solvents (degreasers, cleaners)

- Clinical effect: Delayed ARDS (up to a day)
Phosgene Treatment

- Treatment: Observation, supplemental oxygen, and ARDS ventilation techniques

- Decontamination typically not needed

Chest radiograph 2 hours post phosgene exposure. Patient died 6 hours post exposure.

Source: Medical Aspects of Chemical Warfare – Borden Institute

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Hydrogen Sulfide

- Smells like rotten eggs
  - Exposure occurs in waste management, petroleum, natural gas industries, and asphalt/rubber factories

- Clinical effects
  - Low Concentrations: Skin and mucous membrane irritation
  - High Concentrations: Sudden loss of consciousness, seizure, myocardial ischemia, keratoconjunctivitis, and upper airway and pulmonary injury

- Treatment: Skin irrigation, supplemental oxygen, removal from exposure, **intravenous sodium nitrite (300 mg)**, and supportive care
  - Sodium nitrite associated with methemoglobinemia, and hypotension – infuse over 5-7 minutes
Ammonia

- Pungent odor
  - Common industrial and household cleaner – fertilizer, refrigerant, cleaning agent, plastic and explosive synthesis.
  - Often transported under pressure at sub-zero, liquid form

- Clinical effect: Tearing, skin irritation, eye pain/burning, severe upper airway irritation, and alkali skin burn
  - High concentrations or prolonged Exposure: Tracheobronchial and pulmonary inflammation, respiratory failure at 2-5 minutes of exposure

- Treatment: Skin and eye irrigation, alkali burn skin care, supplemental oxygen, ARDS ventilatory techniques, supportive care
Cyanide

- Colorless, often odorless or bitter almond smell
  - Manufacturing of pesticides and synthetic materials, metal extraction, and in chemical laboratories

- Clinical effects:
  - Early or mild effects: Dizziness, headache, nausea, and anxiety
  - Late or severe effects: Coma, seizure, respiratory depression, hypotension, tachycardia, ARDS, pulmonary edema

- Treatment: Oxygen, mechanical ventilation, rapid administration of hydroxocobalamin (5g over 15 minutes)
  - Second dose of hydroxocobalamin can be administered in patients with severe toxicity or poor clinical response
Colorless and odorless

- Combustion of carbon containing compounds – combustion engines and cooking stoves in enclosed spaces

Clinical effects: confusion, stupor, coma, seizure, and myocardial infarction - may have normal PaO2 and SpO2 readings

- CO levels traditionally measured using CO-oximeter in a blood gas sample
- Newer non-invasive CO-oximetry may allow for early diagnosis and better monitoring

Treatment: 100% oxygen (If available - hyperbaric oxygen therapy)
Fire Suppressants

- Generally a simple asphyxiant (displaces oxygen) often used in military vehicles during fires
  - Most common is HFC227 – Heptafluoropropane – colorless/odorless
  - Small amount can convert to hydrogen fluoride during a fire – which can result in rapidly progressive or fatal respiratory failure

- Clinical effect: shortness of breath, cough, or hypoxia

- Treatment: Supportive
  - If hypocalcemia present: nebulized calcium gluconate (1.5 ml of 10% Ca Gluconate in 4.5 ml water) every 4 hours until normalization of serum calcium
  - If no significant burns, can consider steroids
**INTENT (EXPECTED OUTCOMES)**

All patients who suffer severe toxic or chemical inhalation injuries will receive appropriate supportive care including intubation and mechanical ventilation when indicated.

**PERFORMANCE/ADHERENCE MEASURES**

- All patients with severe toxic or chemical inhalation injuries received appropriate supportive care, including intubation and mechanical ventilation.
- Appropriate evaluation of the posterior pharynx and mucosal inflammation of the airway using standard bronchoscopy assessment.

**DATA SOURCE**

- Patient Record
- Department of Defense Trauma Registry (DoDTR)


5. DeLange DW, Meulenbelt J. Do Corticosteroids have a role in preventingor reducing acute toxic lung injury caused by inhalation of chemical agents? Clinical Toxicology. Vol 49, no 2. February 2011. pp 61-71


References (2 of 2)


17. Emmen HH, Hoogendijk EM, Klopping-Ketelaars WA, et al. Human safety and pharmacokinetics of the CFC alternative propellants HFC 134a (1,1,1,2- tetrafluoroethane) and HFC227 (1,1,1,2,3,3,3heptafluoropropane) following whole-body exposure. Regul Toxicol Pharmacol. 2000;31 (1):22-35.


List of Appendices

- Appendix A: Chlorine Inhalation
- Appendix B: Additional Information Regarding Off-Label Uses in CPGs