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THE EFFECT OF CARBON MONOXIDE SOURCES AND METEOROLOGIC CHANGES IN CARBON MONOXIDE INTOXICATION: A RETROSPECTIVE STUDY

KARBONMONOKSİT KAYNAKLARININ VE METEOROLOJİK DEĞİŞİKLİKLERİN KARBONMONOKSİT ZEHİRLENMELERİNE ETKİSİ: RETROSPEKTİF ÇALIŞMA

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ABSTRACT

Objective: Carbon monoxide (CO) poisoning is frequently seen in emergency departments (ED) especially in cold weather. We investigated the relationship of some of the meteorological factors with the sources of CO poisoning.

Methods: In this retrospective observational study, we included 1153 patients who were admitted to ED due to CO poisoning in a three years period. Atmospheric pressure, wind direction and speed, humidity level and air temperature of the region at exposure time were compared with CO poisoning type.

Results: Mean age of the patients was 39.5±16.3; females were 65.7% (n=761) of the patients. Most frequent source of CO was natural gas heaters (n=628; 54.4%); others were stove (n=393; 34.1%), geyser (n=94; 8.4%) and blaze (n=38; 3.3%). Most frequent direction of the wind was North-North-East (euroclydon). Atmospheric pressure was similar in all of the poisoning types; in blaze, humidity levels was significantly lower, air temperature was significantly higher. Wind speed was faster in blaze and slowest in geyser type poisoning.

Conclusion: Carbon monoxide poisoning is an important cause of emergency visits which can result in serious morbidity or mortality. Main sources are home heating systems. People should be informed about the risks of these heaters and symptoms of CO poisoning and, also in case of important meteorological changes. They should apply to an ED in case of occurrence of intoxication symptoms.

Keywords: Atmospheric pressure, CO intoxication, temperature, wind, humidity

ÖZ

Amaç: Karbonmonoksit (CO) zehirlenmelerine, özellikle soğuk havalarda olmak üzere acil servis birimlerinde sıklıkla karşılaşılır. Çalışmamızda, bazı meteorolojik faktörlerin CO zehirlenmesinin kaynakları ile ilişkisini araştırdık.

Yöntem: Retrospektif gözlemsel çalışmamızda, son üç yılda acil servise CO zehirlenmesi ile başvuran 1153 hastayı dahil edildi. Bölgenin atmosferik basıncı, rüzgarın yönü ve hızı, nem düzeyi ve hava sıcaklığı değerleri ve CO zehirlenme tipi karşılaştırıldı.

Bulgular: Hastaların yaş ortalaması 39,5±16,3; kadın cinsiyet %65,7 (n=761) idi. Karbonmonoksit kaynağının kaynağı en sık doğalgaz ısıtıcıları (n=628; %54,4); daha sonra ocak (n=393; %34,1), şofben (n=94; %8,4) ve yangındı (n=38; %3,3). En sık görülen rüzgar yönü kuzey-kuzeydoğu yönü (poyraz) idi. Atmosferik basınç tüm zehirlenme tiplerinde benzerdi. Yangınlarda nem düzeyleri istatistiksel anlamlı düşüktü ve hava sıcaklığı anlamlı yüksekti. Rüzgar hızı yangın tipinde en hızlı ve şofben tipinde en yavaştı.

Sonuç: Karbonmonoksit zehirlenmeleri ciddi morbidite ve moraliteye neden olabilen acil servis başvuru nedenlerindendir. Başlıca nedeni ev ısıtıcılarıdır. Risk altındaki insanlar CO zehirlenmeleri hakkında ve önemli meteorolojik değişikliklerde ısıtıcaların riskleri hakkında bilgilendirilmelidir. Zehirlenme bulguları görüldüğünde acil servise başvurulmalıdır.

Anahtar Kelimeler: Atmosferik basınç, CO zehirlenmesi, sıcaklık, rüzgar, yangın

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Introduction

Carbon monoxide (CO) poisoning is an important public health problem. The emergency visits increase due to CO intoxication caused by use of stove, geyser and other heating devices especially in cold weather.

Carbon monoxide was first described by a French chemist de Lassone in 1776.[1] Carbon monoxide has more than 210 fold affinity in binding to hemoglobin than oxygen.[2] Carbon monoxide combines with hemoglobin to produce carboxyhemoglobin, which is ineffective for delivering oxygen to tissues that finally causes tissue damage.[3] The mechanism of CO-induced death is thought to be high affinity binding of CO to hemoglobin and myoglobin, resulting in tissue hypoxia that inhibits cytochrome oxidase synergistically with CO.[4] It causes tissue damage in all organs, especially brain, heart and kidney which are very sensitive to hypoxia.[5] Cardiac effects, ranging from mild and transitory injury to necrosis and contractile dysfunction has been known in patients with carbon monoxide poisoning.[6] The myocardial tissue is highly vulnerable to oxygen deprivation, thus causing a substantial reduction of contractility and cardiac output, which ultimately contribute to the direct worsening injury of CO on cardiomyocytes.[7] The most common symptoms of carbon monoxide poisoning are headache, nausea, vomiting, dizziness, fatigue, and a feeling of weakness. Infants may be irritable and malnourished. Neurological symptoms are confusion, disorientation, visual disturbance, syncope and seizure.[8] The most important prognostic factor is the exposure duration. Chronic intoxications has worse prognosis.[9]

It is known in the literature that storms and sudden weather changes lead to epidemic CO intoxications.[10] To the best of our knowledge the only study that investigated the meteorological parameters like humidity, air pressure and wind speed was Tiekuan Du et al.'s study.[11]

In this retrospective study, we investigated the relationship of some of the meteorological factors with the sources of CO poisoning.

Methods

This retrospective observational study is carried out after local ethical committee approval (Dışkapı Yıldırım Beyazıt Educational and Research Hospital, Approval number: 01/46, Date: 27.02.2012).

The study hospital was a third-degree education and research hospital with an annual emergency visit of 250.000 patients. Patients over the age of 18, who were admitted to ED due to stove, natural gas, water heater and smoke-induced CO poisoning with the symptoms of headache, nausea, vomiting, dizziness, syncope, chest pain and dyspnea were investigated in a three year period. Patients diagnosed with CO poisoning were included in the study. Patients with normal carboxyhemoglobin (COHb) levels are excluded. The demographic data of the patients were obtained from the hospital registration records. Our primary outcome was the frequency of CO sources. Secondary outcomes were the frequency of the wind directions and the most common months of CO poisoning.

The analysis was performed in Ankara, 870-meter-high above the sea, in the middle of Turkey. The city is located between the northern latitudes of 39° 50′ and 40° 00′and the longitudes of 32° 35′ and 33° 00′. Generally, the continental climate prevails in Ankara.

The atmospheric pressure, wind direction and speed, humidity level and air temperature of the region at exposition time are recorded from General Directorate of Meteorology. Age and gender of patients, the source of CO, admission time and date are recorded.

Statistical Analysis

The statistical analyses were performed by SPSS 15.0 for Windows package program. The continuous variables are expressed as mean±SD, categorical variables are expressed as n (%). The normal distribution is determined by histogram and One-Sample Kolmogorov Smirnov test. Comparison of means was evaluated by Mann-Whitney-U test if any of the groups is not normally distributed; if both of the groups are normally distributed, Student's t-Test is used. $p<0.05$ is accepted as significant.

Results

One thousand one hundred fifty-three patients were included the study; females were 65.7% (n=761) of the patients. The mean age of the patients was 39.5±16.3. The mean age of males and females were similar (p=0.676). The most frequent source of CO was natural gas heaters (n=628; 54.4%); others were stove (n=393; 34.1%), geyser (n=94; 8.4%) and blaze (n=38; 3.3%).

The most frequent direction of the wind was North-North-East (euroclydon), the second was north winds (Figure 1).

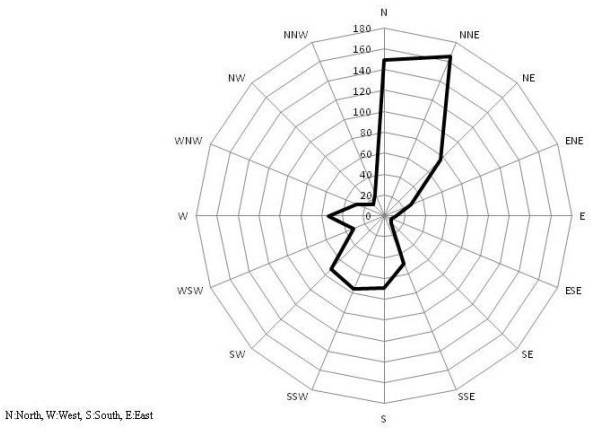

Figure 1. The relationship of carbon monoxide source and wind direction

The most common exposure was in January (Figure 2). The visits have significantly decreased after June.

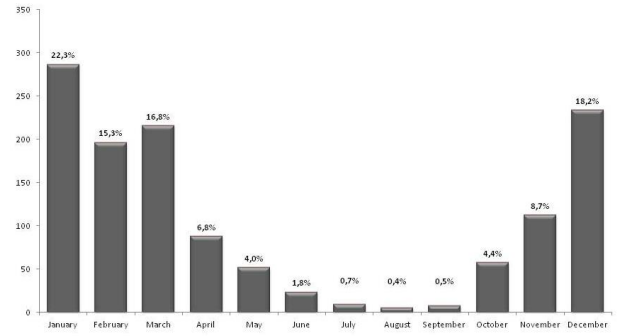

Figure 2. The frequency of carbon monoxide poisoning in months

The mean atmospheric pressure, air temperature, wind speed and humidity levels at exposure time according to the source of CO were expressed in Table 1. The atmospheric pressure was similar in all of the poisoning types; in blaze, humidity levels was significantly lower, air temperature was significantly higher. The wind speed was faster in blaze and slowest in geyser type poisoning. The box-plot graphics of meteorological data according to CO source were given in Figure 3.

Table 1. The relationship of carbon monoxide source and meteorological data

Carbon monoxide Source	Air atmospheric pressure (mean±SD)	Humidity rate (mean±SD)	Air temperature (mean±SD)	Wind speed (mean±SD)
Natural gas heater (n=627)	1014±8	80±16	2.1°±7.1°	9.8±8.3
Stove (n=393)	1013±8	81±14	2.9°±6.0°	10.6±8.6
Geyser (n=94)	1014±7	85±14	2.2°±5.8°	7.4±6.8
Blaze (n=38)	1014±5	65±24	7.2°±10.0°	12.1±8.2

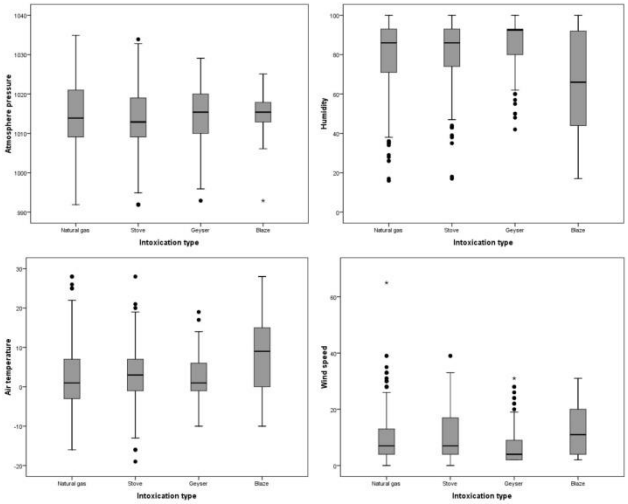

Figure 3. The distribution of meteorological data according to carbon monoxide source

Discussion

The most common reason of CO intoxication in our study was natural gas heaters with 54.4%; the second reason was stove with 34.1%. Natural gas heaters are the most commonly used domestic heating system in our study region; so, the most common cause of CO poisoning was natural gas heaters. Region, ethnic and socio-cultural factors affect the poisoning type.[12] Frequency of CO source type varies by location. In some regions, the geyser is the most common cause with a ratio between 68.3% and 77.5%; but in some regions, stove is the most frequent source with a ratio between 85.9% and 89.7%.[13-17]

In our study, the CO poisoning rate was found to be 74% from December to March, while this rate was found to be between 38.9% and 64.6% in the previous months in our country.[14,17-21] The frequency varies, but the main result is a significant increase in CO poisoning in cold weather especially in ice storms.[22-24] The Centers for Disease Control and Prevention (CDC) reports also support our results that the CO exposure occurs mostly in winter and at least in July and August.[25,26]

In our study, atmospheric pressure was similar in all types of poisoning. Tiekuan Du et al. reported that air pressure is not associated with CO poisoning, similar to our results. They reported that the only factor affecting CO poisoning is air temperature; CO poisoning frequency increases as temperature decreases.[11] This result is partially similar to our study result because we found that the air temperature in CO poisoning associated with the natural gas heater was the lowest. However, the mean temperature was still very low (2.1°±7.1°) compared to winter months. On the other hand, the air temperature was significantly higher at blaze (7.2°±10.0°) but the temperature still indicated cold weather. In case of blaze, humidity levels were significantly low and air temperature was significantly higher. Tiekuan Du et al. also investigated other parameters, but they reported that there is no correlation of wind speed and humidity;[11] but in our study we showed that wind speed was faster in blaze and slowest in geyser type poisoning. In addition, the humidity level in our study was the highest in geyser type CO poisoning and the lowest in blaze.

The retrospective nature was a limitation of our study.

The main sources of CO poisoning are home heating systems. In case of important meteorological changes, especially at the euroclydon wind direction, people at risk can be informed and warned about the risks.

Compliance with Ethical Standards

This retrospective observational study is carried out after local ethical committee approval (Dışkapı Yıldırım Beyazıt Educational and Research Hospital, Approval number: 01/46, Date: 27.02.2012).

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Author Contribution

DY, UYÇ: Concept; DY, UYÇ, OEY: Design; UYÇ: Supervision; DY, GBT, MKB: Resources; SY, BGÇB: Materials; DY, SY, BGÇB, GBT, MKB: Data collection and/or processing; DY, UYÇ, SY, BGÇB, OEY: Analysis and/or interpretation; DY, SY, MKB: Literature search; BGÇB, GBT, OEY: Writing manuscript; UYÇ: Critical review.

Financial Disclosure

There is no financial disclosure.

References

1. Cruickshank W. Some observations on different hydrocarbonates and combinations of carbone with oxygen, etc. in reply to some of Dr. Priestley's late objections to the new system of chemistry. *Journal of Natural Philosophy, Chemistry and the Arts.* 1801;5:1-9.
2. Phin N. Carbon monoxide poisoning (acute). *Clinical Evidence.* 2005;13:1732-1743.
3. Tikuisis P, Kane DM, McLellan TM, Buick F, Fairburn SM. Rate of formation of carboxyhemoglobin in exercising humans exposed to carbon monoxide. *J Appl Physiol (1985).* 1992;72(4):1311-1319. doi:10.1152/jappl.1992.72.4.1311
4. Cooper CE, Brown GC. The inhibition of mitochondrial cytochrome oxidase by the gases carbon monoxide, nitric oxide, hydrogen cyanide and hydrogen sulfide: chemical mechanism and physiological significance. *Journal of Bioenergetics and Biomembranes.* 2008;40(5):533-539. doi:10.1007/s10863-008-9166-6
5. Choi IS. Carbon monoxide poisoning: systemic manifestations and complications. *Journal of Korean Medical Science.* 2001;16(3):253-261. doi:10.3346/jkms.2001.16.3.253
6. Lippi G, Rastelli G, Meschi T, Borghi L, Cervellin G. Pathophysiology, clinics, diagnosis and treatment of heart involvement in carbon monoxide poisoning. *Clinical Biochemistry.* 2012;45(16-17):1278-1285. doi:10.1016/j.clinbiochem.2012.06.004
7. Cervellin G, Comelli I, Rastelli G, Picanza A, Lippi G. Initial blood lactate correlates with carboxyhemoglobin and clinical severity in carbon monoxide poisoned patients. *Clinical Biochemistry.* 2014;47(18):298-301. doi:10.1016/j.clinbiochem.2014.09.016
8. Blumenthal I. Carbon monoxide poisoning. *Journal of the Royal Society of Medicine.* 2001;94(6):270-272. doi:10.1177/014107680109400604
9. Piantadosi CA. Carbon monoxide poisoning. *Undersea& Hyperbaric Medicine: Journal of the Undersea and Hyperbaric Medical Society, Inc.* 2004;31(1):167-177.
10. Henretig FM, Calello DP, Burns MM, O'Donnell KA, Osterhoudt KC. Predictable, preventable, and deadly: Epidemic carbon monoxide poisoning after storms. *American Journal of Public Health.* 2018;108(10):1320-1321. doi:10.2105/AJPH.2018.304619
11. Du T, Zhang Y, Wu JS, et al. Domicile-related carbon monoxide poisoning in cold months and its relation with climatic factors. *The American Journal of Emergency Medicine.* 2010;28(8):928-932. doi:10.1016/j.ajem.2009.06.019
12. Baum CR. What's new in pediatric carbon monoxide poisoning? *Clin Ped Emerg Med.* 2008;9(1):43-46. doi:10.1016/j.cpem.2007.11.002
13. Keles A, Demircan A, Kurtoglu G. Cabon monoxide poisonig: how many patients do we miss? *Eur J Emerg Med.* 2008;15:154-157. doi:10.1097/MEJ.0b013e3282efd519
14. Aslan Ş, Erol MK, Karcıoğlu Ö, Meral M, Çakır Z, Katırcı Y. The investigation of ischemic myocardial damage in patients with carbon monoxide poisoning. *Anatol J Cardiol.* 2005;5(3):189-193.
15. Besli GE, Ergüven M, Karadoğan M, Yılmaz Ö. Carbon monoxide poisoning in children. *Eurasian Journal of Emergency Medicine.* 2009;9(1):26-30. doi:10.4170/JAEM.2009.19480
16. Akkose Ş, Turkmen N, Bulut M, Akgoz S, Işcimen R, Eren B. An analysis of carbon monoxide poisoning in Bursa, Turkey. *East Mediterr Health J.* 2010;16:101-106.
17. Uysalol M, Uysalol EP, Saraçoğlu GV, Kayaoğlu S. A retrospective analysis of pediatric patients admitted to the pediatric emergency service for carbon monoxide intoxication. *Balkan Medical Journal.* 2011;28(3):237-243. doi:10.5174/tutfd.2010.03766.1
18. Wilson RC, Saunders PJ, Smith G. An epidemiological study of acute carbon monoxide poisoning in the West Midlands. *Occupational and Environmental Medicine.* 1998;55(11):723-728. doi:10.1136/oem.55.11.723
19. Ait El Cadi M, Khabbal Y, Idrissi L. Carbon monoxide poisoning in Morocco during 1999-2007. *J Forensic Leg Med.* 2009;16:385-387. doi:10.1016/j.jflm.2009.01.017
20. Mendoza JA, Hampson NB. Epidemiology of severe carbon monoxide poisoning in children. *Undersea&Hyperbaric Medicine: Journal of the Undersea and Hyperbaric Medical Society, Inc.* 2006;33:439-446.
21. Metin S, Yıldız Ş, Çakmak T, Demirbaş Ş. Frequency of carbon monoxide poisoning in Turkey in 2010. *TAF Prev Med Bull.* 2011;10(5):587-592. doi:10.5455/pmb.20110417125648
22. Daley WR, Smith A, Paz-Argandona E, Malilay J, McGeehin M. An outbreak of carbon monoxide poisoning after a major ice storm in Maine. *The Journal of Emergency Medicine.* 2000;18(1):87-93. doi:10.1016/S0736-4679(99)00184-5
23. Ghim M, Severance HW. Ice storm-related carbon monoxide poisonings in North Carolina: A reminder. *Southern Medical Journal.* 2004;97(11):1060-1065. doi:10.1097/01.SMJ.0000144614.38668.60
24. Wrenn K, Conners GP. Carbon monoxide poisoning during ice storms: a tale of two cities. *The Journal of Emergency Medicine.* 1997;15(4):465-467. doi:10.1016/s0736-4679(97)00074-7
25. Centers for Disease Control and Prevention (CDC). Carbon monoxide related deaths-United States, 1999-2004. *MMWR. Morbidity and Mortality Weekly Report.* 2007;56(50):1309-1312.
26. Centers for Disease Control and Prevention (CDC). Nonfatal, unintentional, non fire-related carbon monoxide exposures-United States, 2004-2006. *MMWR. Morbidity and Mortality Weekly Report.* 2008;57(33):896-899.