

PRELIMINARY REPORT

USE OF PULSE CO-OXIMETRY AS A SCREENING AND MONITORING TOOL IN MASS CARBON MONOXIDE POISONING

Bryan E. Bledsoe, DO, Kevin Nowicki, EMT-P, James H. Creel, Jr., MD, Dale Carrison, DO, Harry W. Severance, MD

ABSTRACT

Carbon monoxide (CO) poisoning remains a common cause of poisoning in the United States. We describe a case where responding fire department personnel encountered a sick employee with a headache at an automotive brake manufacturing plant. Using both atmospheric CO monitoring and pulse CO-oximetry technology, fire department personnel were able to diagnose the cause of the patient's illness and later identify the source of CO in the plant. **Key words:** carbon monoxide; pulse CO-oximetry; multiple casualty event; toxicology

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INTRODUCTION

Carbon monoxide (CO) poisoning remains the leading cause of poisoning in industrialized countries.¹ CO is a colorless, odorless, and tasteless gas that results from the incomplete combustion of carbon-containing substances. Because CO is hard to detect without monitoring devices, people often attribute signs and symptoms of CO poisoning to other disease processes. Therefore, emergency personnel must maintain a high index of suspicion for CO poisoning.

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Address correspondence and reprint requests to: Bryan E. Bledsoe, DO, University of Nevada School of Medicine, Emergency Medicine, 901 Rancho Lane, Suite 135, Las Vegas, NV 89106. e-mail: bbledsoe@earthlink.net

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Most modern fire departments have atmospheric gas monitors to detect dangerous gases. Most of these monitors measure atmospheric levels of oxygen (%), carbon monoxide (parts per million [PPM]), hydrogen sulfide (PPM), and combustible gases (% lower explosive limit [LEL]). Biological monitors are available that measure exhaled CO levels or indirectly measure arterial carboxyhemoglobin (SpCO) levels through CO-oximetry technology.²

This case will detail how fire department personnel combined both atmospheric and biological CO monitoring to diagnose CO poisoning in factory workers and to identify an occult source for the poisoning.

CASE REPORT

A suburban fire department and emergency medical services (EMS) unit was dispatched to a local manufacturing plant because an employee developed a headache while at work and other employees noticed a smell of gas in the building. The plant manufactures automotive brake systems and is housed in an insulated steel building built in 2000. The brake parts are initially prepared in a foundry area where raw aluminum is melted in a furnace and poured into molds. Once cooled and prepared, the parts are milled and ultimately sent to another part of the plant where they are assembled into the final products. The foundry area is separated from the assembly area by a steel wall and is not air conditioned and heated. The assembly area is supplied with heating and air conditioning. Because the incident occurred in June, the air conditioning system was operating at the time. Twenty employees were working on the evening of the incident.

Upon arrival at the plant, firefighters entered the assembly area of the building. They immediately began to test atmospheric air within the plant with an atmospheric gas monitor (PhD⁵ Multi-Gas Detector, Sperian-Biosystems, Prairieville, LA).³ The monitor alarmed with a CO reading of 26 PPM. As firefighters

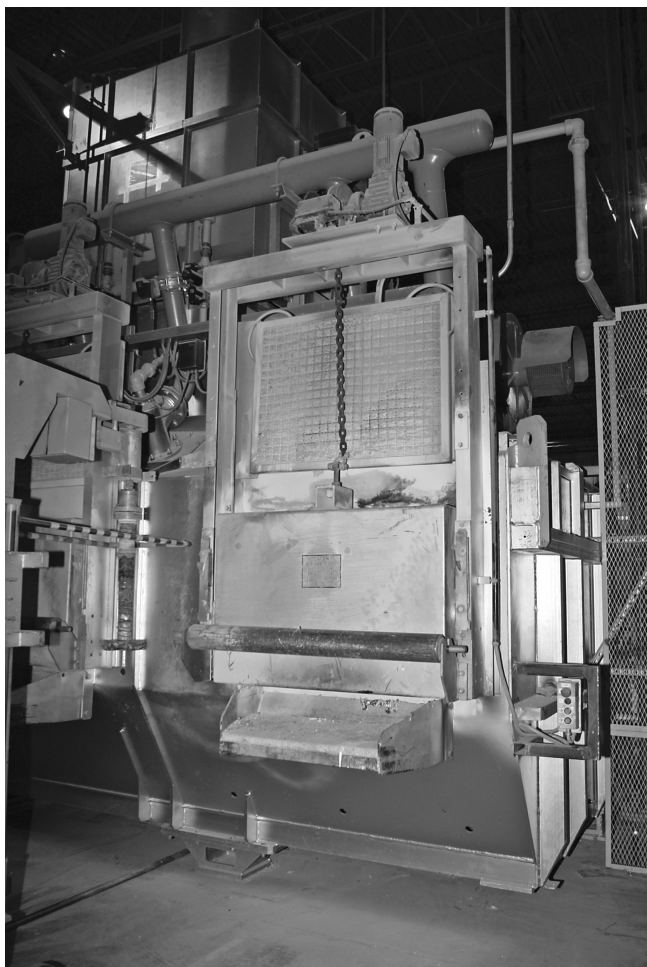


FIGURE 1. Recently installed furnace later determined to be CO source in the factory.

advanced further into the plant, they found CO levels of 70 PPM in the center of the assembly area. Ambient oxygen levels in the assembly area ranged from 15% to 18%. Because of this, all employees were evacuated outdoors and further assessed and treated. A roll call was completed to ensure that all occupants were out of the building and accounted for.

Firefighters, accompanied by an employee of the plant, began to search the building for the source of the CO. Although levels were highest in the assembly area, there were no CO sources identified in that part of the building. An industrial furnace had just been installed in the foundry area of the building and it was investigated with the monitor. However, no detectable CO levels were present anywhere in the foundry area (see Figure 1).

As part of the assessment of evacuated employees, each person was tested with a pulse CO-oximeter (Rad-57, Masimo, Irvine, CA).⁴ The SpCO levels ranged from 5% to 18%. Because the source of the CO could not be identified, a firefighting preplan of the plant was retrieved. Each evacuated employee was



FIGURE 2. Brake assembly area where highest SpCO readings were found.

questioned as to his or her principal location in the plant that day. The employees' locations, along with their measured SpCO levels, were marked on the map. The employees with the highest SpCO levels were found to be working immediately under air conditioning vents in the assembly area (see Figure 2). Firefighters then traced the air conditioning vents to air conditioning units on the roof. They found atmospheric CO levels of 100 PPM and increasing as they approached a vent where the new furnace was venting exhaust. Ambient oxygen levels near the roof were 15%. The CO levels were highest at the level of the roof and virtually absent 1.5 meters above the roof. The intake vent for the air conditioning unit serving the assembly area was close to the furnace exhaust vent and exhaust gases from the furnace were being drawn into the air conditioning system.

Affected employees were treated on scene with high-concentration oxygen. Most were asymptomatic or had nonspecific complaints. Medical control was contacted and the decision was made not to transport any of the employees to the hospital, as SpCO readings were adequately declining with supplemental oxygenation.

The plant was immediately closed and the manufacturer of the furnace found that the natural gas setting for the furnace had been incorrectly set, resulting in incomplete combustion of gas. The furnace was repaired and the plant was ventilated overnight and rechecked the following morning by fire department personnel, and no residual CO was detected in the plant.

DISCUSSION

Sources of CO are often hard to detect in large manufacturing plants and in mass-casualty events. In this case, initial atmospheric monitoring of CO revealed levels to be high in an area where no CO source existed

and absent in the area where the likely CO source was found. Subsequent biological monitoring with a pulse CO-oximeter allowed for mapping of the location of victims with CO exposure and subsequent identification of the CO source. Pulse CO-oximetry uses multiple wavelengths of light to detect carboxyhemoglobin levels. These are then matched with known parameters in the device's algorithmic database that provides an SpCO level, expressed as the percentage of carboxyhemoglobin present. Levels of SpCO detected by pulse CO-oximetry have been found to correlate well with venous carboxyhemoglobin levels.^{5,6}

In this case, firefighters were able to map the location and SpCO levels of employees within the plant. A cluster of employees with high SpCO levels was identified and the common factor was found to be that they worked on the assembly line immediately under air conditioning vents. The air conditioning vents were traced to the roof, where the CO source was identified.

Interestingly, the atmospheric CO levels were highest at the surface of the roof and decreased as the meter was raised from the roof. Carbon monoxide has a vapor density of 0.968, which makes it slightly lighter than dry air at a barometric pressure of 760 mmHg.⁷ However, atmospheric conditions at the time of the incident, as measured at the closest National Weather Service monitoring station (Chattanooga, TN), revealed a temperature of 59.0°F (15.0°C), dew point of 52.0°F (11.1°C), relative humidity of 78%, and barometric pressure of 769 mmHg. Winds were relatively calm at 3.5 mph (5.6 kph).⁸ The relatively humid air mass appears to have trapped exhaust gases from the furnace at roof levels, where they were immediately drawn into the air conditioning system for the assembly area.

The early recognition of CO poisoning and subsequent identification of the source was effective in averting a potential disaster. While atmospheric monitoring revealed elevated CO levels, it was unable to identify a source. Subsequent biological monitoring

and mapping identified a potential exposure point for employees. This was then tracked to an exhaust vent from the malfunctioning furnace. Because employees were promptly removed from the plant, treated, and monitored, transport to the hospital was deemed unnecessary and the patients were allowed to go home once satisfactory SpCO levels were attained. This averted a mass-casualty event for the local EMS system and area hospitals.

This case illustrates that biological monitoring of SpCO levels complements atmospheric monitoring of CO. A possible disaster was averted through the prompt identification of the CO source through geographic mapping of SpCO levels in exposed employees.

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