Original Article

A 5-year Assessment on Carbon Monoxide Poisoning in a Referral Center in Tehran-Iran

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Abstract

Background: Carbon monoxide (CO) poisoning results in hundreds of deaths and thousands of emergency department visits all over Iran annually. In this study, we aim to provide an epidemiologic analysis of this poisoning in different consciousness levels. **Methods:** This single-center retrospective study was conducted at a referral poison center from March 21, 2007 to March 19, 2012 in Tehran, Iran. All CO poisoned children and adults who hospitalized were evaluated based on their on-arrival consciousness level. **Results:** Two-hundred-sixty patients with pure CO poisoning were enrolled with the majority of males (55.4%). CO exposure was unintentional in 99.6% of cases. The average period between CO exposure and the patients' hospital admission was 6.4 hours (SD = 11.2). Most of the toxicities had occurred at home (73.5%). On arrival acid-base status revealed respiratory acidosis cases in 11.9% of cases. Central nervous system imaging revealed 6.2% abnormal finding. Typically, patients presented with vomiting (25.8%), nausea (22.7%), and dizziness (11.3%). Twenty-nine patients (11.2%) needed intubation and mechanical ventilation. Thirty-six patients admitted to ICU with a median [IQR] hospital stay of 6 [2, 18] days. Ultimately, 202 (78.6%) patients discharged and 47 (18.3%) left the hospital against medical advice, 5 (1.9%) died, and 10 (3.8%) experienced sequellae. Two patients (0.8%), were transferred to other hospitals for specialized care. **Conclusions:** The incidence and mortality rate of CO poisoning in the current study are still higher than many other parts of the world. Ongoing health prevention strategies are not efficiently working. Hence, constant public education and warning about CO toxicity should be highlighted.

Keywords: *Carbon monoxide, death, epidemiology, poisoning*

Introduction

Carbon monoxide (CO) poisoning was first described by Claude Bernard (1865) and John Haldane (1895).[1] By and large, CO produces by imperfect combustion of carbon-based fuels and organic compounds. CO can release to air through car exhaust, faulty heaters, fires, and industrial coincidences.[2] Studies showed fire-related causes are responsible for most cases of CO generation followed by non-fire related sources.[3-5]

Carbon monoxide disperses promptly across the pulmonary capillary membrane and attaches to the iron moiety of heme in hemoglobin with higher affinity than oxygen. As a result of an allosteric alteration, hemoglobin loses the binding ability to other three oxygen molecules (leftward shift of the oxyhemoglobin dissociation curve). Also, about 15% of CO attaches to myoglobin, cytochromes, and NADPH reductase. This attachment can cause loss of oxidative phosphorylation at the mitochondrial level resulting in myocardial stunning.[6,7] The significant clinical findings of CO poisoning are loss of consciousness, confusion and hypoxia findings. Likewise, the minor signs are headache, nausea, and vomiting.[8] Approximately 40% of patients will develop delayed neurologic sequelae (DNS) that arise 3 to 240 days after recovery.[9,10]

Having non-irritating and colorless characteristics, CO along with other toxicities was the third cause of unintentional injury (11.6 per 1000 death) in Iran after motor-vehicle crashes and burning; according to official reports of Legal Medicine Organization in 2004.[11] Although it is mainly unintentional in nature,[12,13] China, dominant Chinese regions, and South Korea are facing evolving epidemics of suicidal CO

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poisoning cases.[3,14-16] Compared to Asia, the mortality rates of CO poisoning are much lower in the United States (0.52/100.000),[3] Europe (2.2/100.000),[17] and Australia (1.2/100 000).[16]

Based on Iranian Legal Medicine Organization (ILMO) report, inadvertent poisoning status caused almost 800 autopsy cases per year and encountered delayed and prolonged clinical symptoms in survived patients. This fact would be more substantial considering less use of oil and charcoal heating systems in recent years and expecting less poisoning. In this study, we aimed to describe epidemiologic analysis of CO poisoning cases in different consciousness levels in an attempt to suggest initiatives to decrease carbon monoxide mortality and morbidity.

Methods

This retrospective study conducted at Loghman-Hakim Hospital, Tehran, Iran from March 21, 2007 to March 20, 2012. We designed a self-made review chart of all patients presenting to our emergency department diagnosed as carbon monoxide poisoning based on ICD10 records of hospital documents (T-58 code). The following data was collected: demographic characteristics, type of exposure, the time interval between exposure and admission, patients' symptoms and chief complaints, CO-Hb levels (if available), and patient's outcome. To diagnose the severity of CO-poisoned patients, we performed the following tests: Acid-base status, electrocardiography, cardiac biomarkers, and brain CT in altered mental cases.

We analyzed the patient's characteristics between 5 groups of patients based on Reed Coma Scale categories from zero to four.[18] Data were analyzed with SPSS software version 22. The data were compared among the five groups using the One Way ANOVA for normally distributed data, Kruskal-Wallis test for non-normally distributed data and the Chi-Square test for nominal variables. Comparative data analyzed as independent samples with two-tailed *t*-test for comparing characteristics between survivors and non-survive subjects. Pearson correlation analysis was executed for normally distributed parametric data, and Spearman's rho correlation was used for non-normally or non-parametric distributed data. Statistically, a *P* value of <0.05 considered significant.

Our local ethic committee granted Ethical Permission for the study and waived the patients' consent due to retrospective nature of study considering anonymity. (IR.SBMU.RETECH.REC.1397.31).

Results

We found 424 subjects who hospitalized with CO-poisoning; of whom 283 cases had pure CO poisoning. Eventually, 260 patients included in this study as the data on their on-arrival consciousness was available. The majority of cases were males (55.4%). CO exposure was unintentional in 99.6% of cases, and most of the cases were under 30 years of age (68.5%). The mean age of participants was 24.9 ± 19.0 years (range 1–87 y). The majority of CO-poisoning cases were reported from 2009 (N = 67, 25.8%). The typical month of intoxication was December (25.4%), and the first day of vulnerability was Sunday (23.1%). The average period between CO exposure and the patients' admission was 6.4 hours (SD = 11.2). Most of the toxicities occurred at home (N = 191, 73.5%). Most of the CO resources reported to be unknown (N = 110, 42.3%) and heaters with no chimney (N = 34, 13.1%), and storage water heater (N = 32, 12.3%) came after it. Diagnosis of CO poisoning was mainly based on clinical presentation and Co level was measured in 8 cases with a range of 2 to 35%. The selected demographics, vital signs and laboratory panels of patients with significant *P* values summarized in Table 1. Three cases were pregnant and 79 (30.4%) cases presented with anemia.

Typically, patients presented with vomiting (25.76%, $P = 0.013$), nausea (22.69%, $P = 0.019$) and dizziness (11.30%). During the hospital stay, 11.2% of cases needed intubation/mechanical ventilation, and 13.8% of patients admitted to ICU. The median ICU length of stay was 6 [2, 18] (range, 1–70 days). Electrocardiography was performed in 188 patients that resulted in a significant *P* value for ECG-Rate ($P = 0.029$) between the five groups of patients based on their consciousness level [Table 1]. CT-scan was performed on 40 patients in which 32.5% (13 cases) presented with abnormal finding, 5% (2 cases) had basal ganglia involvement, and 2.5% (one case) had brain edema. Twenty-four patients had normal CT findings.

The complication/sequelae was observed in 12 cases which presented with aspiration pneumonia (0.8%), hypoxic-ischemic encephalopathy (HIE) (1.2%), persistent vegetative state (PVS) (0.8%), delayed neurologic sequelae (DNS) (0.4%), psychomotor retardation (0.4%), gait abnormalities (0.4%), deep vein thrombosis (DVT) (0.4%), and urinary tract infection (UTI) (0.4%). Two patients died from this group after a while.

Ultimately, 196 (75.4%) patients discharged and 47 (18.1%) left the hospital against medical advice, 5 (1.9%) died, and 10 (3.8%) experienced sequellae. Two patients (0.8%), were transferred to other hospitals for specialized care. Among non-survivors mean serum levels of CK, AST, ALT, Cr, Urea and the time between exposure and admission and the hospitalization period were significantly higher than survivors [Table 2]. Mean age of non-survived cases was 26.2 years with a range of 18–37.

Discussion

Carbone monoxide is one of the lethal inhalation gases, and over the 5-years period of this study, CO exposure was ascribed to 260 poisonings with five deaths. In

Table 1: The demographics, vital signs, and laboratory panels of patients (independent samples -One Way ANOVA/ Kruskal-Wallis tests)

Parameter (Mean±SD)	Reed Scaling Groups (*n*=260)					
	0 (*n*=137)	1 (*n*=69)	2 (*n*=27)	3 (*n*=13)	4 (*n*=14)	*P*
Demographics						
Age (Y)	23.88±19.67	22.6±19.6	26.85±14.45	38±19.42	30.71±10.62	0.014
Carbone monoxide level (%)	13±15.55	13.25±6.85	-	34.5±0.7	18.5±12.34	0.135
Duration of Hospitalization (day)	1.69±2	2.1±3.34	3.68±4.85	11.31±11.31	17±20.7	<.001
ICU Stay (day)	9±8.66	9±13	2	12.56±10.77	16.56±20.31	0.188
Vital signs						
Temperature (c)	36.57±2.28	36.73±0.38	37.02±0.34	37.3±0.61	36.96±0.55	0.002
Pulse Rate (per min)	99.47±82.65	93.7±17.8	90.15±13.57	101±23.31	96.38±22.36	0.646
Systolic blood pressure (mm Hg)	106.62±21.12	109.27±16.78	106.27±18.67	108.64±30.17	105.14±24.24	0.717
Diastolic blood pressure (mm Hg)	70.86±13.58	73.37±11.74	69.92±9.69	68.3±20.81	70±10	0.811
Respiratory Rate (per min)	22.43±11.21	23.19±8.26	25.27±14.66	32.11±24.5	24.22±8.62	0.289
O_2 saturation (%)	88.25±21	96±1.41	93.5±7.77	-	98	0.937
Glasgow Coma Scale	14.43±1.28	12.44±1.13	10.67±1.86	10.2±2.95	5.67±1.63	<.001
Laboratory panels						
Sodium (mEq/L)	140.12±4.17	140.85±3.97	141.62±4.52	140.62±3.86	140.29±4.34	0.180
Potassium (mEq/L)	4.32±0.61	4.26±0.46	4.07±0.38	4.1±0.54	4.3±0.82	0.351
Blood Sugar (mg/dL)	120.95±46.39	122.3±51.04	134.15±51.6	152.85±77.67	169.92±78.92	0.008
Hemoglobin (mg/dL)	12.29±1.67	12.5±1.8	13.3±1.81	13.19±2.12	13.52±2.45	0.062
Urea (mg/dL)	33.52±18.08	31.85±12.9	36.83±15.91	39.17±19.64	65±59.43	0.046
Creatinine (mg/dL)	0.91±0.32	0.87±0.29	1.18±0.68	1.05±0.29	1.71±1.39	0.004
Aspartate transaminase (U/L)	47.46±79.47	37.61±28.91	84.7±89.76	86.22±128.18	271.1±314.44	<.001
Alanine aminotransferase (U/L)	31.13±30.92	28.13±24.69	41.6±29.97	687.5±1767.7	315.7±594.89	0.006
Alkaline phosphatase (IU/L)	295.08±176.32	286.39±231.64	163.71±38.75	287.33±363.79	129.7±26.44	0.004
Creatine kinase (mg/dL))	4847.26±13167.29	939.81±2261.26	3134.43±3487.06	8164.67±16028.28	13417.08±26454.19	0.001
Creatine kinase-MB (IU/L)	11±5.91	15.67±6.25	13±8.48	56.25±25.99	348±268.55	0.006
Lactate dehydrogenase (U/L)	728.31±683.45	492.69±198.74	1115.71±896.93	800.25±386.72	1280.25±1245.62	0.022
Troponin (ng/mL)	0.33±0.15	0.5±0.14	0.2	0.92±0.78	4.9	0.279

Table 2: Significant characteristics of deceased patients (Mann Whitney *U* test)

Parameter	Non-survivors (*n*=5)	Survivors (*n*=250)	*P*
Elapsed time to hospital admission Median [IQR] (min, max) h	48 [13, 60] (6, 72)	2 [1, 6] (1, 72)	0.001
Hospitalization period Median [IQR] (min, max) days	24 [6, 41] (4, 42)	1 [1, 2] (1, 73)	0.001
Alanine aminotransferase Median [IQR] (min, max) (U/L)	620 [124, -] (134, 1930)	23 [15, 47] (10, 5060)	0.000
Aspartate transaminase Median [IQR] (min, max) (U/L)	505 [106, 883] (32, 950)	33 [21, 50] (5, 483)	0.011
Creatine kinase Median [IQR] (min, max) (mg/dL)	9800 [777, 57950] (567, 95700)	531 [85, 2697] (16, 56000)	0.028
Creatinine Median [IQR] (min, max) (mg/dL)	1.3 [1.15, 3.1] (1, 4.1)	0.9 [0.7, 1.1] (2, 5)	0.004
Urea Median [IQR] (min, max) (mg/dL)	47 [32, 110] (31, 145)	30 [24, 39] (13, 221)	0.026

Iran, as winter comes, several cases of CO poisonings are reported due to the indoor use of gas, wood, or coal heaters, gasoline-powered electric generators or outdoor fires (REF).[11,13] Should the sources and cases be identified, it can be both preventable and treatable. In this study, we determined the epidemiologic profiles of all CO poisoning cases in a unique toxicological referral center in Tehran.

The findings of our review indicate that the mortality rate of CO poisoning was 1.9% which is higher than in our previous study (0.42%).[19] In single province studies, incidence and mortality have been higher in Golestan,[20] Mazandaran,[21] Tabriz provinces than Mashhad[22,23] or Tehran probably due to the long duration of cold weather and higher usage of old heating appliances. In contrast to Iran, several Turkish cities have greater proportionate mortality rate for CO poisoning.[24] Eventually, the trend of annual deaths rates is decreasing in our country based on the Iranian Forensic Medicine Organization yearly reports (907 cases in 2005 to 528 cases in 2017), similar to England and Wales (166 cases in 1979 to 25 cases in 2012).[25] Nevertheless, the CO-poisoning mortality of Iran is still significant.

In this study, men were more vulnerable to be hospitalized due to CO poisoning (55.4%), and they account for

the majority of fatal CO poisoning which is consistent with other studies.[20,26-29] Engaging men in more industrial activities caused more inadvertent accidents of CO- poisoning and caused this difference. Moreover, the most common exposure sites were inside houses, which is parallel to other studies.[13,25]

Here, individuals younger than 30 years of age were at higher risk of poisoning than people of older ages. It should be reminded that almost half of the general population in Tehran are more than 33 according to last data published by National Organization for Civil Registration.[30] This may be due to the fact that younger ages are living in residential places where the risk of CO poisoning is higher than other areas. Mean age of fatalities (26.2 years, range 18–37 years) indicates that CO is more expected to affect the youth. These results are as same as most studies of poisoning in Iran (25–35 age range), but significantly less than investigations in Turkey, Portugal and Seattle.[24,31,32] Involvement of young population suggests a need for public education regarding potential hazards of CO exposure through the media, particularly during the winter season.[33]

Paraclinical studies revealed an enhancement in serum urea, creatinine, and alkaline phosphatase level which are essential prognostic laboratory factors in favor of rhabdomyolysis. It is notable that patients with carbon monoxide poisoning especially those with chest pain or other symptoms consisted with cardiac ischemia, neurological symptoms, carboxyhemoglobin concentrations >25%, and pregnant women should be admitted to the hospital and get oxygen therapy. Unfortunately, we were unable to measure CO level in most patients (only in eight cases), although many of them had taken oxygen that may cause negative results due to short CO half-life.

Conclusions

To summarize, in CO-poisoning, the leading cause of death is acute cardiac arrhythmias and hypoxic brain injuries. Mild to moderate poisoned cases will usually improve with appropriate treatment. In the cold seasons, the more use of malfuntioning heating appliances triggers more CO poisoning cases that refer to emergency departments. Lack of proper installation of gas appliances that are not standardized and absence of a ventilation system is the main concerns. Co detectors may warn earlier to reduce mortality and morbidity in high-risk places. In this regard, public education seems essential through the media, TV, newspapers, and the websites, particularly, before the start of the cold season and during severe freezing weather. Educational centers can train students appropriately to encounter any unforeseen event. It seems worse installation, misuse, or lack of maintenance of heating appliances are the main cause of CO poisoning in our society. We can probably minimize the CO-poisoned cases and consequently decrease the social and financial losses caused by carbon monoxide poisoning by educational programs predominantly for the young generation.

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Conflicts of interest

There are no conflicts of interest.

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