DOI: 10.37990/medr.1077422 Med Records 2022;4(3):367-71

MEDICAL RECORDS-International Medical Journal

Research Article

Secret Carbon Monoxide Intoxication Assessments of the Patients Who Presented to Emergency

Acil Servise Başvuran Hastaların Gizli Karbon Monoksit Zehirlenmesi Açısından Değerlendirilmesi

Serdar Derya[1], Sukru Gurbuz[2], Hakan Oguzturk[2], Neslihan Yucel[2], Muhammet Gokhan Turtay[2], Muhammed Ekmekyapar[1], Omur Uyanik[3], Hasan Gokce[1]

[1]Malatya Research and Education Hospital, Department of Emergency, Malatya, Turkey
[2]Inonu University, Faculty of Medicine, Department of Emergency, Malatya, Turkey
[3]Elbistan State Hospital, Department of Emergency, Kahramanmaraş, Turkey

Abstract

Aim: The primary aim of this study is to evaluate patients who present to the emergency department with atypical symptoms in terms of occult Carbon monoxide (CO) poisoning, and the secondary aim is to compare the invasive and non-invasive values of Carboxyhemglobin (COHb) levels in patients with high CO levels.

Material and Method: This prospective and descriptive study was conducted on 2775 adult patients who visited the Emergency Department (ED) between January 1 and March 31, 2015. The COHb levels of the individuals who applied to the emergency department with non-specific complaints were measured with a non-invasive multiwave pulse oximeter device and the date of application, age, gender, complaint, smoking history, pregnancy status, pulse COHb, blood COHb and blood metHb parameters were recorded in the preformed form. Values under 10% in smokers and under 6.6% in non-smokers were recorded as secret COHb intoxication.

Results: 52.8% of the patients were male and 34.4% were smokers. The rate of pregnant women among female patients was 13.4%. The first three complaints were shortness of breath, chest pain and stomach ache. It was determined that the mean COHb of the patients was 1.44±1.65 in arterial blood gas and 1.75±1.63 in finger measurement. A highly significant positive correlation was found between the two averages. The COHb value measured by both techniques was higher in male patients and in smokers and non-pregnant patients. The rate of latent COHb intoxication was determined as 1% in smokers and 0.1% in non-smokers.

Conclusion: We came to the conclusion that non-invasive COHb measurement can make positive contributions to the diagnosis of secret carbonmonoxyde intoxications.

Keywords: COHb value, emergency department, secret CO intoxication, secret carbon monoxide intoxication

Öz

Amaç: Bu çalışmanın birincil amacı, acil servise atipik semptomlarla başvuran hastaları gizli karbonmonoksit (CO) zehirlenmesi açısından değerlendirmek, ikincil amacı ise yüksek CO düzeyi olan hastalarda Karboksihemoglobin (COHb) düzeylerinin invaziv ve non-invaziv değerlerini karşılaştırmaktır.

Materyal ve Metot: Bu prospektif ve tanımlayıcı çalışma, 1 Ocak-31 Mart 2015 tarihleri arasında Acil Servise (AS) başvuran 2775 erişkin hasta üzerinde yapılmıştır. Acil servise non spesifik şikayetler ile başvuran bireylerin noninvaziv multidalga pulse oksimetre cihazı ile COHb düzeyleri ölçülmüş ve önceden oluşturulan ve başvuru tarihi, yaş, cinsiyet, şikayet, sigara öyküsü, gebelik durumu, pulse COHb, kan COHb ve kan metHb parametlerini içeren forma kaydedilmiştir. Sigara içenlerde %10'un, içmeyenlerde %6.6'nın altındaki değerler gizli COHb intoksikasyonu olarak kaydedildmiştir.

Bulgular: %52.8'i erkek olan hastaların %34.4'ü sigara kullanıyordu. Kadın hastalar arasında gebe olanların oranı %13.4 idi. İlk üç şikayet nefes darlığı, göğüs ağrısı ve karın ağrısıydı. Hastaların COHb ortalaması arteriyal kan gazında 1.44±1.65, parmak ölçümünde 1.75±1.63 olarak belirlendi. İki ortalama arasında yüksek düzeyde anlamlı bir ilişki bulundu. Her iki teknikle ölçülen COHb değeri, erkek hastalarda, sigara içenlerde ve gebe olmayanlarda daha yüksekti. Gizli COHb zehirlenmesi oranı sigara içenlerde %1, içmeyenlerde %0.1 olarak belirlendi.

Sonuç: Non-invaziv COHb ölçümünün gizli karbonmonoksit intoksikasyonlarının teşhisine olumlu katkılar sağlayabileceği kanaatine vardık.

Anahtar Kelimeler: COHb değeri, acil servis, gizli CO intoksikasyonu, gizli karbon monoksit zehirlenmesi

Received: 14.04.2022 **Accepted:** 24.06.2022
Corresponding Author: Serdar Derya, Department of Emergency, Malatya Research and Education Hospital, Malatya, Turkey,
E-mail: dr.serdarderya@gmail.com

INTRODUCTION

Carbon monoxide is a gas which makes up less than 0.001% of the gases in atmosphere, it forms as a result of incomplete combustion of fuels such as wood, propane, oil, coal, vinyl plastic. It is a colourless, tasteless, non-irritant gas that can be absorbed by lungs easily. The factors that determine the degree of carbon monoxide intoxication include CO amount in the air, additional diseases, length of stay in the environment and specific self-healing metabolism. Carbon monoxyde is one of the leading agents of morbidity and mortality worldwide (1,2). It is in the top spot in our country when it comes to the rate of intoxication cases resulting in death (3) and according to forensic medicine records, CO intoxication accounts for approximately 100-150 death per year (4,5).

It is easy to confuse it with other diseases because of the fact that clinical symptoms and findings are non-specific. Including nausea and vomiting which are symptoms of a variety of diseases, it can manifest itself with loss of consciousness, choma and death. Central nervous system and cardiovascular system are the ones that are the most affected by CO intoxication. Because they are in a greater need of O2

compared to the other sysytems (6). Acute CO intoxication might mimic symptoms such as epileptic seizure, unstable angina and clouding of consciousness. CO exposure repeated in low concentrations might manifest itself with symptoms such as dizziness, headache, fatigue and nausea that characterize flu (7). For the diagnosis of CO intoxication, suspicion and good history taking is crucially important. In the patients who are suspected to suffer from CO intoxication, COHb level must be checked (8-11). CO level is measured by co-oximeter or arteriel blood gases.

The primary aim of this study is to evaluate patients who present to the emergency department with atypical symptoms in terms of occult CO poisoning, and the secondary aim is to compare the invasive and non-invasive values of COHb levels in patients with high CO levels.

MATERIAL AND METHOD

This study was conducted prospectively between January 1 and March 31, 2015 in the ED of Inonu University Hospital, Turkey. The university's Institutional Review Board approved the study design, and patients or patients' relatives provided written consent. In the study which was based on 24 hour principle, overall 2775 patients who presented were included in the study. Under 18 years olds were not included in the study. At least 6 hours of time period after complaints began to be manifested and getting the approval were set as criterias that would put things into the study. The inclusion criteria were ≥18 years of age and admitted to ED within 24 hours. Patients were excluded if they were admitted to ED after 24 hours and ≤18 yeas of age. Patients were also excluded if they were transferred to our ED from another hospital or transferred to another instution, or if they died during ED management.

The study was conducted through nurses and emergency department doctors with sufficient training on the use of oximeter. COHb levels of the patients who presented to the emergency department with non-specific complaints such as nausea, dizziness, vomiting, headache, shortness of breath and fatigue were measured through non-invasive multi-wave pulse oximeter and they were filled into the form that contained presentation dates, ages, genders, complaints, smoking history, pregnant state, pulse COHb, blood COHb and blood met HB parameters of the patients. In COHb measurement made by non-invasive multi-wave oximeter, which was calibrated, patients were seperated into smokers and non-smokers. The cases where we had 10% COHb level in smokers and 6.6% in non-smokers were put under monitor surveillance. After that for complete blood count, biochemical tests and arterial blood gases, blood samples were taken. In addition to routine parameters, from arterial blood gas samples, blood COHb levels were studied. Smoking patients who had more than 10% COHb levels in both arterial blood gas and measured by pulse oximeter were taken to be suffering from carbon monoxyde intoxication, non-smokers who had more than 6.6% COHb levels were taken to be suffering from carbon monoxyde intoxication. Following this, oxygen masks with reservoir and normobaric oxygen therapy with 100% oxygen were used for the beginning phase of the treatment. Patients who got COHb levels back to normal and were with disappeared symptoms were discharged from the hospital.

Statistical analysis was performed using the software package SPSS for Windows version 16.0 (SPSS, Inc., Chicago, IL, USA). Descriptive statistics were reported, including mean, standard deviation, and frequency. Categorical data were analyzed using the chi-square or Fisher's exact test. The data were summarized using means, standard deviations, frequencies, percentage distribution, Spearman correlation, One-way ANOVA, student's t-test and Mann-Whitney U test. $p<0.05$ was taken statistically significant.

RESULTS

Age averages of the patients who were included in the study were 57±20 and 47% of them were females and 53% of them were males. 34.4% of the patients reported to be smoking. It was detected that 13%-of the female patients were pregnant. Most common complaints of the patients were shortness of breath (27.8%), chest pain (25.8%), abdominal pain (18.1%), fever (4.6%), headache (3.7%), inability to urinate (3.1%) and altered state of consciousness (2.9%).

Table 1 showed that COHb average of the patients was 1.44±1.65,finger COHb levels of the patients was 1.75±1.63 and it was detected that there was a positive and significant co-relation between COHb and finger COHb levels ($p<0.001$).

Table 1. The relationship between COHb and finger COHb values

Parameter	x ± SS	Min - Max	Correlation
COHb	1.44 ± 1.65	-16.4 - 35.5	r=0.850[a]
Finger COHb	1.75 ± 1.63	- 27	p<0.001

[a]Spearman correlation

Table 2 presentation that there was a significant statistical difference between age groups and COHb levels. It was detected that the difference was the case in ≤24 and 25-44 age groups (p<0.05). Moreover, it was detected that COHb and finger COHb levels were significantly higher in male patients compared to female patients, in smokers compared to non-smokers and in non-pregnants compared to pregnants (p<0.001).

Table 2. Socio-demographic characteristics of participants and comparison of COHb and finger COHb averages

Variable	n	%	COHb x ± SS	Test	Finger COHb x ± SS	Test
Age						
≤ 24	171	6.2	1.25±1.30	F=3.458[a]	1.49±1.53	F=2.959[a]
25-44	632	22.8	1.58±2.11	p<0.05	1.83±2.13	p=0.052
≥ 45	1972	71.0	1.42±1.50		1.74±1.45	
Sex						
Female	1309	47.2	1.20±1.37	t=-7.29b	1.48±1.58	t=-8.08[b]
Male	1466	52.8	1.66±1.83	p<0.001	1.98±1.65	p<0.001
Smoking						
Yes	955	34.4	2.21±1.82	t=18.85[b]	2.67±1.78	t=23.67[b]
No	1820	65.6	1.04±1.39	p<0.001	1.26±1.31	p<0.001
Pregnancy (n=1309)*						
Yes	175	13.4	0.61±0.77	t=-6.23[b]	0.74±0.92	t=-6.77[b]
No	1134	86.6	1.30±1.42	p<0.001	1.60±1.62	p<0.001

aOne-way ANOVA bStudent's t-test

Table 3 showed that secret COHb intoxication rate for smokers was 1%. COHb (13.36±2.21). In addition finger COHb average levels in smokers and in the ones with secret COHb intoxication were found to be a significant statistical difference compared to patients with no secret COHb intoxication (p<0.001).

Table 3. The comparison of COHb and toxicity detection and COHb and finger COHb averages in cigarette smoking patients

Hidden COHb Intoxication	n	%	COHb x ± SS	Test	Finger COHb x ± SS	Test
Got intoxication	10	1.0	13.36±2.21	-5.449[a]	12.80 ± 1.81	-5.658[a]
No intoxication	945	99.0	2.09±1.40	p<0.001	2.56 ± 1.44	p<0.001

[a]Mann-Whitney U test

Table 4 presentation that non-smokers, detection of secret COHb intoxication allows us to have COHb and finger COHb level comparisons. Statistical assessment did show that secret COHb intoxication rate for non-smokers was 0.1%. It was detected that COHb average levels (30.55±7.00) and COHb finger levels (21.00±8.48) in non-smokers and in the ones with secret COHb intoxication were found to be significantly higher compared to the patients with no secret COHb intoxication (p<0.05).

Table 4. Comparison of COHb and toxic COHb meaning of hidden COHb intoxication in non-smoking patients

Intoxication	n	%	COHb x±SS	Test	Finger COHb x±SS	Test
Yes	2	0.1	30.55±7.00	-2.449[a]	21.00±8.48	-2.554[a]
No	1818	99.9	1.01±0.97	p=0.014[b]	1.24±1.12	p=0.011[b]

[a]Mann-Whitney U test [b]p<0.05

Table 5 showed that distributions of the complaints of the patients with detected secret COHb intoxication are presented. Presentation complaints of the smokers and of the patients with detected secret COHb intoxication were headache (30%), shortness of breath (30%), dizziness (20%), altered state of consciousness (10%) and syncope (10%). Presentation complaints of the non-smokers and of the ones with no detected secret COHb intoxication were dizziness (50%) and shortness of breath (50%).

Table 5. Distribution of complaints of emergency diagnosis of patients with hidden COHb intoxication

Application Complaint	n	%
Smoking (n=10)		
Headache	3	30.0
Dispnea	3	30.0
Dizziness	2	20.0
Change of consciousness-SVO	1	10.0
Syncope	1	10.0
No smoking (n=2)		
Dizziness	1	50.0
Dispnea	1	50.0

DISCUSSION

CO intoxication coming with non-specific symptoms can mimic a lot of diseases which have wide-ranging and a lot of symptoms such as fainting, newly developed convulsion, flu-like disease, headache, nausea, chest pain (12). In emergency department, 12 patients were detected to have CO intoxication as a result of routine COHb measurents made by non-invasive pulse oximeter. The fact that 12 of 2775 patients were diagnosed CO intoxication via non-invasive method that can be play an important role in the prevention of the wrong diagnosis and treatment of COHb. In ED triage, considering similar studies examining the effectiveness of non-invasive COHb scanning, findings back our study about the success in the diagnosis of secret CO intoxication. Roth and his friends scanned 16108

patients in emergency department triage during a year in a study where they used Masimo Radical 7 CO oximeter and blood gases of 2292 patients were taken and in the study it was reported that 17 patients got diagnosed with CO intoxication (8). Suner et al. reported that there were 28 CO intoxications in their study in which they screened 10856 patients, and they found 11 cases of occult CO poisoning (13). In the light of these findings, it can be said that routine screening with the noninvasive Masimo Radical 7 CO oximeter and another device is effective in detecting occult CO poisoning cases. In the study conducted by Chee et al., COHb levels of 74880 patients who applied to the emergency department were measured with a noninvasive pulse CO-oximeter device. Intoxication criteria was to have more than 10% CO level which is in venous blood gas and determined by pulse oximeter. According to the criterias, 7 patients (0.009%) were detected to have CO intoxication. When taken a look at the presentation complaints of the 7 patients who were taken CO intoxication cases, 3 of them presented to the hospital with headache, 2 of them with dizziness and 2 of them with nausea. As a result of this study, for the diagnosis of the patients presenting to the hospital with non-specific complaints, non-invasive pulse CO oximeter was found to be fit for use (14). In this study, the reason why the rate of poisoning was found to be much higher compared to the study conducted by Chee et al. might be that the study was taken from patients who applied to the emergency department with non-specific symptoms, and in addition, in terms of intoxication criteria, COHb levels were above 6.6% in non-smokers and 10% in smokers. However, according to all these criteria, the high rate of CO poisoning in this patient group is very thought-provoking. This shows that; COHb level measurement using noninvasive pulse CO-oximetry in addition to routine vital signs in emergency department triage; In differential diagnosis, early diagnosis and treatment will also help the clinician. At the same time, it will reduce the cost of many tests from an economic point of view.

In a study conducted by Harduar-Morano et al., it was found that latent CO poisoning occurs most frequently in the 35-44 age group (15). In our study, the comparison of the socio-demographic characteristics of the patients with the COHb and Finger COHb averages was evaluated. In the statistical analysis, it was determined that there was a statistically significant difference between age groups and COHb values. It was determined that the difference was between ≤24 and 25-44 age groups ($p<0.05$). In addition, it was determined that COHb and Finger COHb values were statistically significantly higher in male patients than in female patients, in smokers than in non-smokers, and in non-pregnant patients compared to pregnant patients ($p<0.001$).

Patients who are with carbonmonoxyde intoxication present to the emergency departments with non-specific symptoms, in these patients, the diagnosis of secret CO intoxication can be made with the help of non-invasive pulse CO oximeter. After CO intoxication, diagnosis is generally made by blood gas analysis. But this laboratory technique does not exist everywhere and it is a time-consuming process and that is why we used conventional pulse oximeters. Besides, taking blood gas from every patient was impossible for the fact that it could be difficult for differential diagnosis and economy and for this reason in triage measurements with non-invasive pulse oximeters can lead us to CO intoxication in differential diagnosis. When compared non-invasive COHb-COHb levels of 2775 patients who were analyzed with blood gas, these two levels were found to be well correlated with each other ($r=0.850$). In correlation analysis, it was detected that COHb averages of the patients were 1.44±1.65, finger COHb averages were 1.75±1.63 and there was a highly positive relationship between COHb and finger COHb levels ($p<0.001$). In the study conducted by Suner et al.(13), it was reported that there was a good correlation between noninvasive and venous COHb ($r=0.72$). Barker et al. (16) reported that the correlation coefficient between noninvasive COHb measurement and blood gas was 0.86.

In our study, we questioned the patients if they smoked and according to history taken from patient relatives and from the patients themselves, among 12 secret COHb intoxication patients,10 patients were smokers and 2 patients were non-smokers. In our study, while SpCO sensitivity for non-smokers was 100% for 6% and 10% cut-off levels, in smokers it was 90%. In our study, specificity for smokers was 100% and for non-smokers it was 99.83%. Suner et al. in the non-invasive COHb measurement with their study, while the sensitivity was found to be as high as 96%, as in our study, they found the specificity to be 54% (13) and found it lower than our study. In another study, which found a specificity similar to our study, Touger et al. reported the sensitivity of Rad-57 pulse CO oximeter as 48% and specificity as 99% (17). In a study conducted by Roth et al. (8), which was taken at a value close to our cutoff value (8), the measurement of smokers and non-smokers with non-invasive pulse oximetry was calculated separately, as we did, and the diagnostic performance was tried to be determined. Roth et al accepted the cutoff as 6.6% for all patients, resulting in sensitivity 94% (95% confidence interval; 71%-100%), specificity 77% (95% confidence interval; 75%-79%), positive predictive value was reported as 4% (95% confidence interval 2%-7%). For smokers, when the cutoff is accepted as 6.6%, sensitivity is 89% (95% confidence interval; 52%-100%), specificity is 71% (95% confidence interval; 67%-75%), positive predictive value is 5% (95% confidence interval 2%-10%) and negative predictive value 100% (95% confidence interval; 98%-100%). For non-smokers, when the cutoff is considered to be 6.6%, sensitivity is 100% (95% confidence interval; 63%-100%), specificity is 78% (95% confidence interval; 75%-81%), positive predictive value is 4% (The 95% confidence interval has been reported as 2%-7% and the negative predictive value as 100% (95% confidence interval; 99%-100%) (8). In our study, according to the results of the diagnostic tests, the sensitivity of the reference test in smokers was 90.00% (55.50%-99.75%, 95% CI), and the

specificity was 100.00% (99.61%-100.00%). According to this result, 9 out of 10 individuals with a positive diagnosis from the real test were diagnosed with a positive reference test, while all 945 individuals with a negative diagnosis from the real test were also diagnosed with a negative reference test. The sensitivity percentage of the reference test in non-smokers was found to be 100.00% (15.81%-100.00%, 95% CI), and the specificity percentage was 99.83% (99.52%-99.97%). According to this result, all of the 2 individuals diagnosed as positive by the real test were also diagnosed as positive in the reference test, while 1815 of 1818 individuals diagnosed as negative by the real test were also diagnosed as negative in the reference test.

CONCLUSION

We came to the conclusion that non-invasive carboxyhemoglobin measurement can make positive contributions to the diagnosis of secret carbonmonoxyde intoxications. Non-invasive carboxyhemoglobin measurement can be used for an early diagnosis of CO intoxication and reduce differential diagnosis in triage. It is estimated that early diagnosis and early treatment can reduce mortality and morbidity. It is considered that in winter and profession group distributions, it can be used for the scanning of the patients who present to the hospital with non-specific symptoms.

Financial disclosures: *The authors received no support from any financial institution or organization for this study.*

Conflict of interest: *The authors declare that they have no competing interest.*

Ethical approval: *Approval was obtained from the Malatya Clinical Research Ethics Committee for the implementation of the study (Decision no: 2015/02). In addition, this research was accepted as a specialization thesis in İnönü University, Department of Emergency Medicine in 2017.*

REFERENCES

1. Doherty S. History, pathophysiology, clinical presentation and role of hyperbaric oxygen in acute CO poisoning. Emerg Med. 2000;12:55-61.
2. Gerald Maloney. Carbon Monoxide. In: Tintinalli JE editors. Tintinalli's Emergency Medicine: A Comprehensive Study Guide. 7th ed. New York: McGraw-Hill, 2011;1410–3.
3. Özdemir HS, Kaplanoğlu V. Carbon monoxide pisoning. Tukey Cinics J Surg Med Sci. 2006;2:74-80.
4. Sever H, İkizceli İ, Avşaroğulları L. et al. Carbonmonoxide poisoning among patients presenting with nonspesific symptoms to the emergency department. Turkish Journal Of Emergency Medicine 2005;5:18-21.
5. Dökmeci İ. Toxicology. Nobel Medical Bookstore. Ankara. 2001, pp 249-55.
6. Yürüktümen A. Carbon monoxide poisoning. Satar S (editor). In The Emergency Clinical Toxicology 1Edition, Adana:Nobel. 2009:577-80.
7. Diltoer MW, Colle IO, Hubloue I, et al. Reversible cardiac failure in an adolescent after prolonged exposure to carbon monoxide. Eur J Emerg Med. 1995;2:231-5.
7. Roth D, Herkner H, Schreiber W, et al. Accuracy of noninvasive multiwave pulse oximetry compared with carboxyhemoglobin from blood gas analysis in unselected emergency department patients. Ann Emerg Med. 2011; 58:74-9.
8. Kao LW, Nanagas KA. Carbon monoxide poisoning. Emergency medicine clinics of North Am. 2004;22:985-1018.
9. KW VM. Carbon Monoxide Poisoning. In: Tintinalli JE, Kelen GD, Stapczynski JS (eds). Emergency Medicine:A Comprehensive Study Guide (6th ed) McGraw-Hill. 2004:1238-42.
10. Zaouter C, Zavorsky GS. The measurement of carboxyhemoglobin and methemoglobin using a non-invasive pulse CO-oximeter. Respir Physiol Neurobiol. 2012;182:88-92.
11. Kao LW, Nanagas KA. Carbon monoxide poisoning. Med Clinics North Am. 2005;89:1161-94.
12. Suner S, Partridge R, Sucov A, et al. Non- invasive pulse CO-oximetry screening in the emergency department identifies occult carbon monoxide toxicity. J Emerg Med. 2008;34:441-50.
13. Chee KJ, Nilson D, Partridge R, et al. Finding needles in a haystack: a case series of carbon monoxide poisoning detected using new technology in the emergency department. Clinical Toxicol. 2008;46:461-9.
14. Harduar-Morano L, Watkins S. Review of unintentional non-fire-related carbon monoxide poisoning morbidity and mortality in Florida, 1999-2007. Public Health Rep. 2011;126:240-50.
15. Barker SJ, Curry J, Redford D, et al. Measurement of carboxyhemoglobin and methemoglobin by pulse oximetry: a human volunteer study. Anesthesiol. 2006;105:892-7.
16. Touger M, Gallagher EJ, Tyrell J. Relationship between venous and arterial carboxyhemoglobin levels in patients with suspected carbon monoxide poisoning. Annals Emerg Med. 1995;25:481-3.