PATIENT CARE THEORY 2

UNIT 15, PART 4: Chemical Toxicology

Marilyn Niffin BSc, ACP
Professor Georgian College
Winter 2020, 2021, 2023

Chemical Poisonings

- Nerve agents
- Ethylene Glycol
- Methanol

Nerve Agents

- invented in the 1930s as potential insecticides
  - Derived from organophosphate family
- inhibit acetylcholinesterase
  - Consequently excess acetylcholine accumulates in the body
- Most toxic of the chemical agents

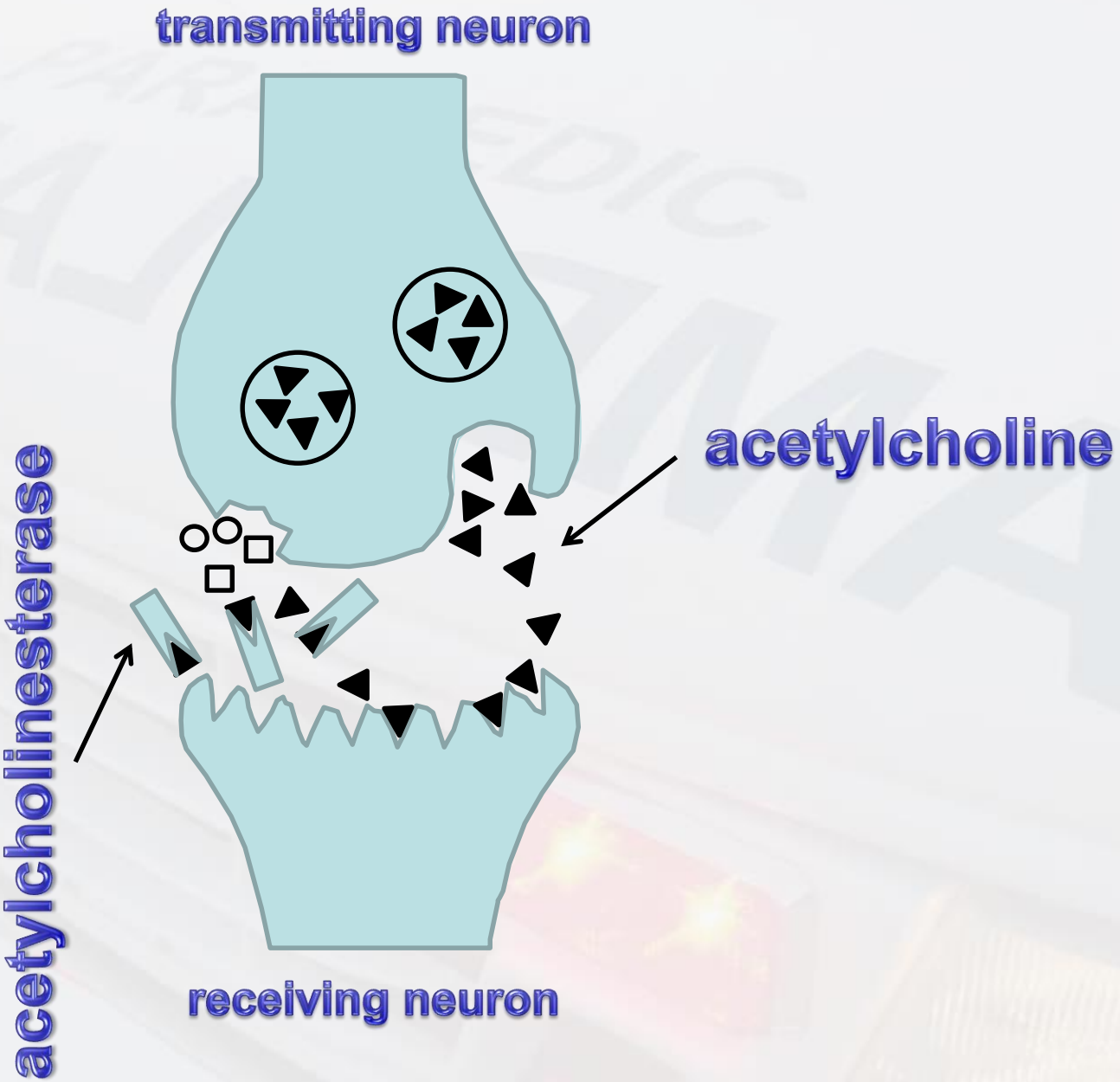
Cholinergics

Pesticides - organophosphates

- cholinesterase inhibitors, such as pesticides (malathion, parathion, diazinon, fenthion, dichlorvos, chlorpyrifos), herbicides.
- Organophosphates can be absorbed cutaneously, ingested, inhaled, or injected
- nerve gases (soman, sarin, tabun, VX)

Cholinergics

- organophosphate pesticides inhibit acetylcholinesterase (AChE)
- AChE - enzyme that breaks down acetylcholine (ACh)
- ACh - found in the central and peripheral nervous system, neuromuscular junctions, and red blood cells (RBCs)
- Acetylcholine accumulates resulting in overstimulation of muscarinic and nicotinic receptors


transmitting neuron
acetylcholine
acetylcholinesterase
receiving neuron

Nerve Agents

- **Sarin (GB) –** sarin gas attack in Syria
- **Soman (GD)**
- **Tabun (GA)**
  - volatile liquids (gas exposure)
  - Volatile nerve agents can cause immediate effects
- **VX**
  - oily liquid that's well absorbed by the skin
  - VX equal in size to 1 column on a penny would be lethal.
  - VX can have delayed effects

Cholinergic Crisis (cont'd...)

Toxidrome: early (muscarinic) signs= SLUDGE

- **S** alivation
- **L** acrimation
- **U** urination
- **D** efecation
- **G** astrointestinal cramps
- **E** mesis

Cholinergic Crisis (cont'd...)

Toxidrome (muscarinic)= DUMBBELS

- **D** iarrhea
- **U** rination
- **M** iosis (constricted pupil)
- **B** ronchorrhea, **B** ronchospasm, **B** radycardia
  - **Killer "B"s**
- **E** mesis
- **L** acrimation
- **S** alivation

Cholinergic Crisis (cont'd...)

- as time progresses - pulmonary edema, hypotension, anxiety, restlessness and profuse sweating.
- late stages have sympathetic signs of tachycardia, mydriasis (dilated pupils) and hypertension, as well as fasciculations, seizures, coma, and eventually death.

Saran Gas Attack – Syria, 2017

Nerve Agents

Sympathetic and parasympathetic ganglia Nicotinic signs-symptoms:

Days of the week

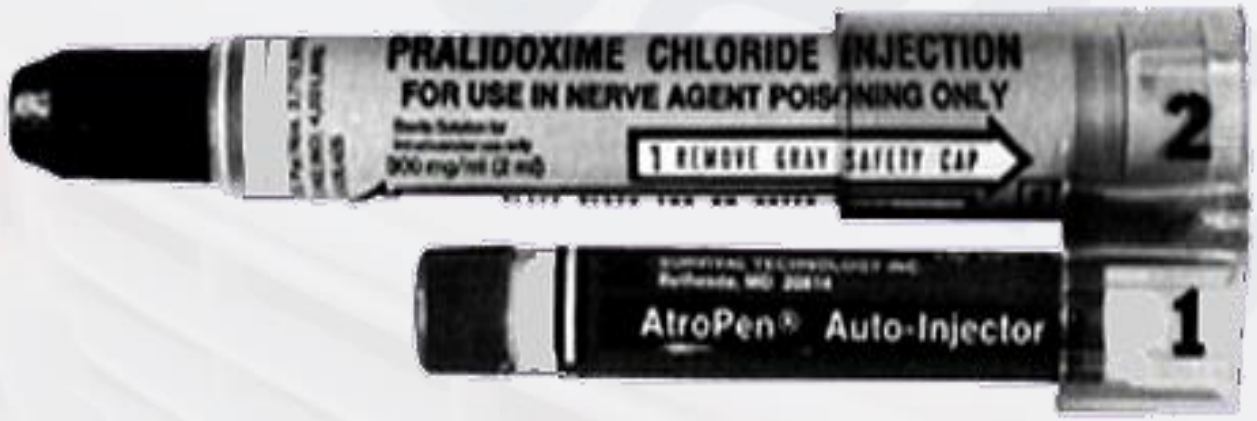
M - Mydriasis
T - Tachycardia
W - Weakness
tH - Hypertension
F - Fasciculations

Differential Diagnosis

- Gastroenteritis
- Ingestion of muscarinic mushrooms (*Amanita muscaria*, *Clytocybe*, *Inocybe*)
- Pesticide poisoning
- Carbamate overdose
- Metal ingestion

Nerve Agents: Treatment

- **Decontaminate** at the scene (Fire)
  - Remove clothing immediately
  - Water wash (+/- soap and shampoo)
- ABCs, SpO2, ECG, O2,
- **Early intubation** prn
- **IV access**
  - Fluid prn
- **Atropine 1-2 mg repeat PRN** IV or IM
- **Pralidoxime (2-PAM)** injection or infusion
  - Removes chemical from acetylcholinesterase
- **Midazolam** for seizures


PRALIDOXIME CHLORIDE INJECTION
FOR USE IN NERVE AGENT POISONING ONLY
REMOVE GRAY SAFETY CAP
2
AtroPen® Auto-Injector
1

Ethylene Glycol

Sources

- antifreeze - most common
- air-conditioning coolant
- brake fluid
- fluids used in film processing
- nail polish (non-acetone)
- etc

example

Ethylene Glycol

Lethal dose:

- a dose of > 1mL / Kg causes death or severe toxicity

Ethylene Glycol

Pathophysiology

- is converted by alcohol dehydrogenase to toxic metabolites, glycoaldehyde, and then to glycolic acid, which is the major cause of metabolic acidosis

Ethylene Glycol

Signs & Symptoms

- tachycardia
- seizures
- renal failure
- hypotension
- severe acidosis (pH < 7.1)
- hyperkalemia
- CNS depression $\rightarrow$ coma

Ethylene Glycol

Treatment

- always attend to the ABC's first
- IV fluids and resuscitation if required (initial hypertension rapidly becomes profound hypotension and will require fluid boluses)
- activated charcoal does NOT work well - ethylene does not bind to it very well

Ethylene Glycol

Treatment

- ethanol (drinking alcohol) should be given IV (in hospital) or P.O. if IV preparation is not available.
- A blood alcohol of 0.1 g/dL) is required to maximally inhibit conversion
  - fomepizole is a safer alternative to ethanol
- $NaHCO_3$ for severe acidosis

Methanol Poisoning

Pathophysiology

- metabolized by alcohol dehydrogenase to formaldehyde, then aldehyde dehydrogenase forms formic acid to CO_2
- a very similar presentation to that of ethylene glycol ingestion with similar results (profound metabolic acidosis)

Methanol Poisoning

Sources of methanol

- cleaning solutions
- windshield washer fluid
- antifreeze
- inks
- adhesives
- paint thinners/strippers
- inhalation of evaporated solvents

example

Methanol Poisoning

Presentation

- blurred vision, photophobia, decreased visual acuity may occur.
- May have fixed and dilated pupils.
- about 25% of patients will have some degree of permanent visual loss.

Methanol Poisoning

Treatment

- Support ABC's
- SpO_2, ECG
- O_2
- IV access
- Fluid resuscitation
- Patch to BHP for advice
  - Query $NaHCO_3$

Methanol Poisoning

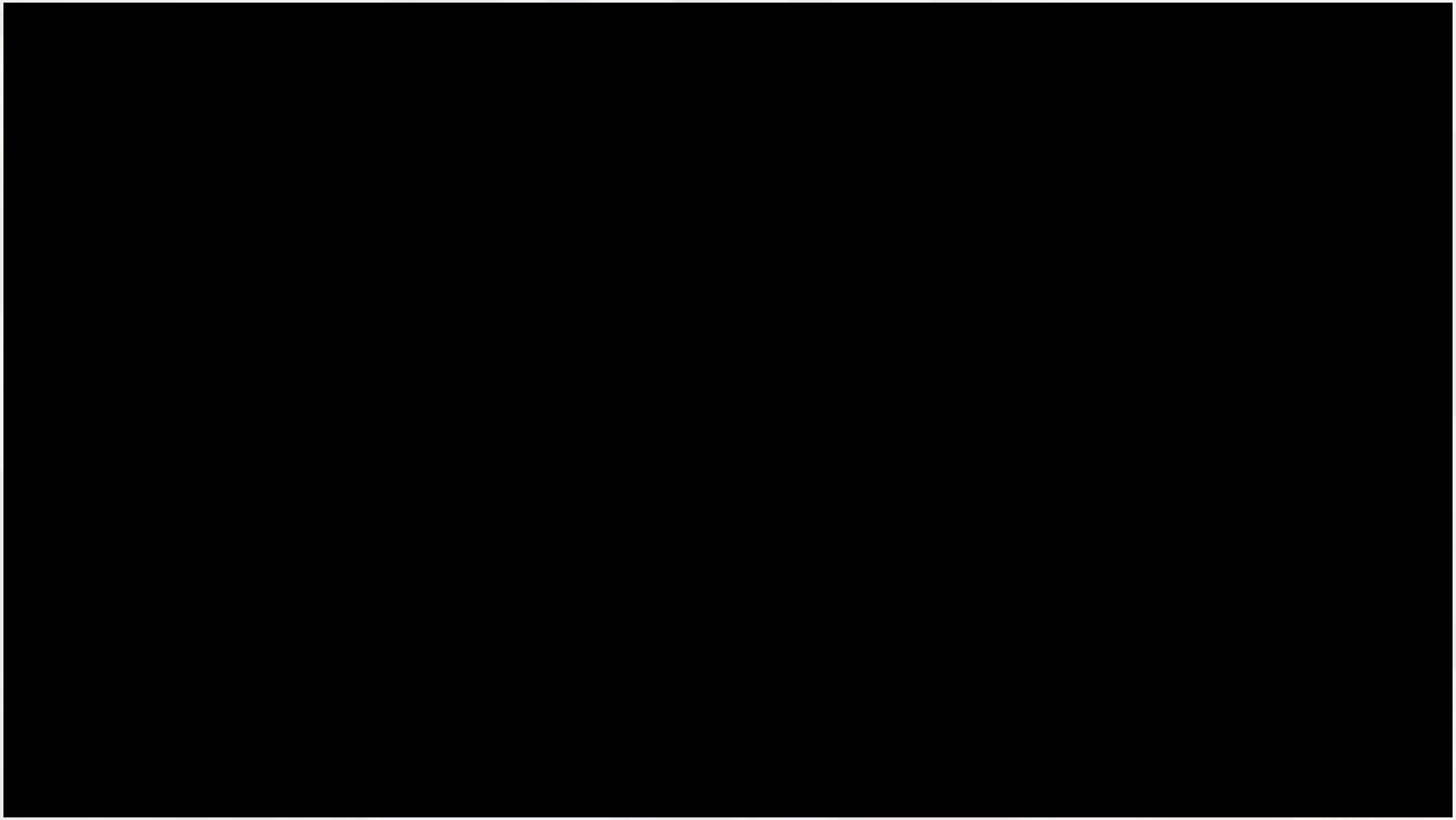
Treatment

- In-hospital: administration of ethanol (IV or PO) is the initial treatment
- ethanol has a higher affinity for alcohol dehydrogenase and competitively inhibits the metabolism of methanol
- fomepizole

Other Chemical Poisonings e.g.

- Batteries
  - e.g. 20 mm lithium coin batteries
  - Typically children < 4 years
  - Often lodges in the esophagus causing burns within just 2 hours
  - A hole in the esophagus may develop and the burn can extend into the trachea or aorta.
  - > 40 deaths/year U.S.

(75) How do button batteries kill kids? - YouTube



OPP warn of hydrogen sulfide suicide trend

(75) Chemical Suicide "Detergent Suicide" - Voice over version - YouTube

Other Chemical Poisonings e.g.

- Cleaning products (Caustics)
  - cause chemical burns
  - Can be just as bad as burns from fire
  - e.g. drain openers, toilet bowl cleaners, rust removers, oven cleaners
- Iron pills
  - adult-strength iron pills are very dangerous for children
  - Expect hematemesis, bloody diarrhea in < 1 hour.

CO poisoning

- Causes of more accidental deaths than any other toxic substance
- Colourless, odorless and tasteless gas
- Produced during the incomplete combustion of organic fuels
- Often used in suicide attempts
- Toxicity is caused by CO’s affinity for Hemoglobin and ability to displace O2

CO poisoning

- Difficult to diagnose in the field in the absence of obvious exposure (i.e. house fire, person locked in garage with running car, CO alarms going off in house etc.)
- Signs and symptoms often vague and vary in severity
  - Headache, nausea, confusion, ***cherry-red colour of skin is a very late sign***

CO Poisoning

- Management
  - Remove patient from environment
  - Monitor and establish ABC's
  - Provide high concentration O2 and ventilation prn
  - Hyperbaric oxygen therapy**

QUESTIONS?