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Effectiveness of Two Scoring Systems in the Outcome Prediction of Acute Carbon Monoxide Poisoning: A prospective study

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Abstract:
Background: Across the globe, carbon monoxide (CO) poisoning is a leading cause of morbidity and mortality. It is regarded as one of the potentially predictable health-related disorders despite the high death rate. The scoring systems are straightforward diagnostic and early result prediction techniques that are easily applied.
Aim: To evaluate two scoring systems used in emergency for early prediction of acute CO toxicity outcomes.
Methods: This prospective observational cohort study was conducted on 36 cases of acute CO intoxication presented to the Poison Control Center of Zagazig University Hospitals (PCC- ZUH), emergency department and intensive care units (ICU) of ZUH. Two scoring systems were assessed.
Results: TheReceiver operator characteristic curve (ROC) curve for modified early warning score (MEWS) and poison severity score (PSS) showed excellent validity results with 100% sensitivity and specificity in prediction of mortality in cases of acute carbon monoxide toxicity.
Conclusion: MEWS and PSS are simple, easy, rapid, reliable and applicable scoring systems that save time and don't require several laboratory variables which could be unavailable at admission or highly qualified personnel. Hence, they could be good predictors of poor outcomes, they may be suitable for prognostic evaluation of CO poisoning on admission and can help in follow-up patients during hospitalization and determining whether the patient will be admitted to the ward or ICU from the start
Keywords: Scoring Systems, Carbon Monoxide, Acute Toxicity, Outcome

Introduction

Carbon monoxide (CO) is a colorless, tasteless, and odorless gas that is created when a carbon-containing substance burns incompletely (1). More than half of poisoning deaths globally may be caused by CO, which is the major source of poisoning mortality in many nations (2). Although CO and oxygen compete for the binding site at the heme part of hemoglobin, CO has a 250-fold higher affinity for hemoglobin binding than oxygen, which means that even traceamounts of CO can result in severe tissue hypoxia (3). Depending on the dose and length of exposure, the most typical signs of carbon monoxide poisoning are headache, dizziness, weakness, disorientation, and loss of consciousness (4).

Fifteen to forty percent of people who survive CO poisoning experience delayed neurological symptoms (1). Neurological manifestations may be motor or sensory in nature. They can also be linked to aberrant vestibular function, dementia, psychosis, and hearing loss (5). Administering 100% oxygen with a non-rebreather mask at a flow rate of 10 L/hrs is the cornerstone treatment for CO poisoning. Mechanical breathing and endotracheal intubation are necessary for a comatose patient. When a patient is unconscious, has cardiovascular involvement, has a carboxyhemoglobin level more than 40%, or does not respond to 100% oxygen therapy, hyperbaric oxygen therapy should be administered(6).

In the emergency room, scoring systems are often straightforward and primarily based on clinical data, with little or no investigational component(7).Their primary goal is to quantify aberrations in many physiological variables to provide an objective measurement of the severity of sickness recognized by clinicians globally. They have primarily been addressed towards the critically ill (8).

Aim of the work

The study aims to evaluate two scoring systems used in emergency settings modified early warning score (MEWS) and poison severity score (PSS) for early prediction of acute carbon monoxide toxicity outcomes

Subjects and methods

This is a prospective observational cohort study conducted from March 2023 to March 2024 on 36 instances of acute CO toxicity reported to Zagazig University Hospitals' Poison Control Center (PCC-ZUH), emergency department, and intensive care unit (ICU).If the patient was still conscious, informed verbal consent was obtained from him and from his family if he was unconscious. The Institutional Research Board (IRB) number (ZU-IRB10544/19-3-2023) ethical committee of scientific research gave its clearance before the investigation could be carried out.

Inclusion criteria

Clear history of CO poisoning exposure, patient age above 18 y, clinical signs of CO poisoning (dizziness, headache, nausea, disorientation, syncope), and carboxyhemglobin level (COHb) >5% in nonsmokers or >10% in smokers.

Exclusion criteria

Patients with comorbidities (such as heart disease, renal or hepatic failure), women who were pregnant, and those who had experienced trauma related to CO poisoning.

Complete history of all enrolled cases was taken, with particular attention paid to the history of CO exposure, the duration of exposure, the sources of CO (such as burning charcoal, exhaust from motor vehicles, fires, or malfunctioning hot water heaters), the mode of exposure, the interval between exposure and presentation, and the treatment received prior to arriving at Zagazig University Hospitals.Vital indicators such as blood pressure, pulse, temperature, respiration rate, and conscious level were assessed using the Glasco Coma Scale (GCS) during the clinical examination (9). Two grading methods were used to evaluate the clinical data: the modified early warning score (MEWS) and the poison severity score (PSS).The confirmed diagnosis of CO poisoning is made based on the patient's medical history, the presence of clinical symptoms such as headache, dizziness, vomiting, and loss of consciousness, as well as a high level of carboxyhemoglobin.

For the purpose of early CO poisoning outcome prediction, the following scoring systems were compared: the MEWSwhich has a minimum score of zero and a maximum score of 14, to measure respiration rate, temperature, systolic blood pressure, pulse rate, and degree of awareness employing the AVPU scale (10)while PSS: divide poisoning severity into five categories(none: no symptoms or signs related to poisoning, minor: mild, transient and spontaneously resolving symptoms, moderate: pronounced or prolonged symptoms, sever: life threatening and Fatal: death)
(11).

Statistical analysis

The Statistical Package for Social Science (SPSS) program version 27.0 (IBM, 2020) IBM crop was used to do the statistical analysis. Released in 2020: Version 27.0 of IBM SPSS statistics for Windows. NY: IBM crop in Armonk. The receiver operating characteristic (ROC) curve analysis, pearson's and spearman's correlation coefficients, chi-square test, Mann Whitney (MW) test, Fisher's Exact Test, Independent-samples t-test, and other tests were employed.

Results:

Table (1): Statistical comparison between survivors and non survivors regarding their baseline data.

Variables		**Survivors(n=33)**	**Non-survivors(n=3)**	**MW/χ^2**	**P**
Sex:	MaleFe male	14(42.42%) 19(57.57%)	1(33,4%) 2(66.6%)	0.74	0.38 NS
Age:(year)	Median(IQR)	38(10-70)	37(9-71)	0.58	0.57 NS
Duration of exposure (hours)	Media n(IQR)	4(2.5-6)	5(3.5-6)	1	0.32 NS
Hospital stay (days)	Media n(IQR)	3(2-3)	3(2-4)	0.55	0.58 NS

IQR:Interquartilerange, MW:Mann-Whitneytest,χ^2:Chi-squaretest,NS:non-significant(P>0.05), IQR:Interquartileran

There was no significant difference between both groups regarding baseline data (Table 1).

Table (2): Statistical analysis of clinical data in survivors (n=33) non-survivors (n=3) of carbon monoxide-poisoned patients

	Survivors(n=33)	**Non-survivors(n=3)**	**Test of significance**	***P*-value**
History of loss of consciousness, *n*, (%)			Fisher's Exact Test	**.02 ***
No	17(51.5)	0(0)		
Yes	16(48.5)	3(100)		
Glasgow coma scale, *n*, (%)			χ^2=12.4	**.002 ****
Mild	17(51.5)	0(0)		
Moderate	7(21.2)	0(0)		
Severe	9(27.3)	3(100)		
Dizziness, *n*, (%)			Fisher's Exact Test	>.99 NS
No	14(42.5)	0(0)		
Yes	19(57.5)	3(100)		
Headache, *n*, (%)			Fisher's Exact Test	.12 NS
No	18(54.5)	0(0)		
Yes	15(45.5)	0(0)		
Vomiting,*n*, (%)			Fisher's Exact Test	.26 NS
No	18(54.5)	0(0)		
Yes	15(45.5)	3(100)		
Confusion, *n*, (%)			Fisher's Exact Test	.05**
No	18(54.5)	0(0)		
Yes	15(45.5)	3(100)		
Seizures, *n*, (%)			Fisher's Exact Test	.04**
No	29(87.8)	0(0)		
Yes	9(27.3)	3(100)		

χ^2, Chi-squared test, *=significant **= high significant
NS: non-significant (P>0.05)

The presenting clinical symptoms: dizziness, headache, vomiting, had no significant relation to the outcome of the case, however history of loss of consciousness and Glasgow coma scale, confusion and seizure had significant relation to the outcome of the case (Table 2).

Table (3): statistical analysis of clinical signs in survivors (n=33)non-survivors (n=3) of carbon monoxide-poisoned patients

Variables	Survivors(n=33)	Non-survivors(n=3)	Test of significance	*P*-value
Systolic blood pressure (mmHg)median(range)	115±15.3	102±15.3	Mann-Whitney *U* test=46.5	.35 NS
diastolic blood pressure (mmHg)	68±11.3	62±12.3	Fisher's Exact Test	.78 NS

Heart rate (bpm)mean ±SD	96.5±11.3	90.5 ±8.8	Independent samples-t test=-0.74	.47 NS
SO2%median(range)	94(85-99)	90(80-95)	Mann-Whitney *U* test=57	**.05****
Respiratory rate	20±2	26±11.3	Fisher's Exact Test	**.002****
Temperature	38.2±0.7	37.2±0.53	Mann-Whitney *U* test=37	**.05****

SO2%, oxygen saturation, χ^2, Chi-squared test, *=significant **= high significant
NS: non-significant (p value > 0.05)

The presenting clinical signs in Survivors (n=33) and non- survivors (n=3) of carbon monoxide-poisoned patients: the mean systolic blood pressure, the mean diastolic blood pressure and mean heart rate had no significant relation to the outcome of the case, however both, the respiratory rate, the mean temperature and the meanSO2% had significant relation to the outcome of the case (Table 3).

Table (4): scoring systems: modified early warning score (MEWS) and poison severity score (PSS) of survivors (n=33) and non- survivors (n=3) in carbon monoxide-poisoned patients

Variables	Survivors(n=33) (N & %)	Non-survivors(n=3) (N & %)	*MW test*	P value
MEWS				
> 2	2(6)	3(100)	3.341	0.001*
≤ 2	31(94)	0(0)		
PSS				
None	0	0(0)	2.881	0.004*
Minor	15(45.4)	0(0)		
Moderate	17(51.6)	0(0)		
Severe	1(3)	0(0)		
Fatal	0	3(100)		

MW:Mann-Whitneytest, *: Significant (P<0.05), MEWS: modified early warning score, PSS: poison severity score

Table (5): spearman's rank-order correlation between scoring systems on admission and outcomes of acutely poisoned patients withcarbonmonoxide(N=36)

Variables	Outcomes	
	R	**P**
MEWS	- 0.33	0.04*
PSS	- 0.267	0.022*
Duration of hospital stay	0.11	0.47 NS

***r:coefficientofSpearman'srank-ordercorrelation;*significantatp<0.05,* **: highly significant (P<0.001), NS: non-significant, MEWS: modified early**

warning score, PSS: poison severity score

Spearman's rank-order correlation revealed negative significant correlation between (MEWS and PSS scores) and patient outcome. On the other hand, duration of hospital stay had nos ignificant correlation to the patient outcome (Table 5).

Table (6): diagnostic performance of modified early warming score (MEWS) and poison severity score (PSS) in prediction of mortality by receiver operating characteristic (ROC) curve analysis.

	Cut off	AUC (95%CI)	P	Sens.	Speci.	PPV	NPV	Acc.
MEWS	>5	1	<0.001*	100	100	100	100	100
PSS	Moderate	1	<0.001*	100	100	100	100	100

AUC: Area under the curve, CI: Confidence interval, sen: sensitivity, Spec: Specificity, PPV: +ve predicted value, NPV:-ve predicted value. Acc: Accuracy, *: Significant (P<0.05), **: Highly significant (P<0.001), MEWS: modified early warning score, PSS: poison severity score

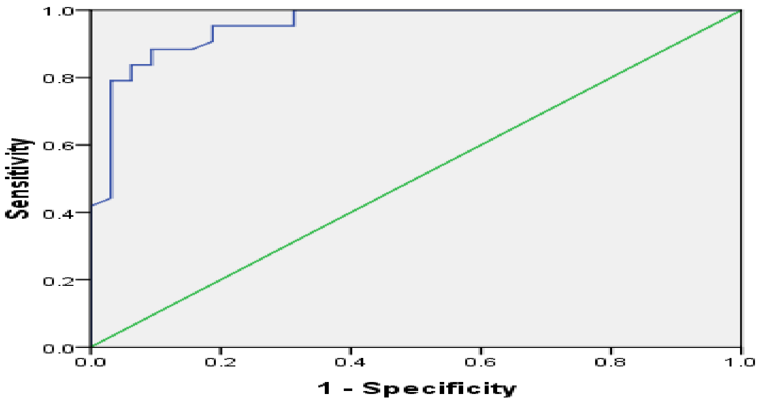

Fig. (1): Receiver operator characteristic curve (ROC) curve for the validity of modified early warning score (MEWS) score

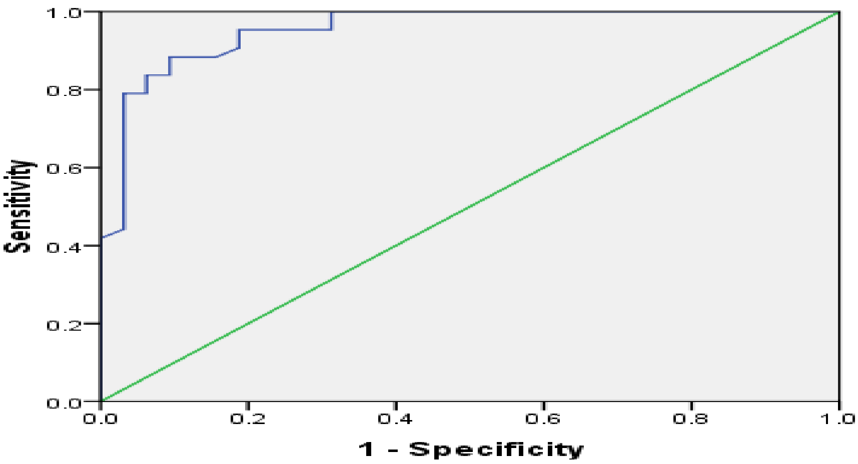

Fig. (2): Receiver operator characteristic curve (ROC) curve for the validity of poison severity score PSS score.

Table (6) and figures (1&2)show the excellent validity results of the ROC curve for modified early warning score (MEWS) and poison severity score (PSS) with 100% sensitivity and specificity.

Discussion

Although carbon monoxide (CO) poisoning is very lethal and has a number of sequelae, it can be difficult to expect these consequences in people who have been exposed to CO poisoning. But if they are identified early and treated effectively, they may be avoidable (12). Therefore, the purpose of this study was to evaluate the contribution of two scoring systems to the timely prediction of the outcome of CO poisoning and to provide trustworthy criteria that clinicians can utilize to evaluate the prognosis of patients suffering from acute CO intoxication. The most prevalent prognostic factors in instances of acute CO poisoning were assessed in this prospective clinical investigations. The Poison Control Center-Zagazig University Hospitals (PCC-ZUH) employed clinical toxicology specialists to handle cases of CO poisoning. These specialists closely monitored the cases until they recovered or passed away, classifying them as survivors or non-survivors and establishing the most accurate prognostic pattern of both clinical and investigative parameters.

Vital signs, conscious level evaluation, poisoning history, and two scoring systems (poison severity score (PSS) and modified early warning score (MEWS)) were among the investigated criteria. 36 cases of CO poisoning were admitted between March 2023 and March 2024, making up the total number of cases enrolled in this study.

Regarding the base line characteristics of patients, the age of the included cases ranged from 18 to 70 years with a meanage (44±12.49). Female patients represented 58.3% of cases while 41.7% of them were males. This was in line with study by **Huang et al. (13)**, that showed the incidence of CO poisoning was higher in females than males. In contrast, a study by**Ashry et al. (14)**showed that(57.1%) of cases were males and (42.9%) were females, with average age of (36.3 years ± 13.6).Age and sex did not statistically correlate with the patient's outcome, which was consistent with other studies by **Abdel Aziz et al. (15)** and **Lee et al. (16)**that revealed, non-significant correlation between the patient sex and age to the patient's outcome

The current study showed no correlation between length of hospital stay and the patient's outcome, which is consistent with findings by **Xu et al. (17)**that showed non-significant difference in length of hospital stay between the delayed neurological sequele (DNS) developing group and non-DNS developing group**.** However, in contrast to our findings a study performed by **Kudo et al. (18)** and **Ashry et al. (14)** revealed a substantial difference in hospital stays between the DNS developing group and the non-DNS developing group with the DNS-developing group having longer hospital stay.

Concerning the source of CO exposure, in the current study most of the CO poisoned cases were caused by gas heaters (58.3%) while 41.7% resulted from burning charcoal. This was similar to the results obtained in Egypt by **Abdel Aziz et al. (15)** whichrevealed that the main source of the poisoning was faulty water gas heater. In contrast, a study by**El-Nagdy et al. (19)** showed that 65% of CO- poisoned cases resulted from burning of charcoal, wood and kerosene.

In the current study, 8.3% of patients did not survive, compared to 90.6% of patients who survived. About 80.6% of the patients who survived, had no issues, while 11.1% suffered complications. These side effects included memory loss, speech impediment, and insanity. This outcome was consistent with the research conducted by**Ashry et al. (14)**; describing the results and death rates from CO poisoning, showing that 20% of patients died and 80% of patients survived.Seizures and a disturbed consciousness level were significantly correlated with the outcome of acute CO poisoning patients. However, there was no statistically significant association found between the patient's outcome and headache, vomiting, or dizziness. This was comparable to the outcomes of**lee et al. (20)** that demonstrated individuals with worse outcomes suffered seizures, shock, or loss of consciousness. This study demonstrated that, a low Glasgow Coma Scale (GCS) was linked to unfavorable outcomes. The GCS and patient fate showed a strong correlation.mild and moderate toxicity survived but patients with severe symptoms nine patients of them survived while three of them did not survive. This was consistent with the research of**Abdel Aziz et al. (15);**demonstrating a substantial difference in GCS across mild, moderate, and severe poisoning. Furthermore, **Lee et al. (16)**Specifically, in cases of acute CO poisoning, a lower GCS score at presentation is a poor prognostic predictor.

An analysis of the patient's vital signs showed no correlation between the patient's outcome and mean arterial blood pressure or mean heart rate. Conversely, there was a noteworthy correlation between the mean temperature and the respiratory rate and the cases' outcomes.**Abdel Aziz et al. (15)** discovered no evidence of a significant relationship between the patients' outcome and the vital indicators of mean blood pressure, pulse, and respiration rate. On the other hand, CO poisoning patients' heart rates differed statistically significantly from those of the control group, according to **El-Nagdy et al. (19).** Furthermore, **Shahin et al. (21)** discovered a significant difference in systolic and diastolic blood pressure between the CO-poisoning group and the control group.

When it comes to scoring systems, non-survivors' modified early warning score (MEWS) and poison severity score (PSS) at the time of admission demonstrated much higher elevations than those of survivors. The Man Whitney U (MW) test findings revealed a highly significant difference between the groups that lived and those that did not, suggesting that this test can be used as a useful prognostic tool for early detection of acute CO poisoning cases. The ROC curve was used to assess the prediction capacity of these scores, and the results indicated high sensitivity and specificity of 100%. This was consistent with **Ae and Ga. (12),** who shown a significant relationship between MEWS components and the requirement for ICU hospitalization. These include elevated heart and respiratory rates together with decreased systolic blood pressure. Comparing mechanically ventilated and non-survivor patients to survivors and non-mechanically ventilated patients, there was a notable increase in MEWS values in both groups. At the cutoff value of greater than 5, MEWS demonstrated excellent predictive power for mortality in the current investigation. As stated by**Kirsch et al. (22),**It was changed from a MEWS cut-off number of 5 to 7 to make the record more sensitive and specific when thinking about ICU admission. The chance of death is three times higher for MEWS scores of seven or more. Also,**Xie et al. (23)** believed that MEWS was a useful tool for predicting death. With a higher death rate at higher scores, this showed that MEWS was strongly linked to patient death.

The PSS's ability to identify the outcome of CO-impaired patients was also tested using the Mann Whitney test MW, which showed a significant increase in the group that did not survive more than the group that survived. The ROC curve was also used to guess how the patient would do, and it was very accurate, predicting with 100% sensitivity and specificity. These values are the same as **Barghash et al. (24)** who found that grades 1, 2, and 3 had statistically higher values in the CO-poisoned group than in the control group. This was a good indicator of how the patients would do. Also, **Wang et al. (25)**used PSS to predict the result of CO poisoning and said that it was a good predictor of bad outcomes. PSS may be useful for evaluating the prognosis of CO poisoning at admission and can help with following up with patients while they are in the hospital.

Conclusion:

In conclusion, MEWS and PSS have the same validity in the prediction of outcome in CO poisoned cases with 100% sensitivity and validity. They are quick, easy, reliable, and useful scoring systems that save time and don't need a lot of lab factors that might not be available at admission or highly trained staff. So, they might be good indicators of bad results. They might also be useful for figuring out the prognosis of CO poisoning at the time of admission and for determining whether the patient will be admitted to the ward or ICU from the start,moreover,keeping an eye on patients while they are in the hospital.

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