Original Article

Carbon monoxide-related fatalities: A fifteen-year single institution experience

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Abstract

Introduction: The winter climate in Delhi is severe, with temperatures dropping below 10°C. As a result, individuals often resort to utilizing diverse heat sources such as electrical heating appliances, coal and gas geysers. Unfortunately, these sources are commonly associated with the emission of carbon monoxide (CO) which can accumulate in inadequately ventilated spaces. Exposure to this noxious gas can lead to acute lethargy and debilitation, leaving individuals in a state of helpless distress. **Materials and Methods:** The present study utilized a retrospective descriptive analysis to examine cases of fatal carbon monoxide exposure retrieved from the Department of Forensic Medicine archives at the esteemed All India Institute of Medical Sciences, New Delhi. Autopsy records were thoroughly examined with respect to various parameters including age, gender, seasonality of the incident, circumstances surrounding the death, source of carbon monoxide generation, post mortem observations, as well as toxicological analysis reports. **Results and Discussion:** This study entailed an analysis of 56 individuals who fell victim to carbon monoxide poisoning, with a staggering 95% of fatalities occurring during the winter season. The majority of the individuals affected belonged to the age bracket of 21–30 years. The most common sources of carbon monoxide exposure were linked to the use of coal-burning earthen or iron vessels for room heating, as well as structural fires. With the exception of one case, all incidents were accidental in nature. Additionally, nearly all of the victims were discovered in enclosed spaces with heating equipment in close proximity, and evidence of a struggle was noted on the crime scene or with the deceased. **Conclusion:** The findings of this study indicate that the principal contributor to the inadvertent build-up of lethal concentrations of carbon monoxide gas is the utilization of heating appliances within inadequately ventilated, enclosed spaces. Due to the scentless and non-irritating properties of this gas, individuals who are asleep may be unable to detect its presence in their surroundings, thereby leading to a silent death. To mitigate such risks, the installation of carbon monoxide detectors is crucial. Additionally, it is of utmost importance to raise public awareness regarding the perils associated with using fire pots, coal burning and electrical heating appliances in areas with insufficient ventilation.

Keywords: Carbon monoxide poisoning, coal, confined spaces, heating, retrospective study

Introduction

Carbon monoxide (CO), often rightfully called 'the silent killer', is a gas that is created when organic materials burn incompletely and have no colour, smell or irritation.[1] It is also produced endogenously as a result of haem-metabolism and recognized as a neurotransmitter.[1] The common exogenous sources of CO are emissions from moving vehicles, the use of charcoal briquettes in

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small places, and malfunctioning or poorly ventilated gas heating equipment like stoves and heaters, among other things. The production of CO combined with inadequately ventilated spaces can cause the gas to accumulate in lethal concentrations. Early signs of acute CO poisoning include non-specific symptoms that might be mistaken for general illness, such as nausea, headaches, vertigo, disorientation and weakness. The acutely affected becomes lethargic and is unable to do much but watch in anguish at his looming doom. Therefore, CO poisoning cases are misreported and often underestimated.[1]

Various scientific studies from different parts of the globe reveal that CO-related deaths are mainly accidental and higher in the winter months of the colder climatic regions. In these areas, the temperature goes down to zero, and alternate heating mechanisms, non-electrical or electrical, are a necessity. These may lead to the production and accumulation of CO.[1-5] These studies have suggested that increasing public awareness and improving the safety measures in heating and cooking appliances can reduce the number of inadvertent CO-related deaths.

The temperature in Delhi during winters often remains below 10^0C,[6] compelling people, especially those with lesser means, to resort to cheaper and easily available methods of keeping warm, like electrical heating appliances, burning coal and gas geysers.[7,8] However, being significantly at risk, they remain oblivious to the fatal nature of such poisoning. These appliances, often with faulty exhaust mechanisms, are prone to produce CO which can cause poisoning and even death.[8] The sudden and incumbent nature of this fatality is often under-reported in the subcontinent thus resulting in a preventable loss of life. The suddenness of the events and easy preventability often leave the relatives of the victims unable to cope with the sudden and seemingly inexplicable demise. Though there has been constant reporting of these cases from various parts of this region,[9-16] however, scientific epidemiological data remains inadequate. This study addresses this issue related to fatal CO poisoning in south and south-east Delhi.

Material and Method

In the current study, autopsy reports from all fatal CO poisoning cases from the department of forensic medicine and toxicology at the All India Institute of Medical Sciences in New Delhi were retrospectively evaluated. This study covered the previous 15 years. The All India Institute of Medical Sciences, Delhi, is a tertiary care facility that provides medical care to the city's more than 5 million residents as well as referred patients from other parts of the nation. It also offers medicolegal services to south and south-east Delhi. The Institutional Medical Ethics Committee of the All India Institute of Medical Sciences in New Delhi gave its approval [Institutional Review Board] to the current retrospective observational study. Only those instances were included in this study that had a CO poisoning diagnosis based on autopsy results, forensic science lab toxicology reports, crime scene investigation reports and after all other potential causes of death that had been ruled out.

Statistical analysis

Descriptive statistics of age were present in graphical form. Season-wise incidence of carbon monoxide poisoning cases were present in tabularly. Sources of carbon monoxide and places of occurrence were present in pie chart. Post mortem finding of cherry red discoloration of the skin also showed by pie chart. Association of external burns was present in tabularly, and blood analysis for carbon monoxide was showed in bar plot. All statistical analysis was performed in SPSS and Microsoft Excel software.

Results

There was a total of 56 victims (41 males and 15 females) of fatal CO poisoning during the study period of 15 years. Out of these, 53 cases occurred during the winter season (November to February) and only one incident with three victims occurred during the Summer season (June to July) [Table 1]. About 70% (n = 39) of cases occurred in the age group 20–40 years, and the highest number of cases (35%, n = 20) were recorded in those of the third decade of life [Figure 1]. Sources of CO in 78% of the cases (n = 44) were coal or wood-burning in earthen or iron vessels for heating the room followed by incidents of structural fire in about 9% of cases (n = 5) [Figure 2]. Other cases were due to electric heat blower and automobile exhaust. Incidents in indoor or closed spaces (95%, n = 53), with heating equipment nearby, were far more common than those occurring outdoors [Figure 3]. In one incident, three victims were recovered from a car in the month of July with the engine running. In another incident, three fatalities were caused due to structural fire in a building while the family was sleeping at the time of the incident. All the cases were accidental in nature, except one in which a young male covered his head in a plastic bag and used a carbon monoxide cylinder (purchased online) as a source of CO to fill the bag and commit suicide. In most of the cases, the sleeping place of the deceased was filled with suffocating gas

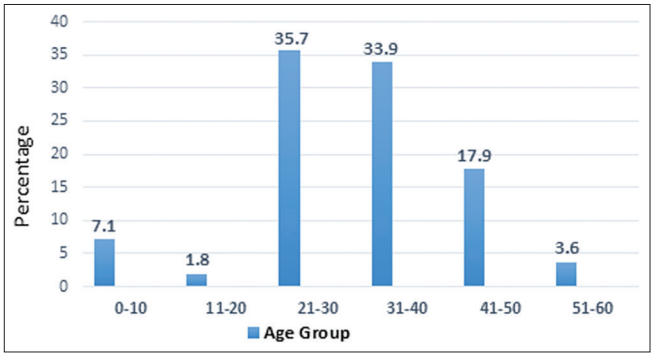

Figure 1: Age group distribution of the cases

Table 1: Season of incident

Season	Frequency	Percentage
Winter season	53	94.6%
Other seasons	3	5.4%
Total	56	100

when the body was discovered. The place of incident was usually found warm containing burning coal or other heating appliances. There was no disturbance found on the crime scene, and there was no sign of struggle on the dead bodies.

The post mortem findings were typically of cherry red discoloration of the skin, blood and viscera in 77% (n = 43) of the cases, whereas the others showed non-specific findings [Figure 4]. Only 14% (n = 10) of cases were from incidents of live fire, and the victims had associated external burn injuries on the post mortem examination [Table 2]. The analysis of blood and viscera for carbon monoxide was positive in 50% [n = 28] and negative in 41% (n = 23) of cases. The report was unavailable for five cases [Figure 5].

In all the cases included in the study, the final cause of death was concluded to be carbon monoxide poisoning, based on circumstantial findings and post mortem examination, which was later confirmed by toxicological analysis.

Discussion

There were a total of 56 cases during the study period of 15 years, and these deaths, almost always accidental, typically occurred in the socio-economically productive age groups, during a particular season of the year. These can be easily prevented with proper information and caution.

Most of the poisoning occurred in the age group of third decade followed by the fourth decade of life. Some of the Western studies conform with our findings.[17,18] These people, being in the economically productive age group, often work hard during the day and require a good sleep at night to get up fresh the next morning. They resort to using easily obtainable cheap warming methods for warmth. However, in other studies, the age group was mainly children and the elderly.[4,19] According to them, children are less protective and preventive while the elderly are predisposed because of their less mobility and associated comorbidity.

Carbon monoxide poisoning in our study was seen mainly in the winter season in the month of November to February.[17,18,20-23]

Table 2: Post mortem findings: External burn injury

Association with external burns	Frequency	Percentage
Absent	48	85.7%
Present	8	14.3%
Total	56	100.0

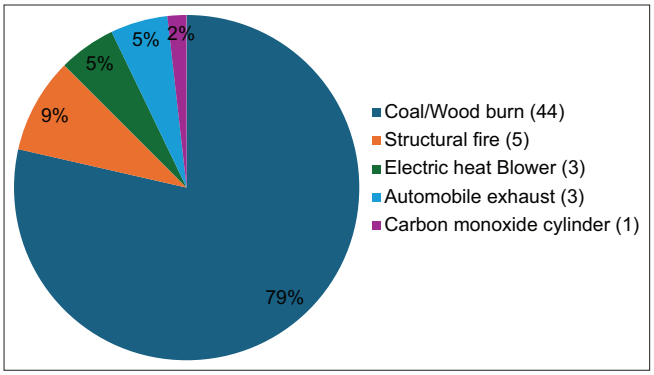

Figure 2: Source of carbon monoxide

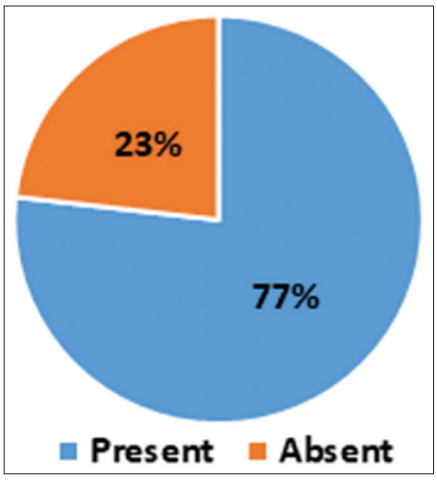

Figure 4: Post mortem finding: cherry red discoloration of the skin, blood and viscera

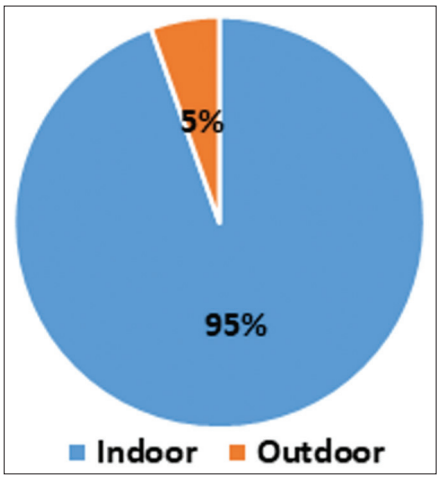

Figure 3: Place of occurrence

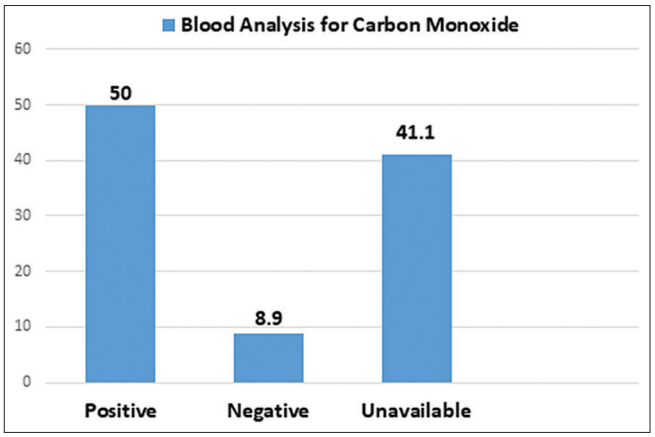

Figure 5: Blood and viscera analysis for carbon monoxide

To combat the unsympathetic weather, people use heating methods, electrical or non-electrical, for warming the sleeping area. However, it is observed that these methods were often used inside ill-ventilated airtight areas or rooms to prevent the entry of cold breeze, creating a carbon monoxide chamber.[19]

In this study, sources of CO were mainly burning coal, wood or other organic materials available domestically in a vessel or furnace. Other sources were electrical heat blower, fire in the building, car with running engine and CO cylinder. In India, burning coal, wood or other organic materials are a frequently used method of keeping warm during winters, therefore often a common source of carbon monoxide. However, compared to the number of heating appliances users, fatal CO poisoning numbers are less which might be because of proper ventilation during their use.

Another important factor in this study was the accidental nature of the death in almost all the cases with only one exception, which was a case of suicide and no homicides. Other studies confirm our findings in which accidental poisoning outnumbered suicidal manner and no homicidal poisoning.[4,18,20,23] In accidental death cases with heating equipment, the deceased are usually regular users of the heating equipment, and none of them was the first-time user. However, on the night of the incident, they were often overworked, exhausted, or were with the equipment in those closed airtight rooms for more than ten hours. There are some reported cases of suicidal deaths in which the victim directed the exhaust pipe of the car into the airtight car with the engine running.[18,24] In our case, the victim brought the CO cylinder online on the pretext of some experiment and committed suicide by wrapping a polythene bag over the head and face with the nozzle of the CO cylinder inside it.[25]

The odourless and non-irritating nature of the gas prevents the victims from detecting it in their sleep, and they succumb to it. We observed that even when there was more than one victim, even a pet dog, all succumb to it simultaneously. The undisturbed crime scene lacking any signs of struggles may signify the obliviousness and inability of the victims to do anything to help themselves once the poisoning started to occur. The body was recovered only in the morning after, at least, ten hours of exposure in most of the cases. These scenarios depict the 'silent unknown killer' nature of the gas.[1]

Conclusion

In conclusion, the authors state that the use of heating appliances in a non-ventilated closed space for a long duration is the main factor for the accidental accumulation of carbon monoxide gas in fatal concentrations. The odourless, non-irritant nature of the gas prevents a sleeping person from detecting it in the environment leading to unresisting deaths. These deaths are almost always accidental, typically occurring in the socio-economically productive age groups. These can be easily prevented with proper information and caution. The general public should be made aware of this silent poison. They should be taught not to use fire pot, burning coal, electrical heating appliances in a non-ventilated area. Good ventilation should be a sine qua non for using these heating mechanisms.

Recommendations

Along with increasing public awareness regarding carbon monoxide poisoning, an important objective method that can serve as an important tool in reducing these inadvertent accidents of CO poisoning is the use of carbon monoxide detectors inside the house, cars and other places. The detection level should be less than 120 ppm to keep the body CO level less than 20%. In this way, there will be no accumulation of gas, and the occupant will be safe. Additionally, there should be some warning signs on the equipment which are prone to produce carbon monoxide. These types of equipment can also be fitted with the CO sensor which will switch off the equipment when activated. It is better to sleep with blanket and warm clothes in a cold CO-free area than in a warm fatal CO-filled area.

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Conflicts of interest

There are no conflicts of interest.

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