Original Article

Carbon monoxide poisoning in Beirut, Lebanon: Patient's characteristics and exposure sources

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ABSTRACT

Background: Carbon monoxide (CO) poisoning is a preventable disease. Patients present with nonspecific symptoms post CO exposure. Causal factors are well described in developed countries, but less in developing countries. **Objectives:** This study examined the characteristics of patients with CO poisoning treated at a tertiary care center in Beirut, Lebanon, and their association with the CO poisoning source. **Materials and Methods:** A retrospective chart review of all patients who presented to the Emergency Department (ED) of the American University of Beirut Medical Center (AUBMC) over 4-year period and for whom a carboxyhemoglobin (CO-Hb) level was available. Patients with CO poisoning diagnosis were included in the study. Patients' characteristics and their association with CO poisoning source were described. **Results:** Twenty-seven patients were treated for CO poisoning during the study period, 55% of whom were males. Headache was the most common presenting symptom (51.9%). Burning charcoal indoors was the most common causal factor (44.4%), whereas fire-related smoke was another causal factor. The median arterial CO-Hb level on presentation for all cases was 12.0% (interquartile range (IQR) 7.3–20.2). All patients received normobaric oxygen therapy. No complications were documented in the ED. All patients were discharged from the ED with a median ED length of stay of 255 min (IQR 210-270). Young females were more likely to present with CO poisoning from burning charcoal indoors than from another cause. **Conclusion:** CO poisoning in Beirut, Lebanon is mainly due to charcoal burning grills used indoors and to fire-related smoke. A clinically significant association was present between gender and CO poisoning source. An opportunity for prevention is present in terms of education and increased awareness regarding CO emission sources.

Key Words: Carbon monoxide poisoning, charcoal, developing countries, fire, Lebanon

INTRODUCTION

Carbon monoxide (CO) poisoning is common, accounting for more than 50,000 emergency department (ED) visits in the US yearly.[1] It is a seasonal disease with higher incidences during fall and winter months and peaks around December and January secondary to increased use of furnaces and heaters.[2,3]

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CO poisoning is also a preventable disease that can acutely lead to rapid health deterioration from seizure and death. Chronic neurologic sequelae such as memory deficits, sleep disturbances, vertigo, neuropathies, and paresthesias have also been described as a result of CO poisoning.[4]

The diagnosis of acute CO poisoning can be challenging since the presenting symptoms are usually nonspecific. These include but are not limited to headache, dizziness, confusion, myalgias, loss of consciousness, and death. High clinical suspicion is therefore needed to detect CO poisoning.[5] A serum carboxyhemoglobin (CO-Hb) level is usually ordered to confirm the diagnosis: Levels higher than 3% in nonsmokers and higher than 10% in chronic smokers are considered abnormal.[6] CO-Hb levels above 5% usually require treatment with normobaric high flow oxygen (administration of 100% oxygen at atmospheric pressure). This treatment speeds up the elimination of CO by shortening the CO-Hb half-life from 4 to 6 h at room air down to approximately 1 h. Hyperbaric oxygen therapy which reduces the CO-Hb

elimination half-life further down to 20 min has also been recommended for serious CO poisoning including patients who have a CO-Hb level of 25% or more and patients with cardiac and severe neurologic symptoms.[7,8]

The source of CO must be identified and removed to prevent CO poisoning. In developed countries, CO sources include house fires, faulty furnaces, inadequate ventilation of heating sources, and exposure to engine exhaust. Data from developing countries regarding this preventable disease is scarce.

Our study described demographic and clinical characteristics, causes, treatment modalities, and outcomes of confirmed cases of CO poisoning treated at a tertiary care center in Beirut, Lebanon. The study also determined the association between CO poisoning source and the different patients' characteristics.

MATERIALS AND METHODS

Study setting and design

The study was conducted in the ED at the American University of Beirut Medical Center (AUBMC), a large tertiary care center in Beirut, Lebanon. AUBMC serves great Beirut area population estimated as high as 2,012,000 and has around 49,000 ED patient visits per year. Hyperbaric oxygen therapy is not available at AUBMC.

We conducted a retrospective chart review of all patients who presented to the ED from January 1st, 2009 to January 1st, 2013 and for whom a CO-Hb level was available. Patients who were diagnosed to have CO poisoning (International Classification of Diseases (ICD)-9 codes of 986 (Toxic effect of carbon monoxide) and E868 (Accidental poisoning by other utility gas and other carbon monoxide)) were included in the study and their corresponding electronic charts were reviewed for data collection. Data elements included date of presentation, demographic information (age and gender), presenting symptom and chief complaint, clinical characteristics (including past medical history, smoking status), CO source (charcoal or fire), vital signs at presentation, physical examination characteristics, CO-Hb levels, treatment therapy, complications in ED, and disposition.

Statistical analysis

The Statistical Package for Social Sciences (SPSS), version 20.0 was used for data entry and analyses. Descriptive analyses were carried out by calculating the number and percent for categorical variables, whereas the continuous variables were presented as the mean and standard deviation (±SD), or median and interquartile range (IQR), as appropriate. Bivariate analysis were conducted to assess the association of the CO poisoning source and the different patients' characteristics, using Fisher's exact test for categorical variables and Mann-Whitney test for continuous ones. A *P*-value <0.05 was considered to indicate statistical significance.

RESULTS

Thirty two patients had CO-Hb levels checked at AUBMC ED during the study period. Five patients were excluded since they had CO-Hb levels less than 2% and discharge diagnoses that were different from CO exposure or poisoning. Twenty-seven patients were treated for CO poisoning and were included in the study. Most of the cases presented during winter months [Figure 1]. The mean and median for age were 33.8 (±1.5) and 31 (IRQ 23.0-37.2) years, respectively with male gender accounting for 55.6% of the cases. The most common presenting symptom was headache (51.9%) followed by cough and dyspnea (33.3%), dizziness (29.6%), nausea and vomiting (25.9%), syncope (22.2%), and chest pain or palpitations (7.4%). Current smokers accounted for 37.0% of the cases. All patients had normal vital signs on presentation. Only two cases were related (two sisters) and presented simultaneously to the ED with different symptoms (one with headache and chest pain and the other with dizziness and syncope). The median arterial CO-Hb level on presentation for all cases was 12.0% (IQR 7.3-20.2). Initial CO-Hb levels ranged from 2.7 to 30%. Only two patients had an initial CO-Hb level <5% and were symptomatic after exposure to smoke from a fire. CO poisoning resulted mainly from using a grill burning charcoal indoor as an alternative heating method (44.4%). The other identified source of CO poisoning was fire (37.0%). No source was identified in five cases (18.5%).

The main treatment therapy used in the ED was non-rebreather mask application (90% oxygen concentration) in 70.4% of cases. A face mask (55% oxygen concentration) was used in 22.2% of cases. The rest of the cases (7.4%) received nebulizers treatment.

No complication (seizure, syncope, loss of consciousness, or need for advanced airway management) was noted during the ED stay. Repeat CO-Hb levels were available for 18 patients with a median of 2.7% (IQR 1.7-4.8). All patients were discharged home (two patients left against medical advice prior to completing treatment). The ED median length of stay was 255 min (IQR 210-270) [Table 1].

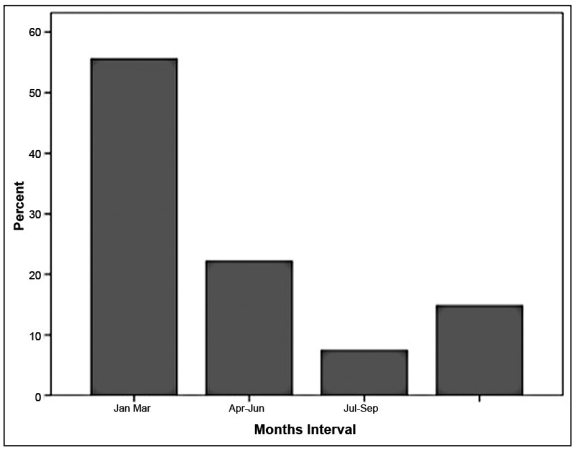

Figure 1: Seasonal variation of carbon monoxide (CO) poisoning cases in Beirut, Lebanon

Table 1: Characteristics, treatment therapy, and outcomes of CO poisoning cases

Variables	*N* = 27
Age in years, mean (±SD)	33.8 (±1.5)
Gender, no. (%)	
Male	15 (55.6)
Chief Complaint, no. (%)	
Headache	14 (51.9)
Syncope	6 (22.2)
Dizziness	8 (29.6)
Nausea/vomiting	7 (25.9)
Chest pain/palpitations	2 (7.4)
Cough/dyspnea	9 (33.3)
Smoking, no. (%)	
Yes	10 (37.0)
No	8 (29.6)
Unknown	9 (33.3)
CO source, no. (%)	
Charcoal	12 (44.4)
Fire	10 (37)
Unknown	5 (18.5)
Oxygen saturation	
Mean (±SD)	99.1 (±1.1)
Initial CO-Hb Level	
Mean (±SD)	14.3 (±7.7)
Median (IQR)	12.0 (7.3-20.2)
Repeat CO-Hb level	
Mean (±SD)	4.1 (±4.0)
Median (IQR)	2.7 (1.7-4.8)
Treatment intervention, no. (%)	
Face mask	6 (22.2)
Non-rebreather	19 (70.4)
Nebulizers	2 (7.4)
No complication during ED stay, no. (%)	27 (100)
ED disposition, no. (%)	
Discharged home	25 (92.6)
Discharged against medical advice	2 (7.4)
ED length of stay median (IQR) in min	255 (210-270)

CO: Carbon monoxide; SD: standard deviation; CO-HB: carboxyhemoglobin; ED: emergency department; IQR: interquartile range

Table 2: Characteristics by CO poisoning source

Source	Charcoal, *N* = 12	Fire, *N* = 10	*P*-value
Mean (±SD) age in years	35.1 (±1.6)	33.0 (±1.5)	1
Male sex, no. (%)	5 (41.7)	9 (90.0)	
Female sex, no. (%)	7 (58.3)	1 (10.0)	0.03
Chief complaint, no. (%)			
Headache	8 (66.7)	3 (30.0)	0.2
Syncope	2 (16.7)	2 (20.0)	1
Dizziness	6 (50.0)	1 (10.0)	0.07
Nausea/vomiting	4 (33.3)	2 (20.0)	0.65
Chest pain/palpitations	0 (0)	2 (16.7)	0.48
Cough/dyspnea	1 (8.3)	6 (60.0)	0.02
Smoking, no. (%)			
Yes	3 (30.0)	5 (41.7)	
No	2 (20.0)	5 (41.7)	
Unknown	5 (50.0)	2 (16.7)	0.23
Physical exam			
Mean (±SD) oxygen saturation	98.9 (±1.2)	99.1 (±1.1)	0.68
Initial CO-Hb level			
Mean (±SD)	17.2 (±5.8)	12.3 (±9.9)	
Median (IQR)	16.8 (11.7-22.6)	7.3 (5.2-21.7)	0.1
Repeat CO-Hb level			
Mean (±SD)	4.6 (±3.0)	4.5 (±6.3)	
Median (IQR)	3.3 (2.7-7.9)	2.1 (1.5-10.1)	0.17
Treatment Intervention, no. (%)			
Face mask	4 (33.3)	1 (10.0)	
Non-rebreather	8 (66.7)	7 (70.0)	
Nebulizers	0 (0)	2 (20.0)	0.16
No complication during ED stay, no. (%)	12 (100)	10 (100)	NA
ED disposition, no. (%)			
Discharged home	10 (83.3)	10 (100)	
Discharged against medical advice	2 (16.7)	0 (0)	0.29
ED length of stay median (IQR) in min	345 (244-570)	240 (180-345)	0.15

CO: Carbon monoxide; SD: Standard deviation; CO-HB: Carboxyhemoglobin; ED: Emergency department; IQR: Interquartile range; NA: Not applicable

The comparison of two groups of patients based on CO source, that is, fire vs burning charcoal [Table 2] revealed a clinically significant association between gender and CO source ($P = 0.03$): Young females were more likely to present with CO poisoning secondary to using grills burning charcoal indoors, while males were more likely to present with CO poisoning from fire-related smoke. Presenting symptoms were similar for both groups with the exception of "dyspnea and cough" which was significantly more common in patients exposed to fire ($P = 0.02$). A nonsignificant trend towards higher initial CO-Hb levels was also found in the burning charcoal exposed group compared to the other group.

DISCUSSION

Our study demonstrates that CO poisoning etiologies in developing countries are different from those reported in developed countries. Charcoal burning grills used indoors as a heating method in winter months account for a large proportion of the confirmed cases that were treated at the ED of a large urban tertiary care center in Beirut, Lebanon. This etiology has been previously reported in the literature as the most cause of CO poisoning in Gulf countries and among immigrants mainly Asians outside their country of origin.[9-14] Our study however highlights further that burning charcoal is the most common cause of unintentional CO poisoning in young females in our setting. Even though the education level was not available for patients included in our study, the prevalence of this etiology in a specific group underlines the need for preventive measures in our society and possibly other developing countries in terms of public education and increasing awareness regarding sources of CO emission and the dangers of burning charcoal indoors.

Presenting symptoms of CO poisoning are nonspecific. In our study, similar to previously published literature, headache was the most common presenting symptom.[9,15] None of the patients in our study presented with seizure, flu-like, or chronic obstructive pulmonary disease (COPD) exacerbation symptoms which are

commonly reported as presenting symptoms of CO poisoning.[15] This suggests that CO poisoning might be underdiagnosed or misdiagnosed as another illness in patients presenting to our ED. Previous studies have reported a misdiagnosis rate of up to 30% in CO poisoning cases.[16,17] Higher clinical suspicion and focused history on CO exposure is therefore needed to appropriately diagnose CO poisoning.

CO-Hb levels usually measure exposure levels rather than symptom severity from CO poisoning.[18] Stronger correlation between CO-Hb levels and specific symptoms such as loss of consciousness (levels >25%) and death (levels >50%) is present with high levels of CO-Hb.[19] In our study, the levels of CO-Hb fell within the range of mild exposure (<30%). No immediate complications were noted in the ED; however, long-term sequelae were not available for review. All patients had improvement in their symptoms after normobaric oxygen administration in the ED and were discharged home except for two patients who left against medical advice because of insufficient elimination of CO-Hb on repeat levels. This is consistent with previous reports regarding disposition of patients with CO poisoning treated in the ED with most patients being discharged home.[9]

The treatment provided in the ED consisted mainly of normobaric oxygen administration with non-rebreather and face mask; both methods provide oxygen at different concentrations. Hyperbaric oxygen therapy use has been recommended to reduce long-term cognitive sequelae in patients with CO poisoning.[4] In our study, hyperbaric oxygen therapy was not available; however, the administration of normobaric oxygen therapy was effective in reducing CO-Hb levels and symptoms resolution in all patients in our study.

Smoking status is an important confounding variable since chronic smokers have been reported to have CO-Hb levels as high as 10%.[20,21] Only nine cases in our study had CO-Hb levels below 10% (two <5%): Six patients were exposed to fire-related smoke. The other three patients with no identified CO source were symptomatic and nonsmokers. All of these patients were diagnosed with CO poisoning on discharge. In a study by Clarke *et al*., patients who presented to urban and rural EDs for a variety of symptoms were screened for CO exposure; smokers had a median CO-Hb level of 2.6% (range 0-33.3%).[15] In our study, symptoms were present with CO-Hb levels as low as 2.7%. This makes it difficult to exclude CO poisoning as a diagnosis solely based on CO-Hb levels even when levels are within normal ranges reported for smokers. Clinicians need to interpret the CO-Hb level carefully taking into account the whole clinical picture and presenting symptoms prior to choosing an alternative diagnosis to CO poisoning.

Limitations

Our study included only patients who were diagnosed with CO poisoning and for whom a CO-Hb level was available. It is possible that other patients presenting with nonspecific symptoms from CO exposure were missed if they received an alternative diagnosis for their symptoms and a CO-Hb was not checked. Previous studies, as discussed earlier, have shown that CO poisoning is a challenging diagnosis that can be underdiagnosed or misdiagnosed in up to 30% of cases.[16,17] The incidence of CO poisoning in our setting was 0.137 per 1,000 ED visits (27 cases for 196,000 ED visits) higher than CO incidence in other settings (0.068 per 1,000 ED visits or 68 CO cases per million ED visits in Louisiana, USA).[22]

Another limitation is inherent to the retrospective nature of the study. Some information regarding smoking status of patients who were included in the study was missing. We only included patients who were diagnosed with CO poisoning. We would have missed some patients by adopting a specific threshold for CO-Hb levels as an inclusion criteria and attributing mildly elevated levels of CO-Hb to smoking rather than CO exposure.

Long-term follow-up was also not available for our patients, especially neurologic sequelae. The main outcomes available were those related to the acute presentation including resolution of symptoms, reduction in CO-Hb levels, complications in the ED, and patient disposition.

CONCLUSION

CO poisoning in Beirut, Lebanon is mainly due to charcoal burning grills used indoors and to fire-related smoke. Young females present more often to the ED with CO exposure from charcoal burning grills indoors. An opportunity for prevention is present in terms of education and increased awareness regarding CO emission sources. Patients were symptomatic with CO-Hb levels as low as 2.7%. Clinicians must have high suspicion to diagnose CO poisoning and must recognize the pitfall of excluding CO poisoning as a diagnosis solely based on CO-Hb level.

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