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A Lexington Medical Center Physician Practice

Working Well

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INSIDE THIS ISSUE:

First Aid for Chemical Exposures

PLUS

Chemical Asphyxiant

Hierarchy of Controls

Chemical Hazards — Resources

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Working Well

This edition of *Working Well* is focused on chemicals in the work setting. We have used chemistry in every aspect of our modern lives to provide innovations and improvements in our way of living. The use of chemicals, however, is not without potential hazards. Exposures to toxic substances need to be evaluated and treated immediately.

The first article outlines basic first-aid treatments for exposures that should be initiated at the workplace. The second article, "Chemical Asphyxiant," highlights a potential, insidious scenario that can occur from exposure to asphyxiant chemicals, which can be fatal. The article on "Hierarchy of Controls" explains levels of mitigation of potential hazards and the relative effectiveness of those processes to protect workers. The "Chemical Hazards: Resources" article lists available resources to assist safety and environmental managers in developing effective programs to manage exposures in the workplace. The last article, "The Horseshoe Crab and COVID-19 Vaccine," associates the two in a roundabout way and throws in a connection to Charleston, SC for a gee-whiz factor.

I hope you find this edition of *Working Well* informative and useful. If you have other health, wellness or safety topics that may be of interest, please pose the suggestion to me at darawl@lexhealth.org.

– Dana Rawl, MD, MPH

First Aid for Chemical Exposures

By Dana Rawl, MD, MPH

What's the first step in mitigating the effects of a chemical exposure? In my opinion, the first step is to protect yourself. Caregivers, co-workers and first responders must not endanger themselves to an exposure of a toxic environment or substance without proper protection. This principle holds true for any exposure whether it's a solid or liquid chemical; a gas, fume or a vapor; or a biological or radiation hazard. The responder should make a quick, logical assessment of the situation and don appropriate protective equipment. If the initial responder cannot safely attend to the patient, he or she should wait until the scene is deemed safe by other first responders. The responder must not become another victim.

Once the victim is removed from the exposure, the toxic environment has been determined safe and/or the responder is properly protected, decontamination and first aid can be started by identifying the chemical exposure and the route of exposure: contact; ingestion; or inhalation. All chemicals used in a specific workplace should already be identified, and there should be a Safety Data Sheet (SDS) on each chemical in that workplace. Familiarity with and education on the SDS should be mandatory safety training for all workers in their workplace. The SDS for an identified chemical should have recommendations for first-aid treatment to minimize effects from the chemical relative to the route of exposure.

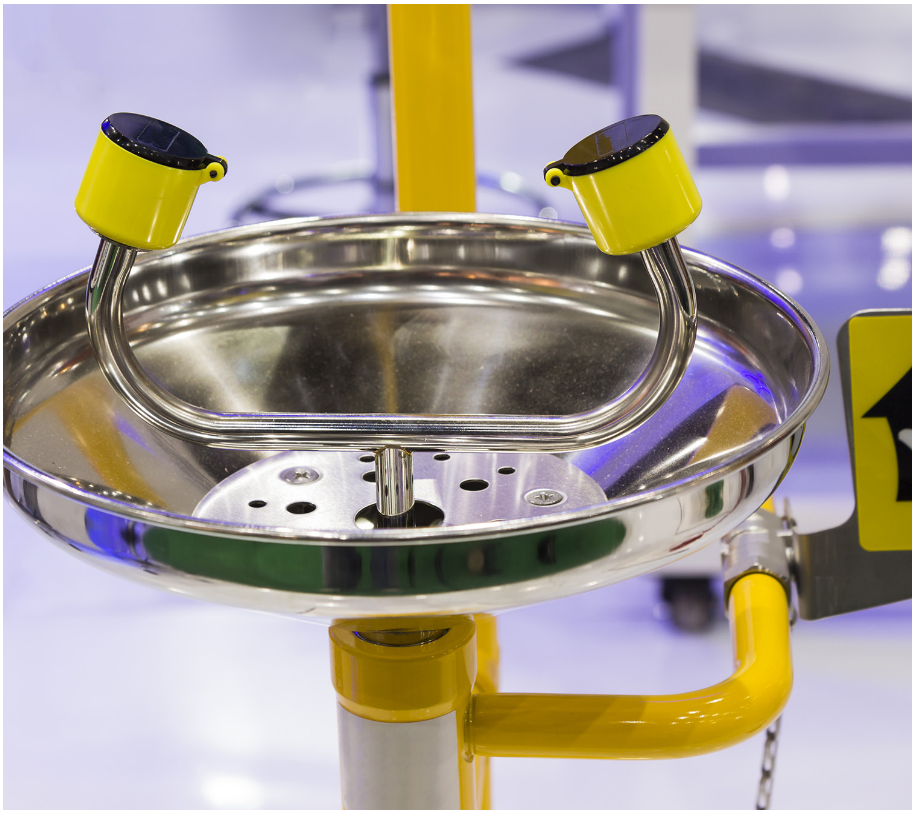
General Concepts in First-aid Treatment

Eye Exposure

- Immediately flush eyes with large amounts of water.
  - Tap water from an eye wash station works.
  - Flush eyes for 15 to 20 minutes for moderate irritants, 30 minutes for corrosive agents and 60 minutes for strong alkali agents (e.g., sodium or potassium hydroxide).
- Transport to an emergency care facility for further evaluation as needed or for pain or vision changes, or if breathing or circulation is compromised.

Skin Exposure

- Remove clothing (and jewelry) contaminated with the chemical.
  - Place clothing in a sealable bag.
- Brush off excess chemical from the skin if the substance is a powder, and blot (do not rub) excess substance. Do not use bare hands to remove a substance.
- Immediately flush the skin with water for at least 30 minutes.



- Be aware of any chemicals that react with water. Review the SDS.
- Use water or soap and water or have the victim shower with soap and lukewarm water.

- For hydrofluoric acid, apply a calcium gluconate slurry and seek immediate emergency room management.
- Larger or deeper chemical burns need emergency treatment and burn management.

Inhalation Exposure

- Remove the victim from the exposure to an area of fresh air.
- Assess airway and breathing.
  - Perform cardiopulmonary resuscitation protocol if needed.
  - Call 9-1-1.
- Use 100 percent oxygen if available.
- Transport to emergency care facility via ambulance.
  - Some chemicals may have delayed pulmonary effects (e.g., ammonia).
  - Some chemicals will disrupt oxygen transport or use of oxygen in body tissues (e.g., carbon monoxide, or hydrogen cyanide and hydrogen sulfide, respectively). Any antidote should be administered by a trained provider.
  - Some chemicals may provoke a severe asthma attack (e.g., toluene diisocyanate).

Ingestion Exposure

- Identify the substance and refer to the SDS.
- Call 9-1-1 and Poison Control (1-800-222-1222).
- Do not induce vomiting after a chemical ingestion in an occupational setting unless directed by a doctor or Poison Control.
- Do not dilute ingestion with water or milk unless directed by a doctor or Poison Control.
- Get medical attention immediately.

The employer obligation to provide a safe work environment is an Occupational Safety and Health Administration regulation. The workplace (or any environment) is not without potential or real chemical hazards. Exposures occur even with extreme mitigation efforts as accidents happen. Preparation, knowledge and use of general first-aid efforts guided by the SDS in the workplace can reduce morbidity from chemical exposures and help provide a safer workplace.

References:

Canadian Centre for Occupational Health and Safety: The Safety Data Sheet – A Guide to First-Aid Recommendations

CCOHS.ca/products/publications/firstaid/

CCOHS.ca/oshanswers/chemicals/firstaid.html

CDC.gov/niosh/npg/firstaid.html

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Chemical Asphyxiant

By Dana Rawl, MD, MPH

The following story is fictional and not based on a specific known event or person.

A middle-aged male forklift operator noted to his supervisor that he felt overly tired and lightheaded with a headache towards the end of the day. He was told to go home to rest and be at work the next morning. The next morning, he felt fine and returned to his forklift operations. Later that day, he passed out and drove his forklift into a support beam in the warehouse.

Colder fall temperatures drive heaters on, windows up and doors closed, creating enclosed space environments with less ventilation and higher risk for asphyxiant hazards. A chemical asphyxiant blocks the body's ability to use oxygen, and carbon monoxide (CO) poisoning is the most common chemical asphyxiant. Incomplete combustion produces carbon monoxide, and concentrations can accumulate in enclosed spaces, outdoor areas with poor ventilation and in chronically exposed conditions, such as constant automobile exhaust exposure with highway toll collectors or tunnel workers.

Oxygen binds to hemoglobin in the lungs and is transported to the organs for release. CO binds 240 times more strongly to hemoglobin than oxygen, thereby reducing oxygen binding sites with hemoglobin and causing less oxygen transport to the body. The symptoms of CO poisoning tend to be insidious but progressive with higher CO concentrations. A nagging headache with lightheadedness may quietly and quickly progress to unconsciousness and death. Early CO poisoning symptoms can start with blood CO concentrations as low as 10 percent. Drowsiness and fainting can occur with CO concentrations of 30-40 percent, and coma and death will occur with levels greater than 50 percent. Non-smokers may have normal carboxyhemoglobin levels up to 4 percent with chronic smokers ranging up to 8 percent.

The forklift operator was lethargic and appeared to have sustained a bruise to his head. He was transported to the emergency room by ambulance and given oxygen in route. His evaluation in the emergency department included routine blood analysis, cardiac enzymes, EKG, a head and neck CT scan and a physical examination. Even though the worker was a one pack-per-day smoker and had high blood pressure, nothing initially pointed to the cause of his black-out spell until his carboxyhemoglobin level was reported to be 13 percent. The patient did well with oxygen and recovered while in the emergency department.

Further history taken by the occupational health nurse highlighted that with the early freezing temperatures, the warehouse ventilation fans had been turned off and the doors had been closed. Also, the regular forklift was being repaired and the older diesel forklift was being used.

Was the 13 percent CO level high enough to cause a black out? Initiation of 100 percent oxygen in the ambulance with continued oxygen in the emergency department drove down the CO concentration in the blood over time. It was deduced that the forklift driver sustained CO poisoning from the diesel exhaust and the lack of ventilation in an enclosed warehouse. Industrial hygiene testing confirmed high levels of CO, and the exposure was mitigated with removal of the diesel forklift and application of engineering controls to increase warehouse ventilation.

The forklift operator in this story survived his CO exposure, but not all chemical asphyxiant outcomes are favorable. Many stories involving CO and other chemical asphyxiants end in permanent debility or death. Other asphyxiants include propane, methane or hydrogen, where gas displaces the concentration of oxygen in the air and results in lower oxygen partial pressures and low blood oxygenation. This effect has been seen in storage tanks where a worker may go into a confined space without proper respirator gear and not survive. Other asphyxiants, such as hydrogen cyanide and hydrogen sulfide, are like CO in that they interfere with the transport, delivery or utilization of oxygen in the body. More frequently, these types of

Colder fall temperatures drive heaters on, windows up and doors closed, creating enclosed space environments with less ventilation and higher risk for asphyxiant hazards.

chemical asphyxiants are produced as a result of some other process, such as metal plating, sewage treatment, leather tanning and oil drilling.

Chemical asphyxiant hazards are well recognized, and primary prevention is the foundation for safety. Once exposures are anticipated, utilizing control measures will help protect workers. These actions include minimizing asphyxiant formation in the manufacturing process, implementing proper ventilation, enforcing proper work practices, providing essential worker training and education, and utilizing personal protective equipment.

Reference:

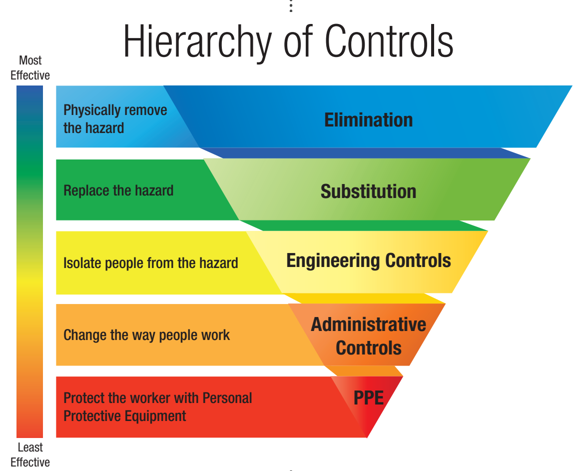
Levy, S. B., et al. *Occupational and Environmental Health Recognizing and Preventing Disease and Injury. Sixth Edition.* Oxford University Press, 2011, pages 197-201.

Hierarchy of Controls

By Dana Rawl, MD, MPH

Protecting workers from any work-related injury, illness or fatality is the primary goal to which every employer aspires for their company. Employers are fully aware that workers are the backbone of any business, and an injured worker from a work-related incident is not only a misfortune or tragedy for the employee but undermines morale in the workforce and affects productivity. Unfortunately, no workplace is without hazards.

A hierarchy of actions outlines a strategy for employers to implement to mitigate hazardous conditions and provide safety measures for workers. These actions describe control methods that graduate from the most effective solution to the least effective solution to combat a workplace hazard. Companies that follow this hierarchy of controls find an inherently safer system that substantially reduces risk of workplace illness or injury.



By far, elimination or substitution of a hazard is the most effective way to control risk of illness or injury from that hazard. Chemicals used in areas such as manufacturing, general industry or janitorial services should be evaluated for any significant toxic or carcinogenic properties and, if found to be hazardous, should be removed from the process or substituted with a less hazardous substance, if possible.

Elimination and substitution may be easier and less expensive to implement if the process is in the development or design stage. Whereas, an existing industrial process may require major changes in equipment and procedures to implement elimination or substitution hazard controls.

Engineering controls are designed to remove the hazard from the source before contacting the worker. One example of an engineering control is the use of a ventilation hood for chemical or medicine isolation in a laboratory setting. Well-designed engineering controls are highly effective in preventing worker exposure to hazards or hazardous materials. The initial engineering control costs can be high, but the long-term benefits are generally cost effective.

Administrative controls are used to reduce exposure of the employee to the hazard. This type of protection is usually implemented into an existing process where the hazard is not well controlled. One such administrative control is limiting employee exposure to repetitive injury by rotating employees through different workstations, thereby reducing duration of exposure to a physical hazard. The employer governs administrative controls and, while inexpensive to institute, they may be costly to sustain.

Personal protective equipment (PPE) is the least effective mechanism of protection under the hierarchy of control. PPE includes gloves, gowns and masks for infection control, as well as safety lines and harnesses for workers at heights. Proper use of PPE is subject to personal responsibility of the user. Wear of PPE will be variable and potentially unreliable. PPE programs are inexpensive to establish, but they can be very costly to sustain as evident with the COVID-19 pandemic.

There are many hazards in the workplace, including physical, chemical, environmental, mechanical and disease hazards. It's up to the employer to provide a safe workplace. Understanding, designing and implementing a hierarchy of hazard controls for the workplace will lower worker risk for illness and injury and provide for a safer and healthier work environment.

Reference:

https://www.cdc.gov/niosh/topics/hierarchy/default.html

Chemical Hazards: Resources

By Dana Rawl, MD, MPH

Chemicals that cause a physical hazard (e.g., flammability, explosibility, oxidation, corrosion) or a health threat (e.g., irritation, sensitization, toxicogenicity, carcinogenicity) are considered hazardous. Exposure to hazardous chemical substances can cause adverse health effects, permanent injury or death. Employers must ensure that workers exposed to hazardous chemicals or substances have been made aware of potential exposure, educated on the risks from exposure and trained on handling the chemicals and protecting themselves with proper use of personal protective equipment. Occupational Safety and Health Administration's Hazard Communication Standard outlines employer responsibilities toward this end.

Exposure to chemical hazards can occur through multiple routes, including skin, inhalation or ingestion, but adverse effects or toxicity is usually dose and time dependent. A high level of exposure over a short time may or may not be as consequential as an exposure of the same substance at a lower level over a longer period of time. There is great variability of dose over time relative to chemical exposure and adverse health effects.

With years of research and studies, occupational exposure limits (OEL) have been developed to help guide mitigation of respiratory hazards. The Toxic Substance Control Act Chemical Substance Inventory currently has listed more than 85,000 commercially available chemicals, yet only about 1,000 of these have an OEL. The National Institute for Occupational Safety and Health (NIOSH) has developed a banding process for chemicals that have no OEL to assist in determining appropriate protective mechanisms for exposed workers. The chemicals are grouped by certain characteristics, such as chemical structure, to predict potential hazardous effects. This occupational exposure banding process "seeks to create a consistent and documented process with decision logic to characterize chemical hazards so that timely, well-informed risk management decisions can be made for chemical substances that lack OELs." Visit CDC.gov/NIOSH/docs/2019-132/default.html to view the NIOSH Occupational Exposure Banding Process for Chemical Risk Management.

The following list of databases and resources provides valuable information on guides, preparedness and responses to managing and mitigating chemical hazards.

Emergency Response Resources

CDC.gov/NIOSH/topics/emres/chemagent.html.

Chemical Databases

Emergency Preparedness and Response Databases

- The Emergency Response Safety and Health Database
  CDC.gov/niosh/ershdb/
- Public Health Emergency Preparedness and Response, Chemical Agents List A-Z Emergency.CDC.gov/agent/agentlistchem.asp

General Chemical Information Databases

- NIOSH Pocket Guide to Chemical Hazards
  CDC.gov/NIOSH/npg/default.html
- International Chemical Safety Cards
  CDC.gov/niosh/ipcs/

Medical Management Resources

- Medical Management Guidelines
  ATSDR.cdc.gov/MMG/index.asp

Toxicological Information Databases

- ATSDR Profiles
  ATSDR.cdc.gov/toxprofiledocs/index.html
- ToxFAQs
  ATSDR.cdc.gov/toxfaqs/index.asp
- Toxicology Interactive Profiles
  ATSDR.cdc.gov/interactionprofiles/index.html
- Acute Exposure Guideline Levels
  EPA.gov/aegl

Guidance

- Chemical Safety Guidance
  - NIOSH Chemical Safety Topic Page
    CDC.gov/niosh/chemicals/default.html?CDC_AA_ref Val=https%3A%2F%2Fwww.cdc.gov%2Fniosh%2Ftopics%2Fchemical-safety%2Fdefault.html
- Emergency Response Guidance
  - Emergency Response Guidebook (Department of Transportation) PHMSA.dot.gov/hazmat/erg/emergency-response-guidebook-erg
- Medical Management Guidance
  - Chemical Hazards Emergency Medical Management
    CHEMM.nlm.nih.gov/

The Horseshoe Crab and COVID-19 Vaccine

By Dana Rawl, MD, MPH

The horseshoe crab predates the dinosaur with fossils dating roughly 450 million years ago. They haven't changed much in those millennia, but to survive, they developed an immunity to fight off a plethora of marine bacteria.

In 1954, Frederik Bang, a scientist in Massachusetts, discovered that the blood from a horseshoe crab would clot when it contacted live or dead Gram-negative bacteria. Further research determined that the blood from horseshoe crabs contains a protein called Limulus amebocyte lysate (LAL). The blood of the horseshoe crab, which is blue because of its copper-based hemocyanin to carry oxygen, reacts to the endotoxin membrane of an offending bacteria and clots, effectively disabling the bacteria.

The horseshoe crab's immunity process has been exploited to benefit modern medicine. Any product that will be introduced into the human body, including vaccines, intravenous antibiotics and implanted medical devices, must be tested for bacterial toxins. Pharmaceutical companies used to test their product in rabbits. If the rabbit became febrile, then that result would indicate an infection and a contaminated product. Now, there is a LAL test that provides a simple positive or negative result for detection of Gram-negative bacteria endotoxins.

Interestingly, there is a LAL manufacturing facility in Charleston, South Carolina. The Charles River Endosafe Endotoxin Microbial Detection Division collects horseshoe crabs by the truckload to prepare them for bleeding. After the sanitization process, the crabs "donate" their blood and return to the ocean alive.

It's quite an accomplishment for the ancient horseshoe crab to be an integral piece of the manufacturing puzzle to develop a COVID-19 vaccine for the world.

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https://www.pacificprime.com/blog/7-living-organisms-that-aid-modern-medicine-in-the-weirdest-ways.html. What is Limulus Amebocyte Lysate (LAL) and Its Applicability in Endotoxin Quantification of Pharma Products. IntechOpen. Yasir Mehmood. Jan 8, 2019.