Toxic Chemical Threats
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GA Poison Center / Emory University / Centers for Disease Control and Prevention
Objectives

• To give you tools to help recognize what chemical agent is present
• To give an overview of chemical agents and their management
• To identify considerations at each level of care in the event of a chemical incident

You don’t have to be a genius to be a toxicologist, you just have to know common sense decontamination and good supportive care
Why Chemical Terrorism?

- Agents are available & relatively easy to manufacture
- Large amount not needed in enclosed space
- Chemical incidents may be difficult to recognize
- Easily spread over large areas
- Psychological impact
- Can overwhelm existing resources
TERRORISM

THAT CONCLUDES
OUR DAILY DOSE
OF HYSTERIA....
UP NEXT,
ALARMIST
CONJECTURE
AND CYNICAL
SECOND-GUESSING!
Are our EMS and hospitals ready?
Are we ready?

Index pt ingests 110 mg OP insecticide

45 y/o tech resp distress (intubated, admitted x 9 days)

32 y/o RN treated with atropine / pralidoxime

56 y/o RN treated with atropine, admitted x 1 day

MMWR, January 5, 2001
Limitations of Chemical Agents

- Effective dissemination difficult
- Delayed effects can detract from impact
- Potentially hazardous to the terrorist
- Development and use require skill
- More expensive than biologic agents
Chemical vs. biological agents

- Chemical
  - More rapid onset
  - More rapid resolution
  - ID requires recognizing syndrome or detection of compound
  - Morbidity / mortality dependent on agent and concentration

- Biological
  - Incubation period
  - Sporadic pt presentation
  - ID requires recognizing syndrome or detecting agent
  - Morbidity / mortality dependent on agent and concentration
Potential Terrorist Targets

- Enclosed spaces
- Large crowds (high profile events)
- Critical facilities and infrastructure
- Accessible facilities with significant hazard / damage potential (materials in transit)
- Facilities of interest to terrorists’ cause
The Myths

• “It can’t happen to us”
• “Chemical agents are so deadly the victims will all die anyway”
• “There is nothing we can do”

http://www.jmorganmarketing.com/social-media-myths/
Steps needed in event of a release

- First responder protection
- Bystander protection
- Substance ID
  - via placarding
  - via shipping papers
  - via physico-chemical properties
  - ideally confirmed by a second method
HAZMAT During Transit

Using the 2008 ERG

EXAMPLE OF PLACARD AND PANEL WITH ID NUMBER
The 4-digit ID Number may be shown on the diamond-shaped placard or on an adjacent orange panel displayed on the ends and sides of a cargo tank, vehicle or rail car.

A Numbered Placard or A Placard and an Orange Panel

Georgi Poison Center
HOW TO USE THIS GUIDEBOOK DURING AN INCIDENT INVOLVING DANGEROUS GOODS

ONE

IDENTIFY THE MATERIAL BY FINDING ANY ONE OF THE FOLLOWING:
THE 4-DIGIT ID NUMBER ON A PLACARD OR ORANGE PANEL
THE 4-DIGIT ID NUMBER (after UN/NA) ON A SHIPPING DOCUMENT OR PACKAGE
THE NAME OF THE MATERIAL ON A SHIPPING DOCUMENT, PLACARD OR PACKAGE

IF AN ID NUMBER OR THE NAME OF THE MATERIAL CANNOT BE FOUND, SKIP TO THE NOTES BELOW.

TWO

LOOK UP THE MATERIAL’S 3-DIGIT GUIDE NUMBER IN EITHER:
THE ID NUMBER INDEX..(the yellow-bordered pages of the guidebook)
THE NAME OF MATERIAL INDEX..(the blue-bordered pages of the guidebook)

If the guide number is supplemented with the letter "P", it indicates that the material may undergo violent polymerization if subjected to heat or contamination.

If the index entry is highlighted (in either yellow or blue), it is a TIH (Toxic Inhalation Hazard) material, a chemical warfare agent or a Dangerous Water Reactive Material (produces toxic gas upon contact with water). LOOK FOR THE ID NUMBER OF INITIAL ISOLATION AND PROTECTION REQUIREMENTS. Then, if necessary, BEGIN PROTECTIVE ACTION (see page 298). If protective action is not required, PROCEED TO THE NEXT MATERIAL.

USE GUIDE 112 FOR ALL EXPLOSIVES WHERE GUARDIAN GUIDES ARE NOT APPLICABLE.

THREE

TURN TO THE NUMBERED GUIDE IF A NUMBERED GUIDE CANNOT BE FOUND IN THIS SECTION, AND A PLACARD CANNOT BE IDENTIFIED. USE OF PLACARDS (pages 16-17) TO IDENTIFY THE SAMPLE PLACARD.

<table>
<thead>
<tr>
<th>ID</th>
<th>Guide No.</th>
<th>Name of Material</th>
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<tbody>
<tr>
<td>1180</td>
<td>130</td>
<td>Ethyl butyrate</td>
</tr>
<tr>
<td>1181</td>
<td>155</td>
<td>Ethyl chloroacetate</td>
</tr>
<tr>
<td>1182</td>
<td>155</td>
<td>Ethyl chloroformate</td>
</tr>
<tr>
<td>1183</td>
<td>139</td>
<td>Ethyldichlorosilane</td>
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<th>Guide No.</th>
<th>Name of Material</th>
</tr>
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<tr>
<td>1202</td>
<td>128</td>
<td>Heating oil, light</td>
</tr>
<tr>
<td>1203</td>
<td>128</td>
<td>Gasohol</td>
</tr>
<tr>
<td>1203</td>
<td>128</td>
<td>Gasoline</td>
</tr>
<tr>
<td>1203</td>
<td>128</td>
<td>Motor spirit</td>
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<th>Guide No.</th>
<th>Name of Material</th>
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<td>1203</td>
<td>128</td>
<td>Petrol</td>
</tr>
<tr>
<td>1204</td>
<td>127</td>
<td>Nitroglycerin, solution in alcohol, with not more than 1% Nitroglycerin</td>
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<th>Guide No.</th>
<th>Name of Material</th>
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<td>1228</td>
<td>131</td>
<td>Mercaptans, liquid, flammable, toxic, n.o.s.</td>
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<tr>
<td>1229</td>
<td>129</td>
<td>Mesityl oxide</td>
</tr>
<tr>
<td>1230</td>
<td>131</td>
<td>Methanol</td>
</tr>
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</table>
POTENTIAL HAZARDS

FIRE OR EXPLOSION

- HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames.
- Vapors may form explosive mixtures with air.
- Vapors may travel to source of ignition and flash back.
- Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks).
- Vapor explosion hazard indoors, outdoors or in sewers.
- Those substances designated with a "P" may polymerize explosively when heated or involved in a fire.
- Runoff to sewer may create fire or explosion hazard.
- Containers may explode when heated.
- Many liquids are lighter than water.
- Substance may be transported hot.
- If molten aluminum is involved, refer to GUIDE 169.

HEALTH

- Inhalation or contact with material may irritate or burn skin and eyes.
- Fire may produce irritating, corrosive and/or toxic gases.
- Vapors may cause dizziness or suffocation.
- Runoff from fire control or dilution water may cause pollution.

PUBLIC SAFETY

- CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.
- As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions.
- Keep unauthorized personnel away.
Medical Management of Hazmat Victims

**Decon**
- Remove the pt from the poison
- Remove the poison from the pt

**Life Threats**
- Stop massive bleeding
- Open airway, support breathing

**HAZMAT Assessment**
- Identify toxidromes
- Administer antidotes
Toxidrome

• Toxic + Syndrome = Toxidrome
• A way to categorize chemical agents that share similar clinical effects
Toxidromes

Nerve Agents

Blood Agents

Blister Agents

Choking Agents
• Military Nerve Agents
• Organophosphate Pesticides
• Carbamate Pesticides
Nerve Agent Toxidrome


http://www.alz.org/braintour/synapses_neurotransmitters.asp
Nerve agents - Recognition

- Muscarinic
  - Defecation
  - Urination
  - Miosis (small pupils)
  - Brocho-spasm/rhea
  - Emesis
  - Lacrimation
  - Salivation

- Nicotinic
  - Fasciculations
  - Weakness
  - Seizures
# Nerve Agent Comparison

<table>
<thead>
<tr>
<th>Agent</th>
<th>LD$_{50}$ (mg)</th>
<th>Aging $t_{1/2}$</th>
<th>Volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tabun</td>
<td>1000</td>
<td>46 hrs</td>
<td>Low</td>
</tr>
<tr>
<td>Sarin</td>
<td>1700</td>
<td>5.2 – 12 hrs</td>
<td>High</td>
</tr>
<tr>
<td>Soman</td>
<td>100</td>
<td>40s – 10 min</td>
<td>Moderate</td>
</tr>
<tr>
<td>VX</td>
<td>10</td>
<td>2.1-5.4 days</td>
<td>Non</td>
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</table>
Cholinergic Toxidrome

• Organ systems affected: respiratory, neurological, cardiovascular
• Decontamination: full decon
• Antidotes: Mark I kit: Atropine and Pralidoxime
• Management: ABC, prompt decon and antidote therapy, supportive care
Nerve Agents

• Treatment
  – Atropine until secretions are gone
  – 2-PAM (pralidoxime) x3 auto-injectors or 30 mg/kg IV
  – Valium for seizures
Nerve Agent Example
Nerve Agent Example

- 1994 – Matsumoto
  - 7 killed
  - 500 injured
- 1995 – Tokyo Subway
  - 12 killed
  - 5500 sought medical attention
Tokyo Sarin Gas Attack

- St Luke’s ED received 640 patients within a few hours
- Medical staff complained about eye and throat pain, nausea, miosis
- ED provisions for privacy to remove clothing or to provide showers was inadequate

The arriving patients

• 640 patients
  – 64 arrived by ambulance
  – 35 arrived by fire department vehicles
  – 541 arrived with the assistance of non-medical motorists

• 106 were admitted for severe symptoms
  – 4 pregnant
• NA antidotes
• Give atropine until secretions are dry
• Dosages for pralidoxime (mention European antidotes)
Choking Agents

- Military Pulmonary Agents
- Industrial Chemicals
Toxic Gases (Choking Agents)
Choking Agent Toxidrome

- Irritant Gases
  - Effects dependent on water solubility
  - Local effects
    - Eyes
    - Mouth
    - Throat
    - Lungs
- Chlorine, Ammonia, Hydrogen Chloride, Phosgene, Chloramine
# Water solubility effect: Chlorine vs. Phosgene

<table>
<thead>
<tr>
<th>Chlorine</th>
<th>Phosgene</th>
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<tbody>
<tr>
<td>Irritates eyes and MM</td>
<td>Non-irritating</td>
</tr>
<tr>
<td>Pungent odor</td>
<td>Odor threshold above toxic threshold</td>
</tr>
<tr>
<td>Immediate symptoms</td>
<td>Delayed</td>
</tr>
<tr>
<td>Full recovery</td>
<td>Prolonged sequelae</td>
</tr>
</tbody>
</table>

RNpedia.com
Particle size influences bioavailability

Droplet Size and Penetration of Respiratory Passages
Toxic Gases / Choking Agents

- Therapy
  - Oxygen as needed
  - Albuterol nebs, steroids controversial
  - Treat local effects
  - Antibiotics not necessary
  - Beware of delayed onset of pulmonary edema in pts with previous bronchospasm

Up to 6-8 hours
Graniteville, SC

Chlorine Gas Still Lingers From South Carolina Train Wreck That Killed Eight

Updated: 01-08-2005 01:01:47 PM

E-MAIL THIS STORY  PRINT THIS STORY

JENNIFER HOLLAND  Associated Press

GRANITEVILLE, S.C. (AP) -- Townspeople and nightshift workers at a textile mill heard the scrape of metal and a house-shaking boom. Then, in rolled a greenish-yellow fog that smelled powerfully like bleach, searing their eyes and lungs and making them cough and gasp.

"I took a breath. That stuff grabbed me," said Charles Reyes Littlepage, a volunteer firefighter who ran to the scene. "It gagged me and brought me down to my knees. I talked to God and said, "I am not dying here.""

At least eight people died and more than 250 were sickened after a freight train carrying toxic chlorine gas crashed early Thursday in one of the nation's deadliest chemical spills in years.

Authorities said all of the deaths appeared to have been caused by the plume of gas that settled over its victims in their homes, their cars and in the textile mill complex. One of the dead was spotted by Gov. Mark Sanford, who flew over the site to survey the wreckage.

About 5,400 residents within a one-mile radius were forced to evacuate. Authorities told people Friday they would not be allowed to return for three to seven days. A dusk-to-dawn curfew was imposed within two miles of the wreck for fear that the cool night air would cause the chlorine to settle close to the ground.

With one ruptured tanker continuing to leak the deadly gas and the possibility of another leak from a second damaged tanker, rescue workers in protective suits searched for a worker still missing from the Avondale Mills textile plant.
Toxic Gases / Choking Agents

- Organ systems affected: Respiratory
- Decontamination: not required unless concentrated liquid
- Antidote: none
- Management: oxygen, supportive care

Effects may be delayed up to 6-8 hours
Nebulized Bicarbonate

- Chlorine gas exposures may respond to bicarb nebs
- Dilute ampule of sodium bicarbonate with equal part sterile water
- Nebulize 3mL
Blood Agents

- Simple Asphyxiants
  - CO₂, inert gases
- Systemic Asphyxiants
  - Cyanide / H₂S
  - Carbon Monoxide
Asphyxiant Toxidrome

• Asphyxiants
  – Simple – volume displacement
    • Carbon Dioxide
  – Systemic (Blood Agents)
    • Carbon Monoxide, Cyanide, Hydrogen Sulfide, Azides

• Symptoms
  – Fast Breathing, Fast Heart Rate, Confusion,
  – Acidemia, Hypoxia
Simple Asphyxiants

- Organ systems affected: Respiratory
- Decontamination: none
- Antidotes: none
- Management: remove them from environment, oxygen
Police say leaking carbon dioxide killed woman, sickened 10 others at Ga. McDonald’s www.privateofficernews.com

SAVANNAH, Ga. Sept 15 2011 — Carbon dioxide piped through gas lines to a soda fountain leaked in a McDonald’s in Georgia and sickened 10 people, including a woman who later died after being found unconscious in a restroom, police said Wednesday.

Investigators determined a leaky gas line between the walls caused the gas, used to pump carbonation into sodas, to build up a week ago to the point where people inside were unable to breathe.

“It caused what is normally a harmless gas to be pumped into the wall cavity and leak into the women’s restroom,” said Pooler Police Chief Mark Revenew. “At a high level of concentration, it displaces oxygen.”

Firefighters were called Sept. 7 to the restaurant in Pooler, about 10 miles west of Savannah, and two women were found unconscious in a
Preventing Knockout Scenarios

5 tactics that can be used to prevent secondary contamination.

• Use PPE, including respirators and chemical-resistant clothing.
• Initial assessment / decontamination should be done outdoors or in a room with separate ventilation to the outside.
• Isolate the patient from others (patients and staff)
• Remove the patient's clothing.
• Decontaminate the patient.
Blood Agents

- Organ systems affected: neurological, cardiovascular
- Decontamination: charcoal for ingestion (cyanide salts)
- Antidotes: Cyanide (Lilykit) treatment kit or hydroxocobalamin (Cyanokit), Hyperbaric oxygen for CO
- Management: oxygen, antidote therapy and supportive care
Blood Agent Example

- Systemic asphyxiants: Pink skin because body cannot utilize oxygen
Blood Agent Example

- Jonestown, 1978
- Kool-Aid mixed with cyanide and sedatives
Treatment of Cyanide Toxicity

• Hydroxocobalamin
• Sodium Thiosulfate
Carbon Monoxide

• Binds to hemoglobin, displaces oxygen
• CANNOT carry oxygen in the red blood cells
• Treatment: 100% oxygen, +/- hyperbaric oxygen chamber treatments
Structure Fires

Background

• Burning silk / wool / plastics liberate cyanide
• Co-exposure to CO and CN not uncommon in structure fires

Clinical

• Cherry red skin can be CO or CN
• Lactate > 10 → treat for cyanide
• Do NOT give nitrate portion of Lily Kit
• No change with hydroxocobalamin
Blister Agents

- Military Blister Agents
- Mustard Gas, Lewisite
Vesicant Toxidrome

• Vesicants
  – Respiratory difficulties
  – Redness and blistering to the skin
    • Lewisite- immediate effects
    • Mustards- delayed
      – Nitrogen
      – Sulfur
    » Also causes bone marrow suppression
Vesicants Agents
Vesicants Toxidrome

- Organ systems affected: respiratory, dermal, cardiovascular
- Decontamination: full decon
- Antidotes: none
- Management: Decontamination and supportive care
Decontamination

Soap and Water
Decontamination

- **Ambulatory decontamination**
  - Ratio 1:4, responders to victims
- **Stretcher decontamination**
  - Ratio 2:1, responders to victims
- **Watch for hypothermia, privacy, valuables**
Miscellaneous Industrial Agents

- Corrosives
  - Dermal burn injuries
  - Mucosal burns
- Hydrocarbons
  - Flammability
  - CNS depression, confusion
  - Heart dysrhythmias
- Hydrazines
  - Seizures
What have we learned?
Recommendations for Japan

- Emergent decontamination areas
- Available chemical resistant suits and masks
- Ventilation in ED and main treatment areas
- Disaster planning must address mass casualties, staff call up, medical charting
- Information network
Steps needed in event of a release

Pre-hospital

• Scene security
• Triage and tracking
• Victim decon *before* transport
• Evacuation and transport
Steps needed in event of a release

Emergency Department

- **Treatment of victims**
  - decontamination *before* entry into the ED
  - treatment, geared to severity of injuries and scope of event

- **Locate health care resources needed, redeploy if necessary**
Considerations for Hospital Preparedness

- Command and Control (ICS)
- Security
- PPE
- Primary Triage
- Patient Tracking
- Patient Decontamination
  - Indoor or outdoor
  - Privacy
  - Environmental exposure
Steps needed in event of a release

Health Department

- Hazard abatement
  - containment
  - risk mitigation
- Scene investigation
- Clean up

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Preparedness efforts

- Most hospitals have been poorly prepared for chemical releases
- Only 3 of 42 metro Atlanta hospitals surveyed had on-site level B decon capabilities 2 weeks before the Olympics, not much improvement 5 yr later
- Prevalent attitude was: “It won’t happen here”
Further Considerations

• Specific antidotes/vaccinations/antibiotics
  – Deployment of pharmaceutical stockpile
• Specific supplies
  – Ventilators, critical care supplies
• Information resources

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Summary

• Chemical event response requires **cooperative interaction**
• **Local education** on HAZMAT response, decontamination and containment is imperative
• Work with **hospitals and clinicians** to plan prior to an event
• Medical treatment will be based empirically on symptoms, **labs will not be readily available** for initial victims
  – Primarily supportive care
  – Antidotes as appropriate
Any Questions?

STATE of GEORGIA