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## Carbon monoxide poisoning at a Florida Hospital following Hurricane Irma

Carbon monoxide (CO) poisoning following natural disasters has proven to be a significant source of morbidity and mortality [1]. Hurricanes precipitate disruptions to the power grid and gas-powered generators are implicated as a common source of CO exposure [1]. CO toxicity itself can result in nonspecific symptoms, requiring heightened suspicion in the emergency department [2].

Although sporadically reported following previous U.S. hurricanes, CO poisoning is increasingly being identified in this setting [3-7]. However, most reporting has been from poison centers, national databases, the Centers for Disease Control and Prevention (CDC), and epidemiological surveillance data in the post storm period [8-12]. Our objective was to characterize hurricane associated CO poisonings occurring at a single regional trauma hospital with 70,000 annual ED visits in Palm Beach County, Florida, following the landfall and power interruption of Hurricane Irma on September 10, 2017. The project received IRB approval and utilized a retrospective study design from September 10, 2017 (the recorded first landfall date of Hurricane Irma) through September 30, 2017. Patients were included if they had ICD-10 diagnosis code beginning with T58, indicating toxic effect of CO.

Demographic variables collected included date and time of emergency department presentation, age, gender, and race. Exposure variables collected include date of exposure, location of exposure, source of exposure, and storage site of the source (i.e. generator). Documented symptoms included: headache, malaise, nausea, vomiting, syncope, altered mental status, dizziness, and dyspnea. Initial co-oximeter values including ABG and CO levels were recorded. Treatment variables collected include oxygen administration, intubation, and hyperbaric treatment.

Charts of identified patients were stratified based on the CDC CO poisoning definition of "suspected", "probable" or "confirmed" [13]. All confirmed cases had carboxyhemoglobin (COHb) level measured by blood sample of greater than 5% in nonsmokers, or 10% in smokers or unknown smoking status. Twenty-three patients were identified for study inclusion, all presenting within four days of hurricane landfall (Fig. 1). Twenty-two were confirmed as CO poisoning based on their CO levels and one was only suspected because no CO level was drawn despite significant environmental exposure. There were 14 males and nine females ranging from 8 to 76 years, with an average of 44.9 years, including nine African-Americans, seven Asians, six Caucasians, and one Hispanic. There were 12 distinct exposure events, with five having multiple victims, ranging from one to five per exposure.

The most common source of CO exposure (20 patients) was gas-powered electrical generators. One patient was involved is a house fire, and two other exposures were not specified. Of the 20 patients with exposures due to generators, six involved indoor usage, five outdoor but adjacent to the house, five outdoor but directly outside of the garage, and three inside the garage. Six patients were exposed while in their bedrooms, 16 in unspecified parts within their home, and one while outside on a patio.

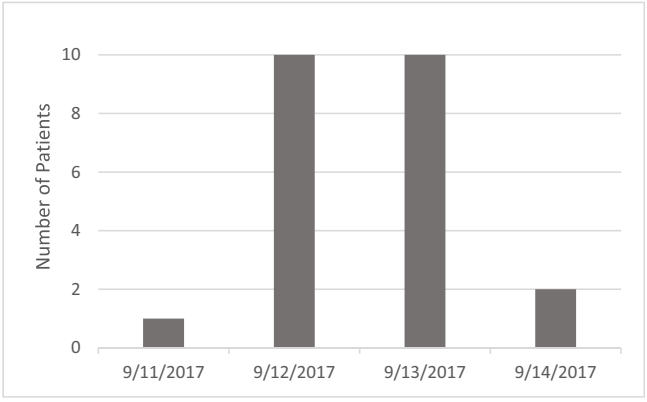


**Fig. 1.** Frequency of patient presentations to the emergency department with CO exposure by date.

**Table 1**
Number of patients presenting to the emergency department by symptom with corresponding CO levels.

| | n (%) | COHb % (range) |
|---|---|---|
| All | 23 (100%) | 19.8% (7.1–35) |
| Symptom | | |
| Headache | 9 (39%) | 21.6% (8.3–27.1) |
| Malaise | 1 (4%) | 30.2% (30.2–30.2) |
| Nausea | 8 (35%) | 19.9% (8.3–27.1) |
| Vomiting | 5 (22%) | 22.5% (15.5–26) |
| Syncope | 1 (4%) | 14.4% (14.4–14.4) |
| Dyspnea | 3 (13%) | 11.5% (8.3–14.4) |
| Dizziness | 7 (30%) | 19% (8.3–25.3) |
| AMS | 10 (43%) | 19.8% (12.8–35) |
| Number of symptoms | | |
| 0 | 2 (9%) | 10.8% (7.1–14.4) |
| 1 | 9 (39%) | 21.9% (12.8–35) |
| 2 | 6 (26%) | 21.6% (11.9–27.1) |
| 3 | 1 (4%) | 14.4% (14.4–14.4) |
| 4 | 5 (22%) | 18.9% (8.3–25) |

**Table 2**
Number of patients who received each treatment modality with corresponding CO levels.

| | n (%) | COHb % (range) |
|---|---|---|
| All | 23 (100%) | 19.8% (7.1–35) |
| Oxygen (NC) | 10 (43%) | 19.4% (7.1–30.2) |
| Oxygen (NRB) | 6 (26%) | 19.4% (14.2–25) |
| Intubation | 5 (22%) | 23.5% (12.8–35) |
| Hyperbaric | 5 (22%) | 19.9% (11.9–35) |

The most common presenting symptom was altered mental status (AMS; 43%), followed by headache (39%), nausea (35%), dizziness (30%), vomiting (22%), dyspnea (13%), malaise (4%), and syncope (4%) (Table 1). Two patients were asymptomatic; one of these was concerned about a potential exposure, while the other was advised by EMS to be evaluated because her spouse was symptomatic. The average pH of all patients was 7.40 (range 7.21 to 7.51). The average PCO2 was 33.2 mm Hg (range 22.8 to 41.1). The average COHb was 19.8% (range 7.1 to 35).

Ten patients (43%) were treated with oxygen by nasal cannula (NC), six (26%) with oxygen by non-rebreather (NRB), five (22%) were treated with hyperbaric oxygen, and five (22%) required intubation (Table 2). Eight patients were admitted, while the rest were discharged from the emergency department. A total of seven were transferred from other emergency departments, and one death occurred.

Although the total number of deaths due to all-cause CO toxicity has significantly declined in the United States from 1999 to 2014, CO toxicity following natural disasters continues to be a significant cause of poisoning in the U.S. due to improper use of gas-powered generators [ 14]. Further heightening the danger is the non-specific presentation of myalgias, headache, fatigue, nausea and dizziness, while more severe exposure may result in syncope, seizure, arrhythmia, coma or death [3].

CO toxicity appears to be common in the aftermath of natural disasters that disrupt the power grid, despite public announcements and educational efforts on proper use of consumer gas-powered electrical generators. Implementation of the Henretig recommendations to make portable generator use safer by pairing CO detector with purchase of a generator, longer cords to enable safe placement at a distance from structures, low CO emission generators, and automatic shutoff systems if elevated CO concentration is detected would help alleviate issues with newly sold generators [1]. Emergency physicians need to remain mindful of this common non-specific presentation of a potentially fatal environmental poisoning especially in a hurricane's aftermath.

## Declarations of interest

None.

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None.

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## Which of hemodialysis and direct hemoperfusion is more recommended for treating severe caffeine poisoning?

In recent years, the number of patients intoxicated with caffeine, a xanthine derivative (1,3,7-trimethylxanthine), has increased in Japan, and severe or fatal cases have been reported [1]. Theophylline is another xanthine derivative (1,3-dimethylxanthine) that shares a similar pharmacokinetic profile with caffeine. For the treatment of severe theophylline poisoning, hemodialysis (HD) is the preferred recommended extracorporeal treatment, whereas charcoal hemoperfusion (CHP) is acceptable if HD is not available [2]. Thus, these hemopurification methods may also be recommended for treating severe caffeine poisoning. However, no studies have addressed whether HD or CHP is superior for