

Overview



Chemical-warfare Agents: An Overview

U.S. ARMY MEDICAL RESEARCH INSTITUTE OF CHEMICAL DEFENSE

CHEMICAL CASUALTY CARE DIVISION

USAMRIID
PROTECT, PROJECT, SUSTAIN

Objectives

- **Course**
 - Overview and relevance
 - Agent characteristics and effects
 - Patient presentation and management

- **This lecture**
 - Conceptual framework
 - NATO codes
 - General concepts

Chemical Agent: Definition (FM 8-285)

- “A chemical substance...intended for use in military operations to kill, seriously injure, or incapacitate humans (or animals) through its toxicological effects.”
- **Compare and contrast**
 - Chemical agents (chemical-warfare agents)
 - Biological agents (biological-warfare agents)
 - Toxins
 - “Toxicants”



Chemical Agent: Definition (FM 8-285)

- “A chemical substance...intended for use in military operations to kill, seriously injure, or incapacitate humans (or animals) through its toxicological effects.”
- **Excluded by FM 8-285**
 - Riot-control agents (**CS, CN, DM**)
 - Chemical herbicides (e.g.. Agent Orange)
 - Smoke and flame materials

Excluded Agents I: Riot-control Agents

- Irritant agents (lacrimators)
 - **CS** (“tear gas”)
 - **CN** (Mace[®])
 - **CA**
 - **CR**
- Vomiting agents
 - **DM** (Adamsite)
 - **DA**
 - **DC**

Riot-control Agents

- **Local irritants** with high safety ratio
- **Short onset** (seconds to minutes)
- **Short duration** (15-30 minutes)
- In low concentrations, cause intense **pain** and **lacrimation** (tearing) with (Adamsite only) or without *vomiting*

Excluded Agents II: Herbicides (Defoliants)

- **Agent Blue** (cacodylic acid)
- **Agent Orange** (1:1 mixture of 2,4,5-T and 2,4-D)
 - Contaminant: TCDD (Dioxin)
- **Agent White** (4:1 mixture of 2,4-D and picoram)
- **Paraquat**

Excluded Agents III: Smokes

- **Petroleum oil smokes** (fog oil=SGF)
- **Diesel fuel**
- **HC**
- **RP** (RED phosphorus) in butyl rubber
- **WP** (WHITE phosphorus)
- **FS**
- **FM**



Classification of “Official” Chemical Agents

- **TOXIC AGENTS** (producing injury or death)
 - **LUNG-DAMAGING AGENTS** (choking agents)
 - Chlorine (**CL**), phosgene (**CG**) [smokes] [vesicants]
 - “**BLOOD**” **AGENTS** (cyanogens): **AC** and **CK**
 - **BLISTER AGENTS** (vesicants)
 - Mustard (**H**), Lewisite (**L**), phosgene oxime (**CX**), [riot-control agents] [T-2 mycotoxin]
 - **NERVE AGENTS** (anticholinesterases)
 - **GA,GB,GD,GF,VX**
- **INCAPACITATING AGENTS** (producing temporary effects)
 - **BZ, Agent 15**, [riot-control agents]

“Official” Chemical Agents I: Toxic Agents

- ***Lung-damaging agents (choking agents)***
 - Chlorine (**CL**), phosgene (**CG**) [smokes] [vesicants]
- ***“Blood” agents (cyanogens): AC and CK***
- ***Blister agents (vesicants)***
 - Mustard (**H**), Lewisite (**L**), phosgene oxime (**CX**), [riot-control agents] [T-2 mycotoxin]
- ***Nerve agents (anticholinesterases)***
 - **GA,GB,GD,GF,VX**

Lung-damaging Agents

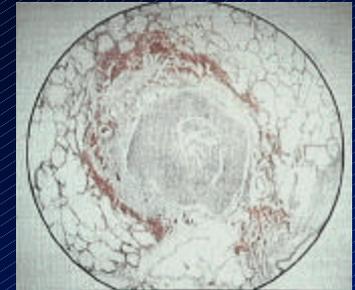
- Chlorine (**CL**)
- Chloropicrin (**PS**)
- Phosgene (**CG**)
- Diphosgene (**DP**)
- [Mustard (**HD, H**) Lewisite (**L**)]
- [Smokes] [isocyanates] [PFIB] [oxides of nitrogen]



Chemical-agent Damage to Respiratory System

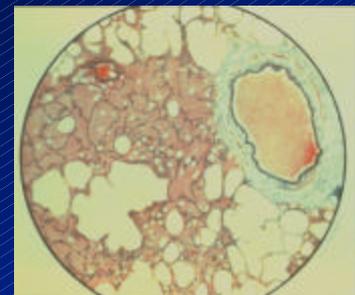
- Central effects (in larynx, trachea, and bronchi) predominate

- Mustard (**H, HD**)
- Lewisite (**L**)
- [Chlorine (**CL**)]



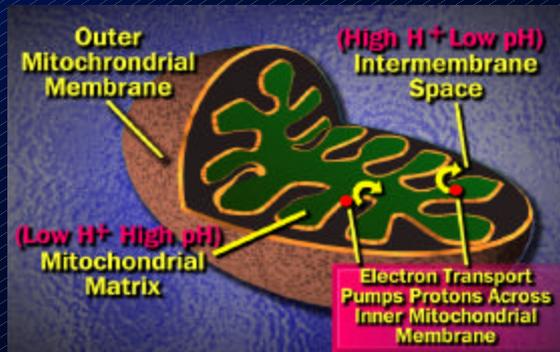
- Peripheral effects (in small airways and alveoli) predominate

- Phosgene (**CG**)
- Perfluoroisobutylene (PFIB)
- Nitrogen oxides (NO_x)
- HC smoke, isocyanates, many others



“Blood” Agents (Cyanogens)

- Hydrogen cyanide (**AC**)
- Cyanogen chloride (**CK**)



Blister Agents (Vesicants)

- Sulfur mustard (**H, HD**)
- Nitrogen mustard (**HN₁, HN₂, HN₃**)
- Lewisite = chlorovinylchloroarsine (**L**)
- Mustard / Lewisite mixtures (**HL, HT, TL**)
- Phosgene oxime (**CX**)
- [Riot-control agents]
- [T-2 mycotoxin]

Nerve Agents (Anticholinesterases)

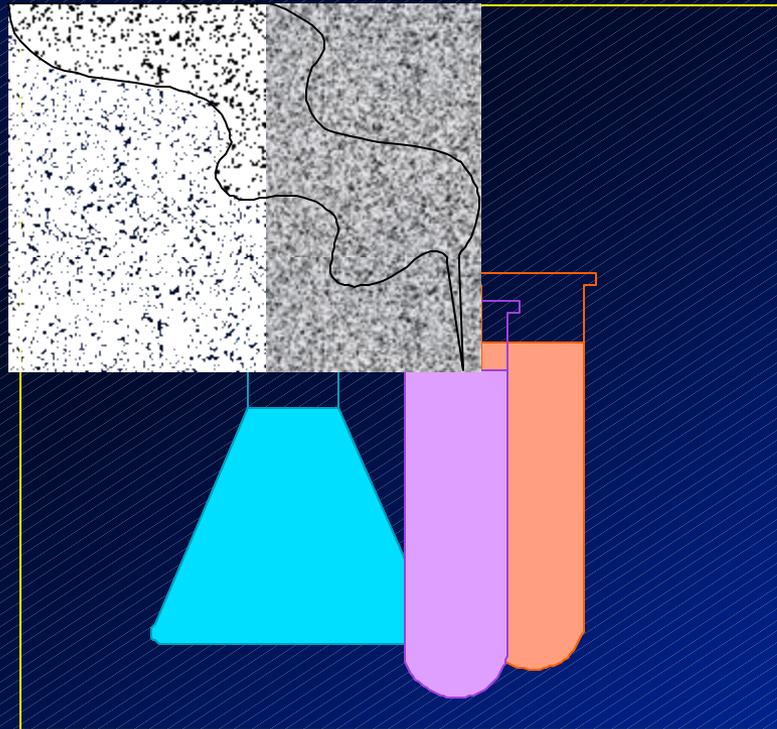
- Tabun (**GA**)
- Sarin (**GB**)
- Soman (**GD**)
- **GF**
- **VX**

“Official” Chemical Agents II: Incapacitating Agents

- **Purpose: Temporary incapacitation**
- **CNS stimulants**
 - Amphetamines, cocaine, caffeine, nicotine, strychnine, metrazole
- **CNS depressants**
 - Barbiturates, opioids, antipsychotics, benzodiazepines
- **Psychedelics**
 - LSD-25, psilocybin, ibogaine, harmine, MDMA (“ecstasy”), PCP
- **Deliriant**
 - Anticholinergic glycolates (**BZ, Agent 15**)

Physical Forms of Chemical Agents

- Solid
- Liquid
- Gas
- Vapor
- Aerosol



Persistence

- **Dependent on several factors**
 - Agent volatility (determined by chemical structure)
 - Temperature
 - Wind
 - Agent-surface interactions
- **“Nonpersistent” agents (usually gone within 24 hours)**
 - **GA, GB, GD, CL, CG, AC, CK**
- **“Persistent” agents**
 - **VX, L, HL, “thickened” nerve and blister agents (e.g., TGD, THD)**

Exposure and Absorption

- **Exposure** (contact with agent) does not necessarily lead to **absorption** (penetration of epithelial barrier)
- Two types of **effects** from exposure and absorption:
 - **Local**
 - (effects are at the site of contact)
 - **Systemic**
 - (absorption and subsequent systemic distribution produce effects at sites distant from contact site)

Routes of Exposure and Absorption

- Absorption through **skin** (percutaneous absorption)
- Absorption through **lungs** (inhalational absorption)
- Absorption through **eyes** (ocular absorption)
- Absorption through the **gut** (enteral absorption)
- Absorption by **injection** (parenteral absorption)
 - *Intravenous* absorption
 - *Intramuscular* absorption

Toxicity (Potency) of Liquid Agents

- **ED₅₀**: Effective Dose for 50% of exposed individuals
- **ID₅₀**: Incapacitating Dose for 50% of exposed individuals
- **LD₅₀**: Lethal Dose for 50% of exposed individuals
- ID₅₀ for liquid HD: 770 mg / 70-kg man
- LD₅₀ for liquid HD: 3000-7000 mg / 70-kg man



Toxicity of Vapors or Gases

The **Ct** concept: **C**oncentration x **t**ime

- $1 \text{ mg} / \text{m}^3 \times 8 \text{ min} = 8 \text{ mg-min} / \text{m}^3$
- $8 \text{ mg} / \text{m}^3 \times 1 \text{ min} = 8 \text{ mg-min} / \text{m}^3$
- $4 \text{ mg} / \text{m}^3 \times 2 \text{ min} = 8 \text{ mg-min} / \text{m}^3$
- $2 \text{ mg} / \text{m}^3 \times 4 \text{ min} = 8 \text{ mg-min} / \text{m}^3$

Toxicity of Vapors or Gases

- **EC₅₀**: Effective Ct for 50% of exposed individuals
- **IC₅₀**: Incapacitating Ct for 50% of exposed individuals
- **LC₅₀**: Lethal Ct for 50% of exposed individuals
- **Ct₅₀** assesses **external dose**, not internal dose
 - **IC₅₀** and **LC₅₀** therefore affected by
 - Route of exposure
 - Respiratory rate and depth, skin moisture, etc.

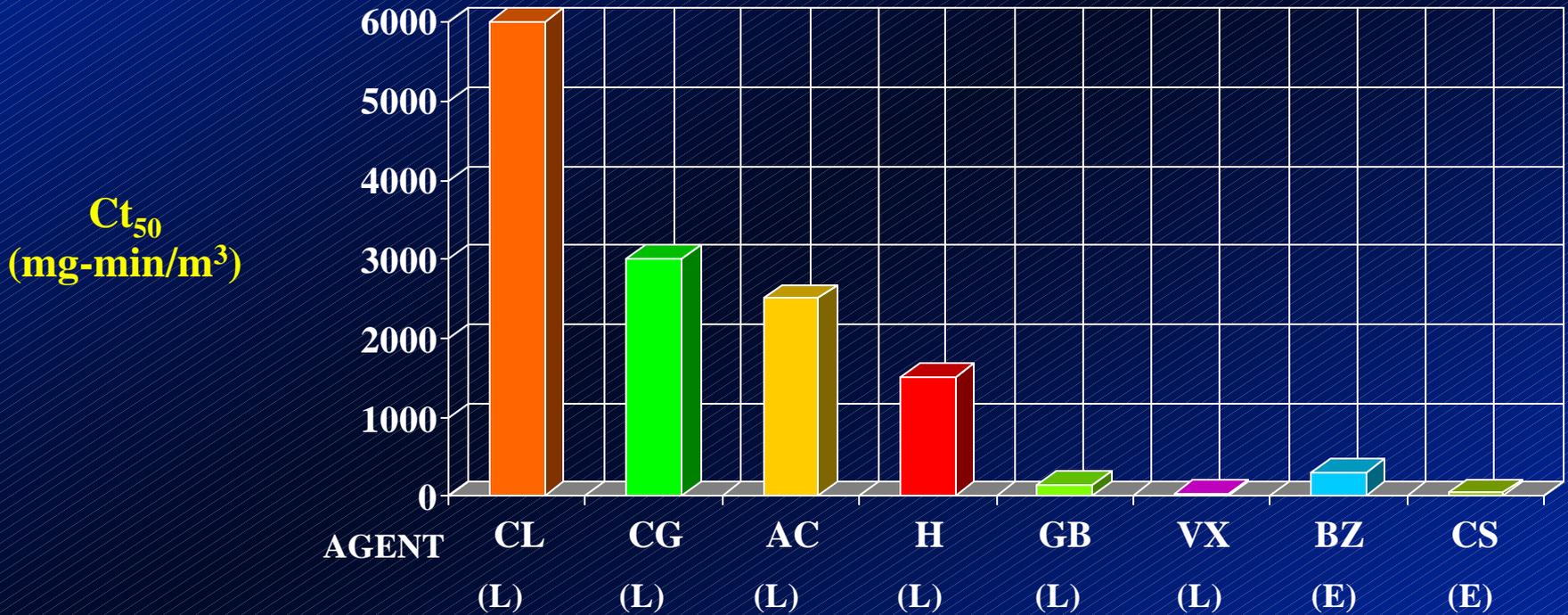
Toxicity of HD Vapor

- HD vapor in eyes:
 - **IC₅₀: 200 mg-min / m³**
- Inhaled HD vapor:
 - **IC₅₀: 200 mg-min / m³**
- HD vapor on skin:
 - **IC₅₀: 1000-2000 mg-min / m³**

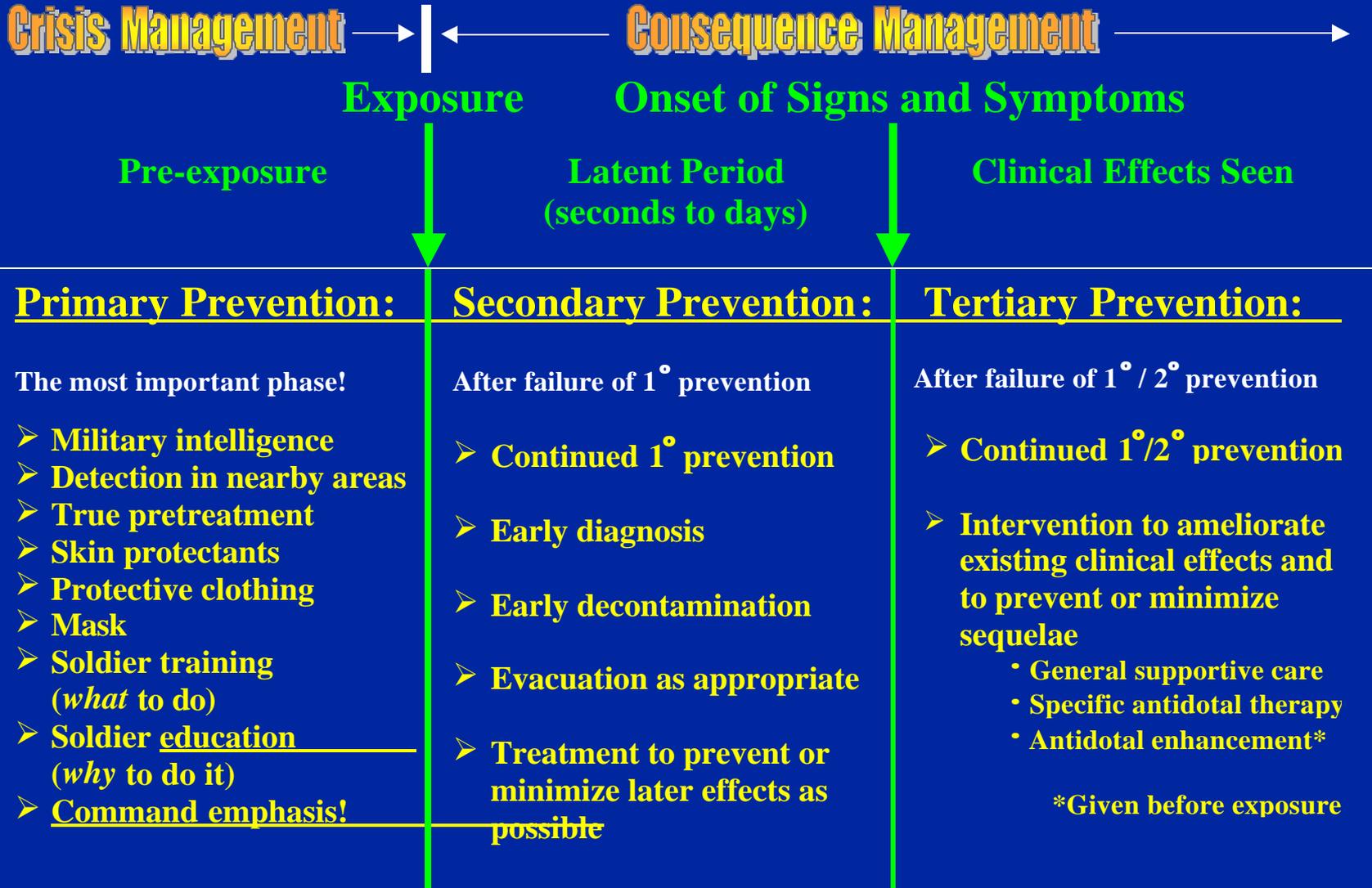
Toxicity of HD Vapor

- HD vapor in eyes:
 - Permanent injury: $> 800 \text{ mg-min} / \text{m}^3$
- Inhaled HD vapor:
 - LCt_{50} : $1000\text{-}1500 \text{ mg-min} / \text{m}^3$
- HD vapor on skin:
 - LCt_{50} : $10,000 \text{ mg-min} / \text{m}^3$

Comparative Toxicity of CW Agents

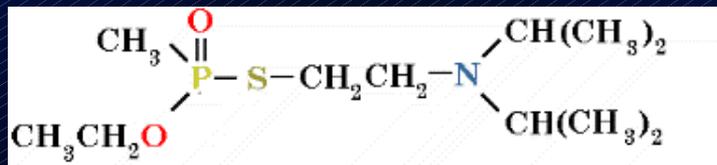


Medical Response to CW Threats



A Framework for Learning about Chemical Agents

- History / background
- Physicochemical properties
- Toxicokinetics (ADBE)
[how the body handles the agent]
- Toxicodynamics (mechanism of action)
[how the agent “handles” the body]
- Clinical presentation / diagnosis: ASBESTOS
- Management
 - Protection, general supportive treatment, and antidotal treatment
 - Decontamination and evacuation



“ASBESTOS”: A Systematic Approach to the Patient

- Agent(s): Type and toxicity (remember LD₅₀)
- State(s): Solid? Liquid? Gas? Vapor? Aerosol?
- Body site(s): Where exposed / Route(s) of entry? [*absorption*]
- Effects: Local? Systemic? [*distribution*]
- Severity: Mild? Moderate? Severe? [*effects and exposure*]
- Time course: Onset? Getting better/worse? Prognosis?
- Other diagnoses? Instead of? [*DDx*] In addition to?
- Synergism: Combined effects of multiple exposures or insults?

Summary: “Official” Chemical Agents

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