Carbon Monoxide (CO): Still lethal in the workplace

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Purpose of presentation

Provide review & information about carbon monoxide (CO) hazards appropriate for health & safety professionals, including:

- Surveillance & occupational CO poisoning rates
- Basics of health effects
- CO chemical characteristics
- CO emission sources & emission strength
- Detection instruments & applications

The material presented is sourced from a variety of public domain materials & research manuscripts

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Concern/ issues related to tracking CO poisoning in occupational settings

- Incomplete, non-systematic surveillance nationally: 13 states & NYC currently list acute CO poisoning as a reportable condition (From reference in Graber & Smith, 2007)
- Significant numbers of exposures are fire-related, suicide-related, or emergency-event related

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Concern/ issues related to tracking CO poisoning in occupational settings

- In 1992, 32 deaths & 867 nonfatal occupational poisonings (NIOSH 1996 from BLS 1992)
- Estimated 480 deaths in 15,200 annual exposures, 2001-2002 (CDC MMWR January 21, 2005 / 54(02);36-39)

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Concern/ issues related to tracking CO poisoning in occupational settings

- Occupational exposures estimated >20% in Maine statewide data (Graber & Smith, 2007)
- 2000-2009, 14.4% of 36,691 occurrences that were transported to a HC facility occurred at workplace (CDC MMWR August 5, 2011 / 60(30);1014-1017 from National Poison Data System)
- Canadian study recorded 6.5% (117 of 1808) of fatalities & 13.3% (264 of 1984) of hospital admissions as occupational (Derived from Table 3, 29 & 16 yr periods respectively, Lavigne et al, 2015)

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Concern/ issues related to tracking CO poisoning in occupational settings

- Ambiguity in initial signs & symptoms of exposure (mimics colds, flu, food-poisoning)
- Ambiguity in severity, diagnosis, classifications as "non fire-related"
- What about fire-related injuries (emergency responders)?
- Long term or permanent injury difficult to attribute to CO poisoning (Adverse cardiovascular & neurological effects)

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Concern/ issues related to tracking CO poisoning in occupational settings

Clinical tests (for % carboxyhemoglobin) conducted after initial exposure, confounded by smoker levels

(Reference ranges of carboxyhemoglobin (COHb):

Nonsmokers: Up to 3% Smokers: Up to 10%-15%

Medscape: http://emedicine.medscape.com/article/2085044-overview)

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Knowledge check

What are signs & symptoms of CO poisoning?

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Main factors for severity of symptoms

1. Concentration of CO in air
2. Interval of exposure
3. Work load & breathing rates
4. Underlying health of exposed person

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Treatment

- Provide 100% oxygen at ambient pressure (NBO_2) (Usually considered medical treatment, meaning certification &/or licensing)
- Provide oxygen at elevated pressure (Hyperbaric oxygen, HBO_2) if available

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Sources of CO

- Exhaust gases from incomplete combustion of carbon-based fuels
- Fuel gas mixtures that contain CO
- Chemical & specialty production manufacturing processes that use CO
- Chemicals that metabolize to CO in bloodstream

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Knowledge check

What chemical is widely recognized as metabolizing to CO in the bloodstream with subsequent carboxyhemoglobin (COHb) formation?

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Chemical characteristics Knowledge check

1. Is CO heavier or lighter than air?
2. Is CO flammable?
3. What is odor of CO?
4. Does CO have incompatibilities to other materials?
5. What type of respirators are protective against CO?

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Implications of CO chemical characteristics: Discussion

1. Mixing & ventilation
2. LEL relative to toxic levels
3. Detection by workers
4. Storage
5. Usage & limitations of respirators

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Thresholds of concern

Agency	Threshold	Time	Notes
EPA	9 ppm	8 hrs	Ambient exposure; Not to be exceeded more than once per year
EPA	35 ppm	1 hr	Ambient exposure; Not to be exceeded more than once per year
OSHA TLV	50 ppm	8 hrs	Occupational exposure
NIOSH REL	35 ppm/ 200 ppm	8 hrs/ Ceiling	Occupational exposure
NIOSH IDLH	1200 ppm	< 30 minutes	Occupational exposure
ACGIH TLV	25 ppm	8 hrs	Occupational exposure

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Important reason for CO toxicity Knowledge check

Affinity of CO to hemoglobin; CO binds to hemoglobin with an affinity …… times more than oxygen

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Workplace sources of CO poisoning

Colorado reported work-related CO poisonings from:

- 40% gas powered equipment
- 25% automobile exhaust
- 12% furnaces

(NIOSH, 1996)

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Common tool CO sources

Gasoline powered:

- Pressure washers
- Power trowels
- Concrete saws
- Compressors
- Welding equipment
- Floor buffers
- Jackhammers
- Pumps
- Carpet cleaners
- Paint sprayers
- Other??

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Time intervals involved in poisonings

Re-creation of an event involving a 5.5 horsepower (HP) gasoline power washer in 2-car garage (8,360 ft^3), no ventilation, breathing zone concentrations:

- 200 ppm in 5 minutes
- 1200 ppm in 15 minutes
- 1500 ppm in 19 minutes

Same scenario w/ garage doors, one window & vent opened (passive ventilation):

- 200 ppm in 3 minutes
- 658 ppm in 12 minutes

(NIOSH, 1996)

In this test, ventilation was apparently not helpful! Consider that elevated CO in confined spaces is often fatal.

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Other emissions information

- 5 HP, 4-cycle engine: CO generation = 670 grams/ HP hour (NIOSH, 1996)
- MY2010 gasoline passenger cars = 1.5 g/mile new, to 4 g/mile at 10 years (Argonne, 2013)
- (HP range for cars approximately 141-577 HP) (http://www.autobytel.com/top-10-cars/high-horsepower-cars/, http://www.autobytel.com/top-10-cars/low-horsepower-cars/)

Note: 1 gram of CO = 0.87 liters (0.031 ft^3) of 100% CO; (1 liter = 0.0353 ft^3), so each gram of CO can cause elevation of CO concentration of 31 ppm in a 1000 ft^3 unventilated room (if I did calculations correctly)

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More about automobile emissions of CO

- Pre catalytic converters, 1973 study found that on 90-min ride on LA freeway, CO levels approached 25-100 ppm. EPA emission standards reduced CO production by over 95%.
- A properly tuned gasoline engine produces >30,000 ppm CO in exhaust stream before catalytic converter. Exhaust systems must be gas tight from engine to end of tailpipe.

Agricultural & Biosystems Engineering, Iowa State University
http://www.abe.iastate.edu/extension-and-outreach/carbon-monoxide-poisoning-vehicles-aen-208/

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Detection instruments & applications

Photos by S Cali

- 4-gas meter w/ CO sensor, audible & visible alarms, confined spaces & entry to suspect areas (w/ probe & pump)
- CO meter w/ alarms, confined spaces & entry to suspect areas (w/ probe & pump)

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Detection instruments & applications

Photos by S Cali

- Detector tubes & hand pump, relatively immediate CO concentration estimate
- CO datalogger, IAQ & appliance long-term monitoring
- Q-Trak w/ CO sensor, IAQ & appliance logging capabilities

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Summary

- Considering hazards, surveillance & occupational CO poisoning rates should be improved
- Awareness of physical symptoms essential
- Awareness of CO chemical characteristics essential
- CO emission sources & emission strength is often underestimated
- Understanding of operation & proper calibration of detection instruments is important to usage

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Primary references

- *Results from a State-Based Surveillance System for Carbon Monoxide Poisoning*, Judith M. Graber & Andrew E. Smith, Public Health Reports / March–April 2007 / Volume 122
- *Carbon monoxide poisoning in the 21st century*, Angela L Chiew & Nicholas A Buckley, Critical Care 2014, 18:221, http://ccforum.com/content/18/2/221
- *Preventing Carbon Monoxide Poisoning from Small Gasoline-Powered Engines and Tools*, NIOSH Alert, 1996, http://www.cdc.gov/niosh/docs/96-118/
- *Mortality and hospital admission rates for unintentional nonfire-related carbon monoxide poisoning across Canada: a trend analysis*, Eric Lavigne, Scott Weichenthal, Joan Wong, Marc Smith-Doiron, Rose Dugandzic, Tom Kosatsky, *CMAJ Open* 2015. DOI:10.9778/cmajo.20140122
- *Updated Emission Factors of Air Pollutants from Vehicle Operations in GREETTM Using MOVES* , Hao Cai, Andrew Burnham, Michael Wang, Systems Assessment Section, Energy Systems Division, Argonne National Laboratory, September 2013

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