

Effects of carbon monoxide poisoning on temperament

Karbonmonoksit zehirlenmesinin mizaç üzerindeki etkisi

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ABSTRACT

Aim: The aim of this study was to investigate the effect of carbon monoxide (CO) poisoning on temperament and associated disorders.

Material and Methods: The study was conducted in healthy volunteers and patients who presented to the Emergency Department of Kirikkale University Hospital after exposure to CO. Patients with a carboxyhemoglobin level of $\geq 10\%$ were considered to have CO poisoning. Patients with psychiatric disease or an illness that could increase CO levels and those who smoked or were using medication were excluded. Healthy volunteers were evaluated once, and CO poisoning patients were evaluated at the time of presentation and 3 months after discharge using the Temperament Evaluation of Memphis, Pisa, Paris, and San Diego Autoquestionnaire (TEMPS-A) temperament scale. Repeated analysis of variance was applied for comparisons. A p value of <0.05 was considered statistically significant.

Results: The study included 110 participants: 68 in the CO poisoning group and 42 healthy volunteers. Significant differences between the groups were observed in the TEMPS-A scores for depressive type ($p=0.016$) and anxious type ($p=0.01$) at first presentation and for the irritability type ($p=0.02$) and anxious type ($p=0.034$) at 3 months after the discharge. When the temperament scale scores of the CO poisoning patients were compared according to evaluation time (first presentation and 3 months after discharge), no significant difference in temperament types was observed.

Conclusion: Although the temperament types related to depression and anxiety were affected after CO poisoning, they did not change completely. Further research is needed to better understand the psychiatric effects of CO poisoning.

Keywords: Carbonmonoxide poisoning, emergency department, psychiatric disorders, temperament, temperament scale

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ÖZ

Amaç: Bu çalışma karbonmonoksit zehirlenmesinin mizaç ve ilişkili olduğu bozukluklar üzerindeki etkisini araştırmak amacıyla yapılmıştır.

Gereç ve Yöntemler: Çalışma, Kırıkkale Üniversitesi hastanesi acil servisine karbonmonoksit zehirlenmesi (KZ) sebebiyle başvuran hastalar ve sağlıklı gönüllü (SG) katılımcılarla yapıldı. Karboksihemoglobin düzeyi $\geq 10\%$ ölçülen hastalar KZ olarak kabul edildi. Psikiyatrik hastalığı veya ilaç kullanımı olanlar ve CO düzeyini yükseltecek hastalığı veya sigara içiciliği olanlar çalışmaya dahil edilmedi. SG bir kere, KZ olanlar ise acil servise ilk başvuru anında taburcu edilirken ve taburcu olduktan üç ay sonra TEMPS-A (Temperament Evaluation of Memphis, Pisa, Paris and San Diego-Autoquestionnaire) mizaç ölçeği ile değerlendirildi. Grupların karşılaştırılmasında Repeated measures ANOVA testi kullanıldı ve $p < 0.05$ anlamlı kabul edildi.

Bulgular: Çalışmaya KZ (n=68) ve SG (n=42) olmak üzere toplam 110 katılımcı dahil edildi. Gruplar TEMPS-A mizaç ölçeği puanları bakımından karşılaştırıldığında, acil servise ilk başvuru anında Depresif ($p=0.016$) ve Anksiyöz ($p=0.01$) mizaç, üçüncü ayda ise Irritable ($p=0.02$) ve Anksiyöz ($p=0.034$) mizaç tipi puanlarında anlamlı farklılık saptandı. KZ olan hastaların mizaç ölçeği puanları, değerlendirme zamanına (ilk başvuru zamanı ve üçüncü ay) göre karşılaştırıldığında hiçbir mizaç tipinde fark saptanmadı.

Sonuç: KZ sonrası hastaların özellikle depresyon ve anksiyete ile ilişkisi olan mizaç tiplerinde etkilenme olsa da, mizaç özellikleri tamamen değişmemiştir. Karbonmonoksit zehirlenmesinin psikiyatrik etkilerinin daha iyi anlaşılabilmesi için ileri çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Karbonmonoksit zehirlenmesi, acil servis, psikiyatrik bozukluklar, mizaç, mizaç ölçeği

Introduction

Carbon monoxide (CO) is a colorless, odorless, tasteless gas that cannot be easily identified in the environment [1,2]. CO poisoning occurs in developing countries as a result of accidents at home, particularly during winter when heating sources such as wood and coal are incompletely burned. In developed countries, CO poisoning results from accidental or intentional exposure throughout the year [3-5]. CO poisoning can have mild clinical severity; however, when carboxyhemoglobin (COHb) levels exceed 20%, loss of consciousness, severe neurological disorders, coma, and death may occur [4,6]. In cases of CO poisoning, the globus pallidus, other regions of the cerebral cortex, basal ganglia, substantia nigra, thalamus, and cerebellum may be affected. Previous studies have shown that the toxic effects of CO can be accompanied by the development of cognitive disorders (particularly poor memory, loss of concentration, attention deficit, and visual and spatial dysfunctions), gait disorders, urinary and fecal incontinence, dystonia, Parkinsonism, amnesia, obsessive-compulsive disorder, mood disorders (with depressive or manic episodes), irritability, anxiety, anger outbursts, major depression, akinesic mutism, psychosis, hallucinations, delirium, and personality changes [6-13].

Although these neuropsychiatric sequelae can develop acutely, symptoms may appear or improve months or even years later. Although these neuropsychiatric sequelae can develop acutely, symptoms may appear or improve months or even years later [10-13].

Temperament describes the persistent characteristics of emotion, thought, and behavior related to several structural, genetic, and biological factors [14]. The affective temperament model defines 5 temperament categories, including depressive, hyperthymic, cyclothymic, irritable, and anxious [14,15]. The Temperament Evaluation of Memphis, Pisa, Paris, and San Diego Autoquestionnaire (TEMPS-A) temperament scale was developed by Akiskal et al. [18] to evaluate temperament types. This scale was translated into Turkish by Vahip [19].

An acute emergent condition such as CO poisoning can be expected to influence features of the psychological state such as affect and mood. However, whether it has effects on trait characteristics such as temperament is unknown. To the best of our knowledge, no studies have evaluated this question; therefore, the aim of this study was to investigate the effects of CO poisoning on temperament.



Material and Methods

Approval for this prospective study was granted by the local ethics committee (no. 2014-29/05). The study included a control group of healthy volunteers (HVs) and patients who presented to the emergency department (ED) of Kirikkale University Hospital after CO exposure between 01 October, 2014 and 31 October, 2015. For each patient, we recorded demographic characteristics, physical and neurological examination findings, Glasgow coma scale score (GCS), COHb level, treatments applied, and TEMPS-A temperament scale scores at initial presentation and, for CO poisoning patients, at 3 months after discharge.

Study design

The study participants were aged >18 years, spoke Turkish as their native language, and had no intellectual deficiencies. CO poisoning was defined as a COHb level of $\geq 10\%$ at presentation at the ED, as measured with arterial blood gas analysis or a non-invasive pulse CO-oximetry device (Massimo Rad 57, Irvine, CA, USA). Patients were excluded if they had COHb levels of $< 10\%$, had a disease that could affect CO levels (chronic obstructive pulmonary disease, asthma, hemolytic anemia), were smokers, had a history of psychiatric disease (major depression according to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition, or depressive mood, schizophrenia, psychoaffective disorder, epilepsy, dementia, encephalitis, or Parkinson's disease), were taking psychiatric drugs, had recently experienced a life-affecting trauma (e.g., death of a loved one, separation from a partner, loneliness, sexual assault), or were unwilling to participate in the study.

TEMPS-A temperament scale form

The TEMPS-A temperament scale comprises 109 questions for men and 110 questions for women. The Turkish version of the scale comprises 100 questions to identify depressive (18 questions), cyclothymic (19 questions), hyperthymic (20 questions), irritable (18 questions), and anxious (24 questions) temperaments. Participants answer the questions with Yes or No, with Yes scoring as 1 and No scoring as 0. A threshold value is defined for each temperament type (depressive=13; cyclothymic=18; hyperthymic=20; irritable=13; anxious=18), and values exceeding this threshold are considered to indicate a change in temperament characteristics. The test-retest reliability of the Turkish version is 0.73–0.93, and the Cronbach's α coefficient is 0.75–0.84 [19].

The TEMPS-A temperament scale evaluation of patients with CO poisoning in the ED was performed within 24 h before discharge or, for patients who were hospitalized, within 48 h after full recovery of consciousness (GCS=15, when consciousness, orientation, and cooperation returned to normal). Patients in the CO poisoning group were contacted by telephone 3 months after discharge and re-evaluated using the TEMPS-A temperament scale.

Statistical analysis

Statistical analyses of the study data were made using SPSS 23.0 software (SSPS Inc., Chicago, IL, USA). Data were presented as mean \pm standard deviation. Repeated analysis of variance was used in the comparison of the TEMPS-A scores between the groups. The group and sex variables were included in the analysis of variance as "between-subject variables," and the data of the 5 temperaments in the scale as "within-subject variables." A two-tailed p value of 0.05 was considered statistically significant.

Results

The study initially included 104 patients diagnosed with CO poisoning and a control group of 42 HVs. Thirty-six patients were excluded from the study because TEMPS-A evaluation could not be performed 3 months after discharge or because they wished to withdraw. The study was completed with a total of 110 participants: 68 CO poisoning patients and 42 HVs. The patient group comprised 36 women (52.9%) and 32 men (47.1%) with a mean age of 38.64 ± 16.61 years. The control group comprised 23 women (54.7%) and 19 men (45.3%) with a mean age of 36.23 ± 7.11 years. No statistically significant difference was found between the groups with respect to age or sex ($p=0.376$ and $p=0.856$, respectively).

In the 68 CO poisoning patients, most presentations to the ED occurred in February ($n=24$), mean GCS was 14.11 ± 2.59 , mean COHb level was 23.39 ± 10.37 , 40 patients (58.8%) were discharged, 28 (41.2%) were admitted to the intensive care unit for treatment, and 2 (2.9%) received hyperbaric oxygen treatment. At the time of presentation, the GCS value was 3 in 2 patients (2.9%) and ≤ 12 in 24 patients (35.3%). Evaluation with the temperament scale was performed within 24 h before discharge in the 40 patients managed in the ED and, in the 24 patients admitted to the intensive care unit, within 48 h or after regaining full consciousness. The data recorded for patients in the CO poisoning group are shown in Table 1.

Table 1. Data recorded for carbon monoxide (CO) poisoning patients. COHb: carboxyhemoglobin; GCS: Glasgow coma scale; HBT: hyperbaric oxygen treatment; NBT: normobaric oxygen treatment.

	Carbonmonoxide poisoning (n=68)	
	n	%
Gender		
• Female	36	52.9
• Male	32	47.1
Poisoning mechanism		
• Accidental	68	100
• Suicide attempt	-	-
Oxygen treatment		
• HBT	2	2.9
• NBT	66	97.1
Months		
• October	6	8.8
• November	7	10.3
• December	6	8.8
• January	7	10.3
• February	24	35.3
• March	8	11.7
• April	3	4.4
• May	7	10.3
	mean±SD	
Age	38.64±16.61	
GCS	14.11±2.59	
COHb levels (%)	23.39±10.37	
Saturation O2 (%)	96.1±2.62	

A comparison of the distribution of temperament characteristics showed no significant differences between the groups at either of the evaluation times. A comparison of TEMPS-A temperament scale scores in the control group and the CO poisoning group at the time of first presentation showed a significant difference for the depressive type ($p=0.02$) and the anxious type ($p=0.01$; Table 2). A comparison of TEMPS-A temperament scale scores between the control group and the CO poisoning patients at 3 months post-discharge showed a significant difference for the irritable type ($p=0.02$) and the anxious type ($p=0.034$; Table 2). When the temperament scale scores of the CO poisoning patients were compared according to evaluation time (first presentation and 3 months after discharge), no differences were found for any temperament type (Table 2).

Table 2. Comparison of the temperament scores of the groups. AT: anxious type; CT: cyclothymic type; DT: depressive type; FAT: first application time; HT: hyperthymic type; HV: healthy volunteer; IT: irritable type; SD: standard deviation; TM: third month

Groups	Temperament type				
	DT	CT	HT	IT	AT
	mean±SD	mean±SD	mean±SD	mean±SD	mean±SD
FAT vs HV	7.50±3.96	7.01±4.29	11.75±3.81	5.16±4.07	6.52±5.72
	5.69±3.39	6.71±4.19	11.26±3.03	3.73±3.36	3.88±4.09
p	0.016	0.72	0.484	0.06	0.01
TM vs HV	7.04±3.87	7.06±4.18	11.58±3.73	5.51±4.10	6.14±6.04
	5.69±3.39	6.71±4.19	11.26±3.03	3.73±3.36	3.88±4.09
p	0.065	0.204	0.634	0.02	0.034
FAT vs TM	7.50±3.96	7.01±4.29	11.75±3.81	5.16±4.07	6.52±5.72
	7.04±3.87	7.06±4.18	11.58±3.73	5.51±4.10	6.14±6.04
p	0.07	0.09	0.77	0.342	0.343

Discussion

The neuropsychiatric sequelae of CO poisoning can occur not only immediately but also weeks, months, or even years later [7,10-13,20]. The most commonly reported psychiatric disorders are depression and anxiety [6-9,27-29]. However, the results of the present study showed no significant difference in temperament characteristics between controls and patients with CO poisoning at either the initial presentation or 3 months later. On the contrary, compared with HVs, CO poisoning patients had higher depressive, anxious, and irritable type temperament scores at both the time of presentation and in the early period after discharge (third month).

Temperament describes persistent emotional, thought, and behavioral characteristics that can directly or indirectly contribute to the development of psychiatric disorders [15-17]. In the current study, a statistically significant difference was found between CO poisoning patients and HVs with respect to depressive and anxious temperament type scores at the time of first presentation. The depressive mood type is related to several psychiatric disorders, primarily depression [21,22]. Rihmer et al. reported that suicide is associated with several temperament types, the most important of which are the depressive and anxious types [23]. Previous studies have



shown that the depressive type is the basic characteristic temperament type of patients with bipolar I disorder and has also often been identified in patients with obsessive-compulsive disorder [21,24,25]. Although the difference in depressive and anxious temperament type scores between groups at the time of presentation in the present study may be explained by the acute toxic effects of CO gas, it could also be explained by the stress, tension, and discomfort felt by patients in the ED environment.

When the scores for the third-month TEMPS-A evaluation were examined, a statistically significant difference was found between patients and controls with respect to the irritable and anxious temperament types. These temperament types underlie anxious personality disorders and suicide, and the irritable type is also closely related to substance abuse [21,23,26]. Previous studies have reported that depression and anxiety are the most frequent psychiatric disorders observed after CO poisoning, and the depressive, anxious, and irritable types are associated with these disorders [6-9,27-29]. Although Gale et al. [27] reported that depression and anxiety are observed at a rate of 95% after CO poisoning [27], Weaver et al. [29] reported the development of depression in 35% in patients with accidental (excluding suicide) CO poisoning despite these patients having no history of depression [29]. Katirci et al. [6] reported an increase in the development of depression at 1 and 3 months post-exposure in CO poisoning patients compared with controls, whereas Karaman et al. [28] reported that symptoms of anxiety emerged 1 month after CO poisoning. In another study, the rates of anxiety and depression were determined to be high at 6 weeks and 6 months after CO poisoning, respectively [9].

Jasper et al. recommended that patients be followed up for at least 1 year after CO poisoning to monitor the development of depression, anxiety, and other psychiatric sequelae [8]. In the current study, the third-month temperament scale evaluations of the CO poisoning patients showed high anxious and irritable temperament type scores, which are related to the development of depression and anxiety as well as to suicide attempts and substance abuse. This finding supports that of other studies that have emphasized that depression and anxiety could develop in patients after CO poisoning. Our results also indicate that it would be useful to evaluate patients for neuropsychiatric disorders in the short and long term periods after CO poisoning.

We found no significant difference in TEMPS-A temperament scale scores between groups at first presentation and at 3 months post-discharge. Furthermore, when the temperament types of the CO poisoning patients were evaluated separately, none of the scores for the 5 temperament types exceeded threshold values. These results show that CO poisoning had only a mathematical effect on the integrity of the emotion, thoughts, and behavior related aspects of temperament, which is a combination of several genetic and environmental factors, and did not wholly change temperament characteristics. Nevertheless, it would be appropriate to evaluate patients for neuropsychiatric disorders that can develop immediately or long after CO poisoning.

Conclusion

Although temperament types related to depression and anxiety were affected to a small degree in patients with CO poisoning in this study, we found no complete change in any temperament type. Additional studies are needed to more fully elucidate the effects of CO poisoning on temperament.

Declaration of conflict of interest

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References

1. Guzman JA. Carbon monoxide poisoning. *Crit Care Clin* 2012; 28: 537-48.
2. Sykes OT, Walker E. The neurotoxicology of carbon monoxide- Historical perspective and review. *Cortex* 2016; 74: 440-8.
3. Aslan S, Uzkeser M, Seven B et al. The evaluation of myocardial damage in 83 young adult with carbon monoxide poisoning in the East Anatolia region in Turkey. *Human Experimental Toxicology* 2006; 25: 439-46.
4. Kandis H, Katirci Y, Cakir Z, Aslan S, Uzkeser M, Bilir O. A retrospective analyse of the patients admitted to emergency service for carbon monoxide intoxication. *Academic Emerg Med J* 2010; 5: 21-25.
5. Quinn DK, McGahee SM, Politte LC et al. Complications of carbon monoxide poisoning: a case discussion and review of the literature. *Primary Care Companion to the journal of clinical Psychiatry* 2009; 11: 74-79.
6. Katirci Y, Kandis H, Aslan S, Kirpinar I. Neuropsychiatric disorders and risk factors in carbon monoxide intoxication. *Toxicol Int Health* 2011; 27: 397-406.

7. Prockop LD. The allegory of a mountain: an environmental introduction to neurotoxicology. *J Neurol Sci* 2007; 262: 7-14.
8. Jasper BW, Hopkins RO, Duker HV, Weaver LK. Affective outcome following carbon monoxide poisoning: a prospective longitudinal study. *Cogn Behav Neurol* 2005; 18: 127-34.
9. Chambers CA, Hopkins RO, Weaver LK, Key C. Cognitive and affective outcomes of more severe compared to less severe carbon monoxide poisoning. *Brain Inj* 2008; 22: 387-95.
10. Weaver LK, Hopkins RO, Elliott G. Carbon monoxide poisoning. *N Engl J Med* 1999; 340: 1290-92.
11. Smith JS, Brandon S. Morbidity from acute carbon monoxide poisoning at three-year follow-up. *Br Med J* 1973; 1: 318-21.
12. Choi IS. Delayed neurologic sequelae in carbon monoxide intoxication. *Arch Neurol* 1983; 40: 433-35.
13. Min SK. A brain syndrome associated with delayed neuropsychiatric sequelae following acute carbon monoxide intoxication. *Acta Psychiatr Scand* 1986; 73: 80-86.
14. Akiskal HS, Akiskal KK, Haykal RF, Manning JS, Connor PD. TEMPS-A: progress towards validation of a self-rated clinical version of the Temperament Evaluation of the Memphis, Pisa, Paris, and San Diego Autoquestionnaire. *J Affect Disord* 2005; 85: 3-16.
15. Akiskal HS, Mallya G. Criteria for the soft bipolar spectrum treatment implications. *Psychopharmacol Bull* 1987; 23: 68-73.
16. Akiskal HS. Toward a definition of generalized anxiety disorder as an anxious temperament type. *Acta Psychiatr Scand* 1998; 98: 66-73.
17. Eory A, Gonda X, Torzsa P, Kalabay L, Rihmer Z. Affective temperaments: from neurobiological roots to clinical application. *Orv Hetil* 2011; 152: 1879-86.
18. Akiskal HS, Placidi GF, Marenmani I et al. TEMPS-I: delineating the most discriminant traits of cyclothymic, depressive irritable and hyperthymic temperaments in a nonpatient population. *J Affect Disord* 2005; 51: 7-19.
19. Vahip S. Affective temperaments in clinically-well subjects in Turkey: initial psychometric data on the TEMPS-A. *J Affect Disorders* 2005; 85: 113-25.
20. Meert KL, Heidemann SM, Sarnaik AP. Outcome of children with carbon monoxide poisoning treated with normobaric oxygen. *J Trauma* 1998; 44: 149-54.
21. Rihmer Z, Akiskal KK, Rihmer A, Akiskal HS. Current research on affective temperaments. *Curr Opin Psychiatry* 2010; 23: 12-8.
22. Aslan AA, Sari BA, Kuruoglu A. From Depressive Symptomatology to Major Depression: Clinical Spectrum. *Turkish J Clinical Psychiatry* 2012; 15: 56-64.
23. Rihmer A, Rozsa S, Rihmer Z, Gonda X, Akiskal KK, Akiskal HS. Affective temperaments, as measured by TEMPS-A, among nonviolent suicide attempters. *J Affect Disord* 2009; 116: 18-22.
24. Henry C, Lacoste J, Bellivier F, Verdoux H, Bourgeois ML, Leboyer M. Temperament in bipolar illness: impact on prognosis. *J Affect Disord* 1999; 56: 103-8.
25. Fistikci N, Hacıoglu M, Ereğ S et al. Differences in affective temperaments in anxiety disorders: comparison of panic disorder and obsessive compulsive disorder. *Archives of Neuropsychiatry* 2013; 50: 337-44.
26. Moore DJ, Atkinson JH, Akiskal H, Gonzalez R, Wolfson T, Grant I; HNRC Group. Temperament and risky behaviors: a pathway to HIV? *J Affect Disord* 2005; 85: 191-200.
27. Gale SD, Hopkins RO, Weaver LK, Bigler ED, Booth EJ, Blatter DD. MRI, quantitative MRI, SPECT, and neuropsychological findings following carbon monoxide poisoning. *Brain Inj* 1999; 13: 229-43.
28. Karaman D, Metin S, Kara K et al. Neuropsychological evaluation of children and adolescents with acute carbon monoxide poisoning. *Pediatric Emergency Care* 2016; 32: 303-6.
29. Weaver LK, Valentine KJ, Hopkins RO. Carbon monoxide poisoning: risk factors for cognitive sequelae and the role of hyperbaric oxygen. *Am J Respir Crit Care Med* 2007; 176: 491-7.