

Carbon Monoxide Poisoning
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Objectives

Upon successful completion of this module, you will be able to:

- 1. Identify physical characteristics of CO
- 2. Identify sources of CO
- 3. Identify statistics of CO incidents
- 4. Identify pathophysiology of CO poisoning
- 5. Identify CO effects on hemoglobin
- 6. Identify CO effects on major body systems
- 7. Identify CO exposures and limits (ppm)
- 8. Discuss importance of being able to monitor CO levels for patients

Objectives cont'd

- 9. Identify signs/symptoms of CO poisoning and smoke inhalation
- 10. Identify the treatment of CO poisoning and smoke inhalation
- 11. Identify possible long term effects of CO poisoning
- 12. Identify the difference between acute and chronic CO poisoning

Carbon Monoxide (CO)

- An odorless, colorless, tasteless gas
- Results from incomplete combustion of carbon-containing fuels
 - Gasoline, wood, coal, natural gas, propane, oil, and methane
- Affects 40 – 50,000 Americans annually who need to seek care
- Kills an additional 6,000 persons annually in the USA
- CO is the #1 cause of poisoning in industrialized countries

Sources of Carbon Monoxide – any combustible item

- Homes
- Cigarette smoke
- House fires
- Automobile exhaust fumes
- Worksites
 - Including fumes from propane-powered equipment like forklifts
- Commercial structures
- Smoke from charcoal-fired cook stoves & ovens

Sources cont'd

- Heat provided to homes
 - Gas-fueled heaters
 - Wood burning stoves
- Indoor stoves
- Camp stoves
- Gas-powered generators
- Recreational environments
- Recreational vehicles
- Boat exhaust fumes

Carbon Monoxide Incidents

- Peak time of day 1800 – 2159
- Overall, 75% of non-fire CO incidents are reported between 0900 and 2259
- Peak months are December and January for non-fire CO incidents
- Almost 9/10 (89%) of non-fire CO incidents took place in the home

✓ Source: Non-Fire Carbon Monoxide Incidents Reported in 2005; NFPA Fact Sheet

What Effect Does Carbon Monoxide Have on Hemoglobin?

- Hemoglobin molecules each contain four oxygen binding sites
- Carbon monoxide binds to hemoglobin
- This binding reduces the ability of blood to carry oxygen to organs
- Hemoglobin occupied by CO is called carboxyhemoglobin
- Body systems most affected are the cardiovascular and central nervous systems

Effects of Carbon Monoxide

- Oxygen cannot be transported because the CO binds more readily to hemoglobin (Hgb) displacing oxygen and forming carboxyhemoglobin
- Premature release of O₂ prior to reaching distal tissue leads to hypoxia at the cellular level
- Inflammatory response is initiated due to poor and inadequate tissue perfusion
- Myocardial depression from CO exposure
 - Dysrhythmias, myocardial ischemia, MI
- Vasodilation – from increased release of nitric oxide; worsening tissue perfusion and leading to syncope

Half-life of Carbon Monoxide

- Half-life – time required for half the quantity of a drug or other substance to be metabolized or eliminated
- CO half-life on 21% room air O₂ – 4 - 6 hours
- CO half-life on 100% O₂ – 80 minutes
- CO half-life with hyperbaric O₂ – 22 minutes

CO Levels

- Fresh air 0.06 - 0.5 ppm
- Urban air 1 – 300 ppm
- Smoke filled room 2 – 16 ppm
- Cooking on gas stove 100 ppm
- Actively smoking cigarette 400 – 500 ppm
- Automobile exhaust 100,000 ppm

Expected Carboxyhemoglobin Levels

- Non-smokers – 5%
- Smokers – up to 10%
 - 5 – 6% for a 1 pack per day smoker
 - 7 - 9% for a 2-3 pack per day smoker
 - Up to 20% reported for cigar smokers
- Urban commuter – 5%

CO Poisoning

- Symptoms are often vague, subtle, and non-specific; can easily be confused with other medical conditions;
 - Flu – nausea, headaches
 - Food poisoning - nausea
 - Cardiac and respiratory conditions – shortness of breath, nausea, dizziness, lightheadedness
- CO enters the body via the respiratory system
- Poisoning by small amounts over longer periods of time or larger amounts over shorter time periods



HEADACHES



NAUSEA



DIZZINESS



BREATHLESSNESS



COLLAPSE



LOSS OF CONSCIOUSNESS

Carbon Monoxide Absorption

- Dependent upon:
 - Minute ventilation
 - Amount of air exchanged in the lungs within one minute
 - Duration of exposure
 - The longer the exposure, the more the absorption
 - Concentration of CO in the environment
 - The higher the concentration, the greater the toxicity
 - Concentration of O₂ in the environment
 - The lower the O₂ concentration to begin with, the faster the symptoms will develop
 - higher altitudes
 - closed spaces

Assessment for CO Exposure

- EMS may be summoned to monitor the air quality for the presence of carbon monoxide
 - Airborne CO meters are used and documentation made whether there is a patient transport or not
- A more immediate concern is the level of CO in the patient's blood
 - RAD 57 monitors are a non-invasive tool that allows results in less than 30 seconds
 - Rapid diagnosis leads to rapid and appropriate treatment

RAD 57 Device

- Used like a pulse ox
- Non-invasive tool
- Readings within seconds
- Helps to quickly hone in a diagnosis
- Used in ED and in the field



Masimo Rad-57 Guidelines

- The following are broad guidelines
- Treat the patient
- SpCO level readings
 - SpCO levels <5%
 - Normal in non-smokers; no treatment
 - SpCO levels \geq 5%
 - 5-10% normal in smokers
 - In non-smokers, treat with 100% O₂
 - EMS should be transported for further evaluation

CO Levels with Related Signs and Symptoms

- $\geq 5\%$ - mild headache
- 6-10% - mild headache, SOB with exertion
- 11-20% - moderate headache, SOB
- 21-30% - worsening headache, nausea, dizziness, fatigue
- 31-40% - severe headache, vomiting, vertigo, altered judgment
- 41-50% - confusion, syncope, tachycardia
- 51 – 60% - seizures, shock, apnea, coma

Signs and Symptoms CO Poisoning

- Carboxyhemoglobin levels of <15 – 20%
 - ✓ Mild severity
 - Headache – mild to moderate
 - Shortness of breath
 - Nausea and vomiting
 - Dizziness
 - Blurred vision

Signs and Symptoms CO Poisoning

- Carboxyhemoglobin levels of 21 – 40%
 - ✓ Moderate severity
 - Worsening headache
 - Confusion
 - Syncope
 - Chest pain
 - Dyspnea
 - Tachycardia
 - Tachypnea
 - Weakness

Signs and Symptoms CO Poisoning

- Carboxyhemoglobin levels of 41 - 59%
 - ✓ Severe
 - Dysrhythmias, palpitations
 - Hypotension
 - Cardiac ischemia
 - Confusion
 - Respiratory arrest
 - Pulmonary edema
 - Seizures
 - Coma
 - Cardiac arrest

Signs and Symptoms CO Poisoning

- Carboxyhemoglobin levels of >60%
 - ✓ Fatal
 - Death
- Cherry red skin is not listed as a sign
 - An unreliable finding

Increased Risks

- Health and activity levels can increase the risk of signs and symptoms at lower concentrations of CO
 - Infants
 - Women who are pregnant
 - Fetus at greatest risk because fetal hemoglobin has a greater affinity for oxygen and CO compared to adult hemoglobin
 - Elderly
 - Physical conditions that limit the body's ability to use oxygen
 - Emphysema, asthma
 - Heart disease
 - Physical conditions with decreased O₂ carrying capacity
 - Anemia – iron-deficiency & sickle cell

Risks to Firefighters from CO Exposure

- On the job from repeated exposures
 - Structure fires
 - Apparatus fumes
 - Portable equipment fumes
 - Gasoline powered saws
 - Generators
- Premature removal of SCBA equipment increases the risk of exposure

CO Identification

- Sooner the suspicion the sooner the appropriate treatment can be initiated
- Complications to monitor
 - Seizures
 - Cardiac dysrhythmias
 - Cardiac ischemia

CDC Diagnostic Criteria

- Suspected CO exposure
 - Potentially exposed person but no credible threat exists
- Probable CO exposure
 - Clinically compatible case where credible threat exists
- Confirmed CO exposure
 - Clinically compatible case where biological tests have confirmed exposure

Patient Assessment

- Continuously monitor SpO₂ and SpCO levels
 - Remember that SpO₂ may be falsely normal
 - If EMS has used a CO-oximeter, findings to be reported to the ED staff
 - Generally, results >3% indicate suspicion for CO exposure in non-smoker
- Cardiac monitor
- 12 lead EKG obtained and transmitted to ED

Pulse Oximetry

- Device to analyze infrared signals
- Measures the percentage of oxygenated hemoglobin (saturated Hgb)
- Can mistake carboxyhemoglobin for oxyhemoglobin and give a false normal level of oxyhemoglobin
- Never rely just on the pulse oximetry reading; always correlate with clinical assessment

Pulse CO-oximeter Device



- Hand-held device
- Attaches to a finger tip similar to pulse ox device
- Most commonly measured gases in commercial devices include
 - Carbon monoxide (SpCO)
 - Oxygen (SpO₂)
 - Methemoglobin (SpMet)
 - Other combustible gases
- Without the device, need to draw a venous sample of blood to test for CO levels

Pulse CO-oximeter Tool



- Firefighters have an increased exposure risk
 - Active firefighting
 - Inhaled products of combustion in structure fire
 - Inhaled exhaust from vehicles and power tools

Treatment CO Poisoning

- Increasing the concentration of inhaled oxygen can help minimize the binding of CO to hemoglobin
- Some CO may be displaced from hemoglobin when the patient increases their inhaled oxygen concentrations
- Treatment begins with high index of suspicion and removal to a safer environment
- Immediately begin 100% O₂ delivery

Treatment CO Poisoning

- Guidelines from different sources may vary when to initiate treatment based on SpCO levels
 - Report levels to the ED MD
 - Remember >5% in non-smokers is abnormal
- Treatment levels vary significantly
 - If you do not have a CO-oximeter to use, maintain a heightened level of suspicion and base treatment on symptoms
- Monitor for complications
 - Seizures
 - Cardiac dysrhythmias
 - Cardiac ischemia

Long Term Effects CO Exposure

- Hypoxemia follows CO exposure
- Effects of hypoxemia from CO exposure is dependent on presence of underlying diseases
- Hypoxemia can cause the formation of free radicals – dangerous chemicals

Long Term Cardiovascular Effects

- Myocardial injury from hypoxia and cellular damage
 - Pump failure
 - Cardiac ischemia
 - Later development cardiovascular complications
 - Premature death especially if myocardial damage at the time of initial exposure
- Factors increasing myocardial injury risk
 - Male gender
 - History hypertension
 - GCS <14 when patient first found

Long Term Neurological Effects

- Effects are primarily affective (mood) and cognitive (thought)
 - Increased depression and anxiety regardless if exposure accidental or suicidal attempt
 - Phenomenon called delayed neurological syndrome (1 - 47% of cases)
 - More likely if there was a loss of consciousness
 - Behavioral and neurological deterioration
 - Memory loss, confusion, ataxia, seizures, urinary & fecal incontinence, emotional lability, disorientation, hallucinations, mutism, cortical blindness, psychosis, gait disturbances, Parkinsonism

