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Editorial article

Carbon Monoxide: A Constant Threat

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Carbon monoxide (CO) is a colorless, odorless and tasteless gas that is slightly less dense than air [1]. CO is a poisonous gas that is produced by the incomplete combustion of natural gas or other carbon-based fuels, like gasoline, kerosene, oil, propane, coal, or wood. It remains the most ubiquitous pollutant of fireplaces and its main source is the indoor use of gasoline generators and gas-fueled space, propane or portable kerosene heaters, gas-fueled furnaces or ranges, charcoal grills and wood stoves [2-4]. CO is not a constituent of natural gas but is produced by incomplete combustion of methane, the principal constituent of natural gas. The production of CO, combined with inadequately vented spaces, may result in toxic and/or lethal concentrations [5]. Deaths of individuals or even whole families have occurred and occur under such circumstances, as they are exposed overnight to slow accumulation or leak of CO from fireplaces, stoves, ovens or fuel generators and other appliances, especially when the ventilation of the room is not adequate [5-7].

During the autumn and winter months, there is a higher percentage of CO poisonings than during the other seasons, a fact clearly related to the use of heaters fueled by gas, wood, or coal, or to the use of gasoline-powered electric generators [8, 9]. Surviving a CO exposure depends on a variety of factors, including escaping the area where the CO source is. The elderly usually are unable to run and are particularly at high risk for death by accidental CO poisoning, due to the fires in the home, especially during the winter season [10-13].

CO is highly toxic and harmful when breathed, because it binds with hemoglobin, which normally carries oxygen, to form carboxyhemoglobin (COHb) with an affinity 200 times greater than oxygen [1, 14]. Thus, COHb is ineffective for delivering oxygen to body tissues and vital organs, like heart and brain, leading to tissue hypoxia or anoxia. Moreover, it creates reactive oxygen species, promotes nitric oxide release and acts directly on neurologic and cardiac ion channels [15]. The symptoms of CO poisoning may include headache, fatigue, dizziness, drowsiness, nausea, vomiting, confusion, disorientation, visual disturbances, suffocation, chest pain, muscle weakness, collapse, loss of consciousness, hypotension and ischemia in the arterial border zones of the brain [1, 14]. As the COHb levels increase, the symptoms become more severe and the victim shows increased possibility of collapse and syncope, tachypnea, tachycardia, coma with intermittent convulsions, depressed heart action and death [16]. Immediate death is most likely cardiac in origin, because myocardial tissues are more sensitive to the hypoxic effects of CO [2, 17]. In general, signs and symptoms of acute CO poisoning can present at COHb levels ranging from 3 to 24% [18, 19]. This level overlaps with levels found immediately following cigarette smoking, up to approximately 10%, a percentage that usually is not associated with symptoms [19]. More severe signs of CO poisoning are poorly correlated with blood COHb, with loss of consciousness occurring at a mean level of 24.3% (range: 2–70%) and fatality at a mean level of 32.1% (range: 3.0–60%) [18]. Exposures that result in COHb levels >50% are frequently fatal [20]. Furthermore, CO disrupts oxidative metabolism leading to the formation of free radicals. Lipid peroxidation and apoptosis follow. It should be mentioned here that the CO tolerance level differs among individuals. As a consequence, the symptoms of CO poisoning vary widely from person to person. Young children, elderly people, individuals with heart or lung disease or smokers (already elevated CO blood levels) can appear symptoms of a CO poisoning at lower COHb levels [1, 14]. It has to be mentioned here that the symptoms and signs of acute CO poisoning correlate poorly with the level of COHb

measured at the time of hospital admission [21], while COHb levels determined post-mortem represent the actual levels at the moment of death [22].

As a general rule, if two or more individuals are found dead in a house or any type of enclosure and there is no external evidence of trauma, the most probable cause of death is an asphyxiating gas and almost invariably CO [9, 23]. In cases where vomits are present, the investigators may misinterpret the cause of death as food poisoning. In general, the signs and symptoms of CO poisoning described above are nonspecific, therefore a differential diagnosis is necessary. Toxicological analysis and the determination of elevated COHb levels will confirm a CO poisoning [18]. Death from CO poisoning is an obscure death, and fatal cases also are grossly underreported or misdiagnosed by medical professionals and too often diagnosis is overlooked, because of the nonspecificity of its clinical presentation [2, 24]. An adequate history may give the clue to the cause of death, but there are many circumstances in which the history may be obscure, and only the vigilance of the pathologist and his staff will pick up the possibility of this type of toxicity. The thorough scene investigation remains of critical importance [6].

To control CO exposure indoors, all sources of combustion should be checked. To prevent high concentrations of CO from occurring in residences and other indoor environments, the following parameters must be accomplished:

(1) frequent inspection and routine maintenance of vented combustion appliances and fireplaces; (2) not allowing automobiles to idle in closed or open garages; (3) not using unvented combustion sources indoors, such as space heaters, cooking devices and tobacco products, and (4) installation of CO detectors in residences along with smoke detectors and fire alarms is necessary and could help target prevention measures and reduce CO poisonings [25].

The incidence of CO poisoning in winter recommends the encouragement of preventive messages through the media about potential sources of CO exposure. This information must be understandable to the entire population at risk, including those persons, mostly immigrants, who do not understand the written or spoken local language. In some cases, the message may need to be distributed by alternative methods to populations at risk and especially foreigners or immigrants who do not have access to mainstream media [26]. As the CO poisonings and deaths in the elderly represent a serious but often neglected area of public health, health authorities should be encouraged to promote public awareness against the dangers of CO exposure. CO poisoning represents a potentially preventable and treatable cause of mortality and morbidity if sources and cases can be identified [3].

Although CO is a very old poison, it can cause even today severe poisoning and can be the cause of several deaths each year worldwide [23, 27], particularly when power outages occur forcing people to use traditional wood burning as a source of heat [26]. Despite efforts in prevention, and in public and medical education, CO intoxication remains frequent, has severe consequences, including immediate deaths and involves complications and late sequelae [2]. Public alert about possible sources of CO in the indoor environment and the relative problems from CO exposure as well as its prevention should always be a major concern of health authorities.

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