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The Relation between the Clinical Presentation of Acute Carbon Monoxide Toxicity and Carboxy-hemoglobin Level

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background and Objective: The symptoms of carbon monoxide (CO) poisoning are nonspecific; symptoms can mimic those of other common diseases such as nonspecific viral illness, flu- like syndrome and hypertensive attack. Elevated blood carboxy-hemoglobin (COHb) measurements are used to confirm a clinical diagnosis of exposure to CO. The main objective of this study is to study the correlation between carboxy-hemoglobin (COHb) levels and clinical manifestations in patients with acute (CO) poisoning.
Subjects and Methods: Over 6th month's period, eighty patients who presented to Poison Control Center, Ain Shams university Hospital due to CO intoxication were included. Examination of vital signs, skin, cardiovascular (CVS), central nervous (CNS), gastrointestinal (GIT), and

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musculoskeletal systems were performed as well as arterial blood gases (ABG), carboxyhemoglobin level (COHb), random blood sugar, serum of sodium (Na), potassium (K^+), alanine aminotransferase (ALT), serum creatine phosphokinase (CPK), serum urea and creatinine, hematological parameters (red blood cells, white blood cells and hemoglobin), serial cardiac markers (serum of aspartate aminotransferase (AST), creatine kinase-MB, lactate dehydrogenase (LDH), and cardiac troponin-I (cTnI) quantitative determination).

Results: Tachycardia was present in 46.3% of patients, cyanosis in 10%, tachypnea in 73.8%, headache in 67.5%, vomiting in 75%. There was a statistical significant negative (inverse) correlation between the mean COHb level and pH. & mean COHb level and K^+. There is no correlation between COHb level and clinical presentation. There is no correlation between COHb level and the outcome in patients with CO intoxication.

Conclusions: COHb cannot be used as a prognostic marker of CO intoxication and, therefore, patients must be monitored closely.

Keywords: Carbon monoxide intoxication; COHb level; clinical manifestations; acidosis.

1. INTRODUCTION

Serious consequences of acute carbon monoxide poisoning are cardiac, neurologic and other delayed effects [1]. Carbon monoxide cardiotoxicity may be clinically occult and often remain undiagnosed. Conventionally diagnostic tests such as ECG and standard biochemical markers appear in some cases inadequate [2]. CO is the leading cause of poisoning mortality in the United States and may be responsible for more than half of all fatal poisonings worldwide, an estimated 5000 to 6000 people die in the United States each year as a result of CO exposure [3]. Although most accidental deaths are due to house fires and automobile exhaust, consumer products contribute to approximately 180 to 200 annual deaths [4].

The incidence of CO- related mortality and morbidity is similar worldwide, and CO may be responsible for more than half of all fatal poisoning. When normalized to regional population densities, fatality rates are around 0.5 to 1 per 100,000 in Belgium, Denmark, France, South Korea, Switzerland, Taiwan, United Kingdom, and the United States [5]. There are approximately 50,000 ED (Emergency Department) visits for CO poisoning in the USA annually, 3-5 times the numbers previously estimated. As this disease can result in significant long-term morbidity even when treated, enhanced prevention efforts are warranted [6].

CO binds with hemoglobin with an affinity about 200 to 250 times greater than that of oxygen to form COHb. Arterial oxygen content will be reduced and leftward shift of the oxygen hemoglobin dissociation curve occurs. This can explain the acute hypoxic symptoms which are seen in patients with CO poisoning [7]. Acute CO poisoning indicates those cases of poisoning that have come to the attention of medical practitioners immediately after exposure. This usually occurs after a single, large exposure to the gas, and may involve one or more people [8]. The signs and symptoms of non-lethal CO exposure may mimic nonspecific viral illness i.e. influenza like. Since viral illness and CO exposure both peak during the winter, a substantial number of initial misdiagnoses may occur [9]. Overt signs and symptoms usually appear at COHb level of 10 to 20% with headache, and dyspnea on exertion and weakness. Those with COHb levels of 20 to 30% have severe headache and nausea. Levels of 30 to 40%, show severe headache, nausea, vomiting and impaired judgment, above 50 percent; confusion, syncope, seizures, and coma may occur. Death can occur at level more than 70 percent COHb [10].

Carbon monoxide poisoning is also frequently misdiagnosed as food poisoning, gastroenteritis and even colic in infants**.** In one study, the diagnosis of CO poisoning was initially missed in up to 30% of cases; the most common incorrect diagnosis, food poisoning was made in 43% of these cases [11]. With longer exposures, syncope, seizures, or coma can result. Patients may present with symptoms of an acute stroke. The EEG can show diffuse frontal slow-wave activity [12]. Continued exposure to CO can lead to symptoms attributable to oxygen deficiency in the heart. Myocardial infarction, life-threatening dysrhythmias, and cardiac arrest are commonly described in victims of CO poisoning [13].

Shortness of breath, dyspnea on exertion and tachypnea are common. Lung examination is almost free but in severe CO intoxication respiratory depression, pulmonary edema and hemorrhage may be seen secondary to left ventricular dysfunction or due to direct CO effect on the lung parenchyma [14,15]. Blurring of vision, decreased dark adaptation up to frank blindness may occur due to the effects of CO on the CNS. Retinal affection may also occur including optic disk edema, venous engorgement and hemorrhages [16].

COHb levels do not correlate well with clinical severity, outcome, or response to therapy. The role of a COHb level is documented concurrently with history, signs, and symptoms suggestive of poisoning [11]. Although high COHb levels confirm exposure to CO, particular levels are not predictive of symptoms or outcome. COHb can return to normal or be zero if the patient was treated with oxygen prior to the blood test [17].

This prospective study examined the correlation between carboxy-hemoglobin levels and clinical manifestations in patients with acute carbon monoxide intoxication.

2. SUBJECTS AND METHODS

2.1 Study Population

The present prospective study included eighty selected patients exposed to CO poisoning and admitted to the Poison Control Center (PCC) of Ain Shams University Hospitals in Cairo during the period from 1-11- 2007 to 30-4-2008. They were admitted to the PCC with history or presentation of acute CO poisoning symptoms which were variable starting from headache, dizziness, weakness, nausea up to confusion, cardiorespiratory depression and coma. The diagnosis was confirmed by serum level of carboxyhemoglobin on admission. The cases under study were chosen to have no past history of neurological, cardiovascular, gastrointestinal, respiratory or renal disorders. Those with risk factors such as hypertension, diabetes and smoking were also excluded from this study to exclude their effects. All cases with acute CO poisoning were subjected to full medical history and clinical examination. As regards ethical consideration, written informed consent was obtained from patients or from their next kin.

2.2 Study Assessment

Patient age, gender, delay time, presenting symptoms, vital signs, CVS, CNS, GIT, skin and musculoskeletal manifestations, arterial blood gases (ABG), carboxyhemoglobin level (COHb), random blood sugar, serum of sodium (Na), potassium (K^+), alanine aminotransferase (ALT), serum creatine phosphokinase (CPK), serum urea and creatinine, hematological parameters (red blood cells, white blood cells and hemoglobin), serial cardiac markers (serum of aspartate aminotransferase (AST), creatine kinase-MB, lactate dehydrogenase (LDH), and cardiac troponin-I (cTnI) quantitative determination), treatment and outcome were assessed.

2.3 Statistical Analysis

Statistical analyses were carried out using the SPSS® software package, version 15.0 (SPSS Inc., Chicago, IL, USA) for Windows®. Numerical variables are shown as mean ± SD, and qualitative variables are shown as number and percentage. The χ2-test and Pearson's correlation test (r) were used to determine differences between qualitative variables. One way ANOVA (Analysis of Variance) was used to compare between means of more than two groups. A P-value of < 0.05 was considered to be statistically significant.

3. RESULTS

A total of 80 patients were included in the study. The mean age ± SD was 36.22 ± 13.65 years. The present study included 42 males and 38 females with acute CO poisoning. There was no statistical significant difference for the mean COHb level in males and females. There was no significant difference between COHb levels in patients with normal body temperature, hypothermia and hyperthermia as in Table 1.

The highest percentage of cases with tachycardia, bradycardia, and normal pulse (29.7%, 28.6% and 30% respectively) were occurred in COHb level 21-30%. There was no statistically significant difference between COHb levels in patients with bradycardia, tachycardia and normal pulse as shown in Table 2.

The highest percentage of cases with hypotension, hypertension and normal blood pressure (25%, 66.7% and 29.5% respectively)

were occurred with COHb level (21-30%). There was no statistically significant difference between COHb levels in patients with different blood pressure categories.

The highest percentage of palpitation occurred in 5 cases (45.5%) at COHb level (11-20%). The highest percentage of dyspnea occurred in 3 cases (75%) at COHb level (21-30%). There was no statistically significant difference between COHb levels in patients with dyspnea and palpitation as shown in Table 4.

Table 5 showed that, the highest percentages of cases with tachypnea (28.8% and 25.4%) were occurred in the COHb level 21-30% and 0-10% respectively, while the highest percentages of cases with bradypnea (60% and 20%) were occurred in the COHb level 21-30% and 11-20% respectively. The highest percentages of cases with normal respiratory rate (31.3%, 25%) were occurred in the COHb level 11-21% and 41-50%. there was no statistically significant difference between COHb levels in patients with different respiratory rates.

Table 1. The relation between carboxy-hemoglobin (COHb) level and temperature in the studied acute carbon monoxide poisoned cases

COHb%	Temperature						*P*-value
	Normal (No. = 57)		Hypothermia (No. = 14)		Hyperthermia (No. = 9)		
	Frequency	%	Frequency	%	Frequency	%	
0 – 10	12	21.1	0	0	4	44.4	0.081
11 – 20	8	14	4	28.6	0	0	
21 – 30	17	29.8	4	28.6	3	33.3	
31 – 40	12	21.1	3	21.4	2	22.2	
41 – 50	7	12.3	3	21.4	0	0	
51 – 60	1	1.8	0	0	0	0	

P>0.05 = Non signifiant; No.: Number of cases; COHb: Carboxyhemoglobin

Table 2. The relation between carboxy-hemoglobin (COHb) level and pulse in the studied acute carbon monoxide poisoned cases

COHb%	Pulse						*P*-value
	Bradycardia (No. = 7)		Tachycardia (No. = 37)		Normal (No. = 36)		
	Frequency	%	Frequency	%	Frequency	%	
0 – 10	2	28.6	7	18.9	7	19.4	0.955
11 – 20	2	28.6	8	21.6	6	16.7	
21 – 30	2	28.6	11	29.7	11	30.6	
31 – 40	0	0	7	18.9	8	22.2	
41 – 50	1	14.3	3	8.1	4	11.1	
51 – 60	0	0	1	2.7	0	0	

No.: Number of cases

Table 3. The relation between carboxy-hemoglobin (COHb) level and blood pressure in the studied acute carbon monoxide poisoned cases

COHb%	Blood pressure						*P*-value
	Hypotension (No. = 16)		Hypertension (No. = 3)		Normal (No. = 61)		
	Frequency	%	Frequency	%	Frequency	%	
0 – 10	4	25	1	33.3	11	18	0.946
11 – 20	3	18.8	0	0	13	21.3	
21 – 30	4	25	2	66.7	18	29.5	
31 – 40	3	18.8	0	0	12	19.7	
41 – 50	2	12.5	0	0	6	9.8	
51 – 60	0	0	0	0	1	1.6	

No.: Number of cases; COHb: Carboxyhemoglobin; P>0.05 = Non signifiant

Table 4. The relation between carboxy-hemoglobin (COHb) level and cardiovascular symptoms in the studied acute carbon monoxide poisoned cases

COHb% levels	Cardiovascular symptoms			
	Dyspnea (No. = 4)		Palpitation (No. = 11)	
	Frequency	%	Frequency	%
0 – 10	0	0	2	18.2
11 – 20	0	0	5	45.5
21 – 30	3	75	2	18.2
31 – 40	1	25	2	18.2
41 – 50	0	0	0	0
51 – 60	0	0	0	0
P-value	0.405		0.289	

P>0.05 = Non signifiant; COHb: Carboxyhemoglobin; No.: Number of cases

Table 5. The relation between carboxy-hemoglobin (COHb) level and respiratory rate in the studied acute CO poisoned cases

COHb%	Respiratory rate						*P*-value
	Tachypnia (No. = 59)		Bradypnia (No. = 5)		Normal (No. = 16)		
	Frequency	%	Frequency	%	Frequency	%	
0 – 10	15	25.4	0	0	1	6.3	0.298
11 – 20	10	16.9	1	20	5	31.3	
21 – 30	17	28.8	3	60	4	25	
31 – 40	12	20.3	1	20	2	12.5	
41 – 50	4	6.8	0	0	4	25	
51 – 60	1	1.7	0	0	0	0	

P>0.05 = Non signifiant

The highest percentage of cases that need mechanical ventilation (29.03%) was occurred in level 21-30%, while 14.7% occurred in COHb level 0-10%. The highest percentage of cases with respiratory distress (33.3%) and pulmonary edema (37.5%) were occurred in COHb level 21-30%. There was no statistically significant difference between COHb levels in patients with different respiratory manifestations as shown in Table 6.

Table 7 showed that, the highest percentage of cyanosis (62.5%) occurred in COHb level (21-30%). There was no statistical significant relation between COHb level and skin manifestations.

As regard the neurological manifestations, the most common manifestation was headache where it was presented in 54 cases (67.5%). There was no statistically significant difference between COHb levels in patients with different neurological manifestation as shown in Table 8.

Table 6. The relation between carboxy-hemoglobin (COHb) level and respiratory manifestations in the studied acute CO poisoned cases

COHb%	Respiratory manifestations					
	Mechanical ventilation (No. = 31)		Respiratory distress (No. = 15)		Pulmonary edema (No. = 16)	
	Frequency	%	Frequency	%	Frequency	%
0 – 10	5	14.7	2	13.3	1	6.3
11 – 20	5	14.7	3	20	4	25
21 – 30	9	29.03	5	33.3	6	37.5
31 – 40	7	20.6	3	20	4	25
41 – 50	4	11.8	2	13.3	1	6.3
51 – 60	1	2.9	0	0	0	0
P-value	0.739		0.968		0.629	

P>0.05 = Non signifiant; No.: Number of cases; COHb: Carboxyhemoglobin

Table 7. The relation between carboxy-hemoglobin (COHb) level and skin manifestations in the studied acute CO poisoned cases

COHb%	Skin manifestations										*P*-value
	Normal (No. = 68)		Sweating (No. = 1)		Cyanosis (No. = 8)		Pallor (No. = 2)		Blister (No. = 1)		
	No.	%	No.	%	No.	%	No.	%	No.	%	
0 – 10	16	23.5	0	0	0	0	0	0	0	0	0.120
11 – 20	14	20.6	0	0	1	12.5	1	50	0	0	
21 – 30	19	27.9	0	0	5	62.5	0	0	0	0	
31 – 40	12	17.6	0	0	2	25	1	50	0	0	
41 – 50	6	8.8	1	100	0	0	0	0	1	100	
51 – 60	1	1.5	0	0	0	0	0	0	0	0	

P>0.05 = Non significant; COHb: Carboxyhemoglobin
No.: Number of cases; PSS: Poisoning severity score

Table 9 showed that, the level of consciousness was graded according to Glasgow coma scale (GCS). Twenty nine cases (36.3%) had (13-15) GCS, 27 cases (33.8%) had (4-8) GCS, 19 cases (23, 8%) had (9-12) GCS, and 5 cases (6.3%) had (3) GCS. The highest statistical significant prevalence, 19 cases (23.8%) had score (9-12), 27 cases (33.8%) had score (4-8) and 5 cases (6.3%) had score (3).

Table 10 showed that, there was non-*statistical* significant inverse correlation between COHb level and GCS.

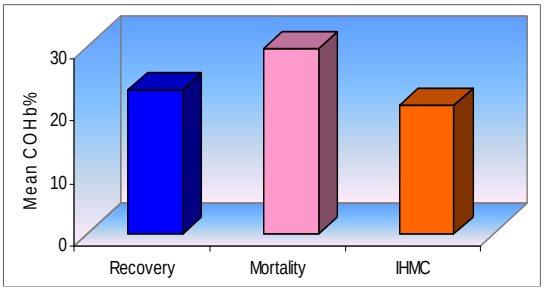
The most common gastrointestinal manifestation was vomiting (75%). The highest percentage of cases with nausea (33.3%), vomiting (30%), diarrhea (33.3%) and colic (33.3%) occurred in COHb level 21-30%. There was no significant difference between COHb levels in patients with different gastrointestinal manifestations as shown in Table 11.

As regard musculoskeletal manifestations, Table 12 showed that, 17 cases (21.3%) had malaise. The highest percentage of weakness (40%) occurred with COHb (11-20%), the highest percentage of asthenia (60%) and malaise (47.1%) occurred with COHb (21-30%). While no musculoskeletal manifestations were met with COHb (51-60%). There was no statistically significant difference between COHb levels in patients with different musculo-skeletal manifestations.

Table 13 showed that, there was a statistical significant negative (inverse) correlation between the mean COHb level and pH & the mean COHb level and K^+. Oxygen treatment was administered to all patients in the present study on presentation to the emergency department.

Hyperbaric oxygen treatment was administered to 17 (21.25%) of the patients. there was no statistically significant difference between the means of COHb level with different treatment modalities as shown in Table 14.

Histogram 1 showed that recovered cases had significant highest mean of pH (7.3 ± 0.07) in contrast to mortal (7.1±0.04) and IHMC (7.1±0.02) cases. There was no statistical significant difference between patients with IHMC and mortality cases which showed the statistical significant lowest mean of pH values.



Histogram 1. The relation between mean carboxy-hemoglobin (COHb) level and the outcome in the studied acute carbon monoxide poisoned patients

4. DISCUSSION

Carbon monoxide (CO) poisoning is a worldwide environmental toxin. It may be the cause of more than one half of the fatal poisonings reported in many countries [18]. An Egyptian study done at the Poison Control Center (PCC), Ain Shams University Hospitals in Cairo, showed that CO poisoning represented the 6th most frequent toxic exposure of cases admitted to the PCC in the year 2004 [19].

Table 8. The relation between carboxy-hemoglobin (COHb) level and neurological manifestations in the studied acute CO poisoned cases

	Neurological manifestations													
	Headache (No. = 54)		Flu-like symptoms (No. = 21)		Dizziness (No. = 29)		Confusion (No.= 32)		Convulsions (No. = 13)		Agitations (No. = 14)		Blurred vision (No. = 10)	
COHb%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0 – 10	11	20.4	7	33.3	7	24.1	7	21.9	1	7.7	1	7.4	1	10
11 – 20	11	20.4	7	33.3	9	31	6	18.8	2	15.4	4	28.6	2	20
21 – 30	15	27.8	2	9.5	8	27.6	11	34.4	8	61.5	3	21.4	5	50
31 – 40	11	20.4	4	19	3	10.3	4	12.5	2	15.4	2	14.3	1	10
41 – 50	6	11.1	1	4.8	2	6.9	3	9.4	0	0	3	21.4	1	10
51 – 60	0	0	0	0	0	0	1	3.1	0	0	1	7.1	0	0
P-value	0.729		0.070		0.309		0.683		0.139		0.089		0.745	

P>0.05 = Non signifiant; COHb: Carboxyhemoglobin; No.: Number of cases

Table 9. Frequency and percentages and results of chi-square test of Glasgow Coma scale (GCS) evaluated in the studied acute carbon monoxide poisoned cases

GCS	Number	%	*P*-value
(13-15)	29	36.3	<0.001*
(9-12)	19	23.8	
(4-8)	27	33.8	
(3)	5	6.3	
Total	80	100	

**: Significant at P ≤ 0.05; GCS: Glasgow Coma Scale*

Table 10. The correlation between carboxyhemoglobin (COHb %) levels in the studied acute carbon monoxide poisoned cases and Glasgow coma scale

Correlation coefficient (r) between COHb level and Glasgow coma scale	*P*-value
-0.166	0.140

**: Significant at P ≤ 0.05*

Table 11. The relation between carboxy-hemoglobin (COHb) level and gastrointestinal manifestations in the studied acute CO poisoned cases

COHb%	Gastrointestinal manifestations							
	Nausea (No. = 36)		Vomiting (No. = 60)		Diarrhea (No. = 15)		Colic (No. = 21)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0 – 10	8	22.2	10	16.7	4	26.7	4	19
11 – 20	9	25	13	21.7	4	26.7	5	23.8
21 – 30	12	33.3	18	30	5	33.3	7	33.3
31 – 40	5	13.9	10	16.7	1	6.7	2	9.5
41 – 50	2	5.6	8	13.3	1	6.7	3	14.3
51 – 60	0	0	1	1.7	0	0	0	0
P-value	0.527		0.389		0.737		0.777	

P>0.05 = Non signifiant; COHb: Carboxyhemoglobin; No.: Number of cases

Table 12. The relation between carboxy-hemoglobin (COHb) level and musculo-skeletal manifestations recorded in the studied acute carbon monoxide poisoned cases

COHb% levels	Musculo-skeletal manifestations									
	Musculoskeletal edema (No. = 1)		Weakness (No. = 10)		Asthenia (No. = 5)		Malaise (No. = 17)		Tenderness (No. = 1)	
	No.	%	No.	%	No.	%	No.	%	No.	%
0 – 10	0	0	1	10	0	0	1	5.9	0	0
11 – 20	0	0	4	40	1	20	4	23.5	0	0
21 – 30	0	0	2	20	3	60	8	47.1	0	0
31 – 40	1	100	1	10	0	0	1	5.9	1	100
41 – 50	0	0	2	20	1	20	3	17.6	0	0
51 – 60	0	0	0	0	0	0	0	0	0	0
P-value	0.495		0.417		0.512		0.167		0.495	

P>0.05 = Non signifiant; COHb: Carboxyhemoglobin; No.: Number of cases

As regard sex, the present study included 42 (52.5%) males and 38 (47.5%) females with acute CO poisoning. The above mentioned observations find agreement with those of Homer, who recorded that males represented the majority of cases in both groups (accidental exposures and suicidal attempts) [20]. In addition Handa and Tai, stated that males to females' ratio were 3:1 CO poisoning [21]. Henry reported that males represented 77% of the study population [13].

This could be attributed to that the males may be exposed to CO during high risk activities such as working in enclosed garages with generators or power tools [21]. On the contrary, males represented 44% in the study performed by Hampson and Zmaeff, and 37.5% in the study done by Deschamps [22,23].

In the present study females had higher COHb levels (23.5 ± 12.9%) than males (22.9 ± 12.4%) but with no statistical significance difference between mean COHb level in males and females. While Cevik, reported that, males had higher COHb levels (24.7 ± 14.9%) than females (19.9 ± 11.3%) with no statistical significance [24].

There was no statistically significant difference between COHb levels in patients with normal body temperature, hypothermia and hyperthermia. Hypothermia actually increases mortality in animals with CO poisoning [25].

As regard skin manifestations in the form of cyanosis, pallor, blister, sweating. Sixty eight patients in the present study (85%) showed normal skin. Eight patients (10%) showed peripheral cyanosis. Cyanosis may be due to decreased oxygen tension [26].

One patient (1.25%) had bullae. This agreed with Tomaszewski, who stated that another classic but uncommon phenomenon is the development of cutaneous bullae following severe exposures. These bullae are thought to be caused by a

combination of pressure necrosis and possibly direct CO effects in the epidermis [25].

None of the cases presented with cherry red coloration and this agreed with the opinion of Carson and Esslinger, who stated that the classic cherry red appearance of the skin and mucous membranes was uncommon in acute CO poisoning [27]. When you're cherry red, you're dead [28].

Table 13. Correlation coefficients between the mean of carboxyhemoglobin level and laboratory investigations recorded in the studied acute carbon monoxide poisoned cases

Laboratory investigation	Correlation coefficient (r)	*P*-value
pH	-0.332	0.003*
$PaCO_2$ (mmHg)	0.015	0.895
PaO_2 (mmHg)	-0.015	0.892
HCO_3 (mEq/L)	-0.209	0.063
Glucose (mg/dl)	-0.040	0.725
Na (mEq/L)	-0.151	0.181
K^+ (mEq/L)	-0.324	0.003*
ALT (U/L)	-0.143	0.205
CPK (U/L)	-0.146	0.195
Urea (mg/dl)	-0.139	0.218
Creatinine (mg/dl)	-0.114	0.316
WBCs	-0.074	0.513
RBCs	0.059	0.601
Hb%	0.025	0.826
AST (U/L)	-0.095	0.400
CPK MB (U/L)	0.021	0.850
LDH (U/L)	0.111	0.326
cTnI	-0.114	0.202

P>0.05 = non significant;
**: Significant at P ≤ 0.05*

As regard the pulse in the present study, the highest percentage of cases with tachycardia, bradycardia, and normal pulse (29.7%, 28.6% and 30% respectively) were occurred in COHb level 21-30%. There was no statistically significant difference between COHb levels in patients with bradycardia, tachycardia and normal pulse. Meert, reported that tachycardia was one of the most common presenting signs in CO poisoning [29]. Swank, stated that CO-induced sinus tachycardia was reported in a study in Ruby Memorial Hospital in the United States [30]. Aslan, found that sinus tachycardia was present in 26.5% of patients with CO poisoning [31]. Hampson and Zmaeff, stated that bradycardia was found among 10 cases out of 18 cases (55.5%) in a study done to examine the outcome of group of patients with extreme CO poisoning in the United States [22]. Gandini, reported that, although tachycardia is a common finding in CO poisoning and usually considered as a compensatory response to systemic hypoxia and cardiac dysfunction, yet bradycardia may be present, indicating rhythm disturbances [32].

Regarding to the neurological manifestations in the current study, they were in the form of headache, flue like symptoms, confusion, dizziness, seizures, blurring of vision and agitation, headache was the most outstanding feature presented in fifty-four patients (67.5%). And this coincided with that mentioned by Hampson and Hampson, who described headache as the most commonly reported symptom in acute CO poisoning which was often throbbing, continuous, diffuse and mostly located in the frontal area [33]. In addition, Kao and Nanagas, reported that, headache, particularly frontal and flu-like illness in the winter time with symptomatic cohabitants should raise the suspicion for CO poisoning [4]. Regarding grading of the clinical picture by Glasgow coma scale (GCS), in the present study, there were 29 cases (36.3%) had score (13-15) which showed the highest statistical significant prevalence, 19 cases (23.8%) had score (9-12), 27 cases (33.8%) had score (4-8) and 5 cases (6.3%) had score (3). Concerning the GIT affection in the presented CO poisoned patients, vomiting was observed in (75%) of the studied patients, nausea in (45%), diarrhea in (18.8%) and abdominal colic in (26.3%). These findings agreed with those of Felta-Zaragozano et al. [34], who recorded that, gastrointestinal symptoms such as nausea, vomiting and abdominal pain were observed in children hospitalized for acute CO poisoning, also, stated that vomiting and nausea were considered manifestations of both CNS and gastrointestinal tract involvement due to hypoxic effect of CO poisoning.

In the present study, there was no statistically significant difference of the means carboxyhemoglobin (COHb) level between recovered (23±11.8), mortality (29.6±12.1) and IHMC (20.4±18.3). There was a statistical significant negative (inverse) correlation between mean COHb% and pH levels & the mean COHb level and K^+. The emerged results in the present work find agreement with those of many authors suggested that there was no correlation between the COHb level and the severity of the cases. Hampson and Hauff, concluded that, despite the

Table 14. The relation between the mean carboxyhemoglobin (COHb) levels with different treatment modalities in the studied acute carbon monoxide poisoned patients

Modalities of treatment	Oxygen (n = 49)		Mechanical ventilation (n = 14)		Mechanical ventilation + HBO (n = 17)		*P*-value
COHb%	Mean COHb	SD	Mean COHb	SD	Mean COHb	SD	
	22.9	10.1	25.1	11.4	22.4	11.7	0.307

P>0.05 = Non signifiant

fact that statistically significant differences in average COHb measurements were seen with regard to a number of variables, the clinical significance of these differences appeared to be minimal. Moreover, the utility of COHb measurements as predictors of clinical status in CO poisoning was not apparent [35]. At least in part, this likely relates to delay and interval oxygen administration before obtaining COHb measurements.

The general belief is that COHb is not a reliable indicator of either the severity of intoxication or prognosis [36]. Also Turner et al. [37] found that measurement of COHb concentration is indicated to confirm the diagnosis, but the percentage of COHb in the blood is not always a good indicator of severity. Dan Hatlestad, also concluded that, an elevated carboxyhemoglobin level is a diagnostic of poisoning, but does not predict the mortality or severity of clinical signs and symptoms [38]. Also in clinical practice the precise time measurement are rarely known, making the assessment of COHb level insignificant and also once the patient is removed from the CO source, levels fall rapidly with time. These results also in agreement with Lam et al., who performed a study on 148 patients suffering from CO poisoning [39]. They found 25 patients (16.9%) were unconsciousness (GCS ≤ 8) on arrival. The mean initial carboxyhemoglobin (COHb) level was 21.0%. And there was no relationship between initial COHb with consciousness level on arrival. This poor correlation between COHb levels and neurologic presentation is related to unmeasured tissue uptake of CO which increases during hypoxia because of competition between carbon monoxide and oxygen at the oxygen-binding sites on hemoproteins [40].

The severity of clinical symptoms is related not only to the concentration of CO, but also to the duration of exposure. A patient who attains a high COHb level after a brief, high-level exposure may not manifest any clinical toxicity, whereas a patient who attains the identical COHb level after a prolonged lower level exposure may be significantly symptomatic [4]. Cevik, reported in their study that, COHb levels by outcome were not different. COHb levels were 25.2 ± 7.0, 25.5 ± 13.7 and 21.7 ± 12.9 in mortality, IHMC and recovered cases, respectively [24].

On the contrary, Varon and Marik, reported a categorised COHb levels, and symptoms related to the level of COHb. In his report, it was mentioned that the clinical presentation of acute COP is variable, but in general, the severity of observed symptoms correlates roughly with the observed level of COHb. In his report, with levels less than 10% the patients are usually asymptomatic. As COHb levels increase above 20%, the patients may develop headache, dizziness, nausea and dyspnea. Visual disturbance is found with levels over 30%. Confusion, coma and seizures are common with levels greater than 40% [41].

Also Turner et al. [37] found that the initial carboxyhemoglobin (COHb) concentration showed only a trend to being higher in those who needed multiple sessions of HBO treatment than those needed one session. In addition, Chou, concluded that high COHb level together with cardiac or respiratory arrest were highly associated with poor outcome and death indicating that they are predictors of the severity of CO poisoning [42].

Raub, stated that the symptoms, signs and prognosis of acute CO poisoning correlated poorly with the level of COHb [18].

Richardson stated that, in mild CO poisoning COHb may reach 20% [43]. Blumenthal, stated that, the levels above 40% are associated with severe manifestations such as coma or death [44]. Meert, considered that, alteration of consciousness level, metabolic acidosis, tachycardia, hypertension and COHb level more the 25% are indication of severe CO toxicity [29].

Estella investigated the link between the hazardous effects of CO on the respiratory system using COHb level as a marker for (CO) exposure. Their findings provided strong evidence of the relationship between COHb level and susceptibility to respiratory system affection [45].

Cevik et al. [24] reported in their study that, there is moderate correlation between COHb levels and PSS grade. COHb levels of PSS grades were found: 33.2 ± 13.9% in grade 3, 24.9 ± 11.1% in grade 2, 19.9 ± 12.0% in grade 1, 12.8 ± 15.1% in grade 0. Grade 3 had significantly higher COHb levels than other grades (from 0 to 2) ($p < 0.05$, $p < 0.001$ and $p < 0.05$, respectively). Headache, dizziness and blurred vision were found in 37.8, 27.2 and 55.6% of cases, respectively, in 10% COHb and below levels. In addition, they found negative correlation of headache and nausea with COHb. Dyspnea was seen equally in all levels up to 50% COHb, confusion and syncope distribution between levels of COHb did not show any difference. The most of the comatose patients' COHb level was between 21 and 30% in this study. There results showed that common and severe symptoms may be evident in lower level of COHb. They found that only coma has significantly positive correlation with COHb levels. Particular COHb levels are not predictive of symptoms or final outcome [25].

In the present study, there was no statistically significant difference between the means of COHb levels with different treatment modalities so the treatment modalities not determined by the COHb level. The emerged results concerning treatment modalities in the current work were in agreement with those of Cevik, who reported, one hundred sixty-eight cases (92.3%) received oxygen by mask. Nine cases (4.9%) required endotracheal intubation. Four of nine intubated cases did not receive HBO therapy. Ten cases (5.4%) received HBO therapy (with mask or intubated). Minor cases were mostly treated with oxygen by mask. Mean COHb levels of cases by treatment modalities (mask and oxygen, intubated with HBO and HBO) were different (20.9 ± 12.0, 32.5 ± 10.8 and 35.0 ± 16.5%, respectively, $p = 0.001$) [24].

5. CONCLUSION

Elevated carboxyhemoglobin level is a diagnostic of CO poisoning, but does not predict the mortality or severity of clinical signs and symptoms.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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