Asphyxiation by Cake
An Unusual Case of Dyspnea

Richard Schreckengaust, MD, Joseph P. Lang, MD, Francis L. Counselman, MD, CPE

A 58-year-old traveling salesman with a history of hypertension presents to the emergency department with shortness of breath, lightheadedness, and nausea.

A 58-year-old man presented to the emergency department (ED) via emergency medical services (EMS) with shortness of breath, lightheadedness, and nausea. Upon arrival to the ED, most of his symptoms had resolved. The patient reported that he had taken a two-hour flight into town the previous day and had spent an uneventful evening at a local hotel. He said that he began experiencing shortness of breath and lightheadedness soon after entering his rental vehicle an hour prior to presentation, explaining that he felt as if he "could not get any air."

He denied chest pain, leg pain or swelling, abdominal pain, or recent illness. Medical history was significant for hypertension, for which he was taking losartan and amlodipine. He had no drug allergies, surgical history, or smoking history. Of note, when the hotel clerk got in the same rental vehicle to move it, he developed symptoms similar to those of the patient. As with the patient, the clerk's symptoms quickly resolved after he got out of the vehicle.

The patient's vital signs at examination included an oral temperature of 97.5°F; pulse, 62 beats/min; respiratory rate (RR), 18 breaths/min; blood pressure, 133/83 mm Hg; and O_2 saturation, 100% on room air. He was alert and oriented, in no distress, easily conversational, and without diaphoresis. The lungs were clear to auscultation bilaterally, and there was no calf swelling, tenderness, or palpable cords. The remainder of the physical exam was normal.

Richard Schreckengaust is an emergency physician in the Department of Emergency Medicine at Camp Lejune, North Carolina. **Joseph P. Lang** is an Assistant Professor in the Department of Emergency Medicine at Eastern Virginia Medical School (EVMS) and practices at Emergency Physicians of Tidewater, both in Norfolk. **Francis L. Counselman** is the Distinguished Professor and Chairman of the Department of Emergency Medicine at EVMS and practices at Emergency Physicians of Tidewater. This article originally appeared in *Emergency Medicine* (2014;46[12]:558-561).

Ancillary studies included a normal chest X-ray. An ECG demonstrated sinus bradycardia with a rate of 56 beats/min but no evidence of ischemia or right heart strain. Complete blood count, troponin I, D-dimer, and creatine phosphokinase (CPK) with MB fraction levels were all within normal limits. A serum chemistry panel was also within normal limits, except for a serum glucose level of 181 mg/dL. Venous co-oximetry showed a carboxyhemoglobin level of 0.0, and methemoglobin level of 0.5 gm% (normal range, 0.4-1.5).

Since both the patient's and hotel clerk's symptoms started when each was in the rental car, the patient was questioned about the vehicle and its contents. The car was a late-model rental in good condition per report. The patient informed the treating emergency physician that he worked as a decorative cake salesman and had brought cake samples with him to display at a trade show. He further stated that he had left these samples in the car overnight, packed in dry ice.

Upon learning this information, EMS was contacted and instructed to return to the hotel and rental vehicle. The hotel room was noted to have normal levels of O_2 and carbon monoxide (CO) on measurement. Investigation of the car revealed normal levels of CO but O_2 levels too low to read on the sensor. The emergency team concluded that the dry ice (the solid form of carbon dioxide [CO_2]) sublimed to CO_2 gas overnight. This displaced the O_2 in the vehicle, resulting in severe hypoxia and the symptoms of both the patient and hotel clerk.

The patient was initially placed on 15 L of O_2 via a nonrebreather mask, then switched to 2 L of O_2 via nasal cannula. He was observed for a total of four hours after arrival; as he remained symptom-free, he was discharged home. Postdischarge follow-up information was not obtainable.

DISCUSSION

Carbon dioxide is prevalent in everyday life, from an agent in fire extinguishers and carbonation in beverages to byproducts of cellular metabolism. Similar to CO, it is a colorless and odorless gas.

Carbon dioxide is commonly used in the food industry as dry ice to keep items cold. In its solid state, CO_2 can cause severe frostbite with direct contact, similar to a burn. However, when dry ice is warmed and sublimated to a gaseous state, large amounts of CO_2 are generated, and this heavy gas can accumulate and displace air (ie, atmospheric O_2), especially in confined spaces. In low concentrations, gaseous CO_2 appears to have minimal toxicologic effects, but at higher concentrations it can cause tachycardia, tachypnea, dyspnea, visual disturbances, arrhythmias, impaired levels of consciousness, and death.

Carbon dioxide primarily acts as a simple asphyxiant, but it also dissolves in serum as carbonic acid, resulting in a metabolic acidosis. Compensation for this acidosis is accomplished by an increased RR (ie, respiratory alkalosis), which further worsens the intake of CO_2.[1,2]

The normal concentration of CO_2 in the atmosphere is approximately 0.04% (396 ppm). The Occupational Safety and Health Administration (OSHA) has set a maximum safe exposure level of CO_2 at 0.5% (5,000 ppm) over an eight-hour day.[3] Concentrations as low as 1% (10,000 ppm) may cause drowsiness. Exposure to concentrations of 7% to 10% for several minutes to an hour results in headache, tachycardia, dyspnea, and hyperventilation. At levels of 10% to 15%, dizziness, severe muscle twitching, and loss of consciousness can occur after only a few minutes. Death occurs within minutes at concentrations greater than 30%.[2]

Carbon dioxide also acts as a potent cerebral vasodilator, which may explain symptoms such as headache and dizziness.[2] The severity of symptoms is dependent on the concentration of CO_2, the length of the exposure, and the underlying health of the patient. Elevated concentrations of CO_2 can occur in areas where there is limited or poor ventilation, such as in a mine (where it is known as *blackdamp*, *stythe*, or *choke damp*),[4] submarine, grain silo, or a sealed building without mechanical ventilation.

Other case presentations

Similar cases have been described in the literature. In one case, following Hurricane Ivan, a 34-year-old man placed four 25-pound blocks of dry ice wrapped in paper in the front seat of his truck with the windows closed.[5] After driving less than one-quarter of a mile, he developed dyspnea and telephoned for help before losing consciousness. Fortunately, he was found in time and recovered soon after the doors to his truck were opened.[5]

In another case, a 59-year-old man entered a walk-in freezer that contained dry ice wrapped loosely in plastic. He was found inside the freezer 20 minutes later in cardiac arrest; resuscitation efforts were unsuccessful. Investigation of the freezer found an initial O_2 concentration of 13% (normal level, 20.93%) and an estimated CO_2 level of 40%.[5]

Similarly, a 35-year-old woman was inadvertently locked in a bank vault while storing receipts. In a bid for help, she pulled the fire alarm, which triggered a CO_2-based fire-extinguishing system. The fire department responded and found the woman dead in the vault 30 minutes later. The cause of death was labeled as CO_2 intoxication.[6]

Natural phenomena

There have also been documented cases of CO_2 toxicity associated with volcanic eruption and other natural phenomena; for example, the Lake Nyos, Cameroon, West Africa incident in 1986. In this event, a magma pocket underlying the lake saturated the water with CO_2 stored as carbonic acid in the water. When a landslide hit the lake, it caused the carbonic acid stored in the depths of the lake to be upheaved to the surface, where it turned back into CO_2 and was released into the atmosphere. Since CO_2 is heavier than O_2, it displaced the O_2 near the ground, resulting in the suffocation and death of 1,700 people in the surrounding villages.[2]

Differential diagnosis

When CO_2 toxicity is suspected, other conditions should be considered, as there may be more than one process involved. For example, other causes of coma or dyspnea should be investigated, including trauma, hypoglycemia, CO, methemoglobinemia, or other metabolic processes. In addition, a patient may have a pre-existing condition, such as a trauma or an altered mental status due to drugs or alcohol, all of which can increase his or her susceptibility to the effects of CO_2.

Evaluation and treatment

Useful laboratory testing includes arterial blood gas, venous co-oximetry for carboxyhemoglobin, chemistry panels, ethanol testing, and radiographs or CT, as indicated.

Initial management of suspected CO_2 toxicity entails first removing the patient from the source of the gas. Rescuers must exercise caution so as to prevent a mass-casualty incident. Once out of the dangerous environment, as long as the patient is conscious and spontaneously breathing, supportive measures are generally all that are necessary. Oxygen should be applied, after which the spontaneously breathing patient without underlying lung disease should rapidly return to normal.

If there is marked decrease in mental status or poor respiratory drive despite O_2 administration, intubation with mechanical ventilation may be required. A higher-than-normal RR will help remove excessive CO_2 in this instance.

If a respiratory acidosis is present, IV sodium bicarbonate should be avoided, as this may increase the level of serum CO_2. IV fluids and other supportive measures, including treatment for any concurrent conditions, may be indicated. **CR**

REFERENCES

1. Nelson LS, Odujebe OA. Simple asphyxiants and pulmonary irritants. In: Nelson LS, Lewin NA, Howland MA, et al, eds. *Goldfrank's Toxicologic Emergencies*, 9th ed. New York, NY: McGraw-Hill; 2011:1644-1645.
2. Langford NJ. Carbon dioxide poisoning. *Toxicol Rev.* 2005;24(4):229-235.
3. Occupational Health and Safety Standards. Table Z-1, Limits for air contaminants. Occupational Safety and Health Administration Web site. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9992. Accessed January 19, 2015.
4. Hedlund FH. The extreme carbon dioxide outburst at the Menzengraben potash mine 7 July 1953. *Safety Sci.* 2012;50(3):537-553.
5. Dunford JV, Lucas J, Vent N, et al. Asphyxiation due to dry ice in a walk-in freezer. *J Emerg Med.* 2009;36(4):353-356.
6. Gill JR, Ely SF, Hua Z. Environmental gas displacement: three accidental deaths in the workplace. *Am J Forensic Med Pathol.* 2002;23(1):26-30.