Carbon Monoxide Poisoning from Portable Electric Generators

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Background: While the overall death rate from unintentional carbon monoxide (CO) poisoning has decreased in the United States due to improved automobile emissions controls and a decline in CO poisonings from motor vehicles, exposures have not changed from some sources of CO. One of these is the operation of portable electrical generators in poorly ventilated spaces. This study sought to describe the population poisoned from CO produced by portable electric generators, and to determine the reasons that generators are operated in a hazardous fashion.

Methods: Cases of CO poisoning referred for treatment with hyperbaric oxygen at Virginia Mason Medical Center in Seattle from November 1978 to March 2004 were reviewed. Those cases that resulted from portable generator use were selected for analysis.

Results: Sixty-three patients aged 2 to 85 years were treated for CO poisoning from portable electric generators. They included 34 males and 29 females who were poisoned in 37 separate incidents. Thirty-four lost consciousness with the exposure. Of the 63 total patients, 60 spoke English. Generators were typically used when normal electrical service was disrupted by a storm or in remote locations. In 29 of 37 incidents, the generator was operated in the home environment, most commonly in the garage. Lack of awareness of the dangers of CO poisoning or lack of knowledge of ventilation requirements were the most commonly identified reasons.

Conclusions: CO poisoning from portable electric generators occurs in a characteristic population, in a few typical locations and for a limited number of reasons. This information may help target prevention efforts for this form of poisoning, such as warning labels or educational programs.

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Introduction

Carbon monoxide (CO) poisoning may account for up to an estimated 40,000 emergency department visits annually in the United States,[1] and is also the most common cause of poisoning death in the country. The death rate from unintentional CO poisoning has declined over the past 3 decades, attributed in large part to prevention of motor vehicle exhaust exposures by stricter emissions controls and public education programs.[2] However, unintentional CO poisoning from some sources remains common. One of these is exposure to CO produced by portable electric generators, powered by fossil fuels such as gasoline or propane and typically operated when normal electrical service is disrupted by a storm or in remote locations. Data from the U.S. Consumer Product Safety Commission (CPSC) indicate that 179 CO poisoning deaths associated with portable generators were reported to the CPSC in the years from 1990 to 2002, with no decrease in overall frequency during that time.[3] From 1990 to 1996, an average of 11 deaths per year from generators occurred, as compared with 17 deaths annually from 1997 to 2002. This study sought to describe a population of individuals poisoned with CO from portable generators and to identify the reasons that they are operated in a hazardous fashion in hopes that the information can be used for exposure prevention efforts.

Methods

An institutionally approved departmental database of patients administered hyperbaric oxygen (HBO_2) therapy for severe, acute CO poisoning at Virginia Mason Medical Center (VMMC) in Seattle from November 1978 through March 2004 was used to identify individuals unintentionally poisoned by CO produced by portable electric generators. VMMC is a regional referral center for HBO_2 treatment, predominantly serving the State of Washington. A case of

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CO poisoning was defined as an individual with a history of CO exposure and exhibiting both symptoms characteristic of CO intoxication as well as an elevated blood carboxyhemoglobin (COHb) level. An elevated COHb level was defined as greater than 2% for nonsmokers and greater than 9% for smokers.[4] Emergency and hyperbaric department records of identified cases were then reviewed to extract patient demographic data and information about the poisoning incidents. As possible, patients were contacted by the authors by telephone and interviewed about the circumstances of their poisoning and the reason(s) for generator operation in the fashion described.

Simple descriptive statistics were used to analyze results. The Institutional Review Board of Virginia Mason Medical Center approved the study.

Results

During the period studied, 63 people were identified with unintentional CO poisoning involving the operation of portable electric generators in 37 incidents, with 1 to 5 individuals per incident (median=2). The patients (34 male, 29 female) ranged in age from 2 to 85 years (mean=39, standard deviation [SD]=20 years; median=39 years). Loss of consciousness was reported in 34 cases (54%). Blood COHb levels ranged from 6.6% to 49.7% (mean=23.0, SD=10.2%). Of the 63 patients, 60 spoke English and 3 spoke only Spanish. Twenty-seven of 29 poisoning incidents occurred among English-speaking individuals.

Poisonings typically occurred in autumn and winter months, with 81% of incidents in the 6 months from October to March. CO poisoning from generator use occurred in the home environment in 29 incidents (78%), on a boat or ship in 3 incidents, in association with a recreational vehicle (e.g., motor home or trailer) in 3 incidents, and in an industrial setting in 2 incidents. The reason for using an electric generator could be determined in 24 incidents. In 16 of these, generators were used in power outages, typically during winter storms. In seven incidents, generators were used to provide electricity at sites where power was not normally available (e.g., campgrounds or new building construction). In one incident, power to the victim's home had been turned off by the utility company for failure to pay the bill.

In 22 of the 29 incidents occurring in the home environment, it was possible to determine the location of the generator. The generator was located in the garage in 15 incidents (71%), basement in 4, living room in 2, and back porch in 1. A door or window often had been left open or ajar in an attempt to provide ventilation for generator exhaust.

In 21 incidents, the reason for operation of a generator in an enclosed space could be identified. Lack of awareness of the dangers of CO poisoning or lack of knowledge of ventilation requirements was most common, as reported in 16 incidents. Three owners did not locate the generator outdoors because they did not want it to get wet. In one case, a generator was used indoors because of fear of theft if left outdoors. In another case, the owners did not have a sufficiently long extension cord to operate the generator outdoors and deliver electricity to their refrigerator.

Discussion

Carbon monoxide poisoning from indoor use of electric generators has been reported in the medical and lay literature, typically in the aftermath of major storms. Over the past decade, epidemics of storm-related CO poisoning have been reported, many involving generators. In January 1993, a winter windstorm disrupted electrical power to 776,000 residents of Washington State.[5] Over the following days, at least 81 patients were seen in western Washington emergency departments for CO poisoning. In 26 cases (32%), the source of CO was an electric generator. In January 1998, a severe ice storm struck the northeastern United States, resulting in the loss of electrical power to 600,000 Maine residents, some for up to 2 weeks.[6] Over 400 cases of CO poisoning were evaluated at hospitals across the state. Of 100 CO-poisoned patients presenting to four hospitals, electric generators were involved in 74% of cases. In December 2002, a winter storm struck central North Carolina, disrupting electrical power to over 1 million customers. During the next 5 days, temperatures were unseasonably cold. Some 200 patients were referred to Duke University Medical Center for CO poisoning; 29 received HBO_2 therapy for severe poisoning, 28% of which were poisoned by indoor use of electric generators.[7] In another part of the state, 124 cases of symptomatic CO poisoning were reported during the same storm.[8] Electric generators were the CO source in 15 of the 55 exposure incidents in which a source could be identified. Of 40 deaths resulting from Hurricane Isabel in September 2003, eight were due to CO poisoning, at least two of which resulted from improperly ventilated electric generators.[9]

The significance of this problem is apparent. People find generators useful when conventional power is lost or in remote areas not otherwise supplied by electricity, but the reason(s) that generators are operated so often without adequate ventilation has not been clear. The reasons speculated have included (1) lack of awareness of the risk of CO poisoning; (2) concern for electric shock by use in wet conditions; (3) fear of theft if the device is left outdoors; and (4) lack of a long enough extension cord to operate the generator outdoors.

Underwriters Laboratories (UL) is now developing a U.S. safety standard for portable engine-generator assemblies. The U.S. Consumer Product Safety Commis-

sion (CPSC) is participating in UL's development process for this standard. CPSC has recommended that the standard include (1) requirements for weatherization of generators so that a warning against wet outdoor operations is not necessary, and (2) requirements for warning labels to be placed on generators and in their instruction manuals.[10,11]

To develop effective prevention schemes such as these requires knowledge of the reasons that generators are used in poorly ventilated spaces, information that has not been previously reported. Based on the current study, it would appear that people poisoned commonly lack awareness of CO risk. Among those who are aware, there is a lack of understanding of ventilation requirements. Fear of theft, inadequate extension cord length, and concern for the generator getting wet were reported only infrequently.

In light of this finding, educational information for buyers of generators and the general public may be helpful, particularly for populations at highest risk of CO poisoning. While individuals poisoned with carbon monoxide from indoor burning of charcoal briquettes are typically members of minority racial or ethnic groups and frequently non-English speaking,[7,12] people treated for CO poisoning from electric generators at VMMC almost always speak English (95% of patients and 93% of incidents). In isolation, these data might suggest that prevention programs in the United States could focus on English language–speaking populations, that an English-language warning label for use on generators would reach the vast majority of individuals at risk for this form of CO poisoning, and that a pictogram, similar to that printed on bags of charcoal, would not necessarily be needed. However, according to Eric Lavonas, MD, Department of Emergency Medicine, Carolinas Medical Center, Charlotte, NC (personal communication, March 2004), the author of another study reporting CO poisoning from electric generators,[8] about one third of generator incidents involved non–English-speaking patients. In light of this, further study is needed before the issue of language for warnings can be appropriately decided.

Data from the present study demonstrate that the populations typically poisoned from generators are middle-aged individuals of both genders. This suggests that some targeting of educational prevention programs may be possible. From these demographics, education at the point of sale and in the device operation manual should be strongly considered.

Unintentional CO poisoning is preventable with appropriate strategies, as evidenced by experience with motor vehicles.[2] Effective prevention requires identifying common CO sources, and describing the population and the behaviors that place individuals at risk. An aggressive prevention effort in the case of CO poisoning from portable electric generators is past due.

What This Study Adds . . .

Carbon monoxide poisoning from portable electric generators is a recognized problem in the United States, typically resulting from operation of the generator in an enclosed space.

Underwriters Laboratories (UL) is currently developing a U.S. safety standard for portable generators.

This study is the first to describe the reasons that severely poisoned individuals operated a generator indoors, providing valuable information to UL in the development of the standard and allowing future targeted prevention strategies.

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