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Carbon Monoxide Poisoning: from the Perspective of Ten Years and 2417 Cases

On Yıl ve 2417 Olgunun Perspektifinden Karbonmonoksit Zehirlenmesi

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Abstract

Objective: Carbon monoxide (CO) poisoning is a common problem in various countries, especially in Winter months. CO exposure results in the formation of carboxyhemoglobin (COHb), which is responsible for toxicity symptoms. In this study, we aim to demonstrate the demographic features and seasonal variations of this particular public health problem.

Materials and Methods: We retrospectively evaluated hospital police reports and medical records of 2417 ED patients diagnosed with CO poisoning between 1999 and 2009. Sources of exposure, seasonal variation and demographic characteristics were analyzed.

Results: The mean age of the patients, of whom 1418 (58.7%) were female, was 29±18 years. While 1708 patients (70.7%) were admitted to adult ED, 709 (29.3%) patients were admitted to pediatric ED. January and subsequent Winter months represented the most dangerous periods for CO exposure. No intentional (suicidal attempt) exposure to CO intoxication was reported and the major cause for intoxication included unsecured stoves and gas heaters.

Conclusion: Emergency physicians should be familiar with symptoms and remedies of CO intoxication, which still constitutes a serious health problem.
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Key words: Carbon monoxide, poisoning, emergency medicine

Özet

Amaç: Karbonmonoksit zehirlenmesi birçok ülkede, özellikle kış aylarında önemli bir sorundur. Zehirlenme, toksisite semptomlarından sorumlu olan karboksihemoglobinin (COHb) oluşmasıyla sonuçlanır. Biz çalışmamızda, bu önemli halk sağlığı sorunuyla ilgili demografik özellikleri ve mevsimsel farklılıkları göstermek istedik.

Gereç ve Yöntemler: Çalışmamızda acil servise 1999-2009 arasında karbonmonoksit zehirlenmesiyle başvuran 2417 hasta, hastane polis kayıtları ve hasta dosyaları incelenerek retrospektif olarak çalışmaya dahil edilmiştir. Maruziyet kaynakları, mevsimsel değişimler ve demografik özellikler değerlendirilmiştir.

Bulgular: Hastaların ortalama yaşları 29±18'di, 1418'i (%58.7) kadındı. 1708 hasta (%70.7) erişkin acil servise, 709 hasta (%29.3) çocuk acil servise başvurmuştu. Ocak ayı ve diğer kış aylarının karbonmonoksit maruziyeti açısından en tehlikeli aylar olduğu görüldü. Kasıtlı maruziyet (özkıyım girişimi) bildirimi yoktu ve zehirlenme için en önemli nedenler uygun güvenliğin sağlanmadığı soba ve diğer gazlı ısıtma sistemleriydi.

Sonuç: Acil tıp hekimleri, hala önemli bir sağlık sorunu olan karbonmonoksit zehirlenmesinin semptomlarına ve tedavi yaklaşımlarına aşina olmalıdır.
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Anahtar kelimeler: Karbonmonoksit, zehirlenme, acil tıp

Introduction

Carbon monoxide (CO) is an odorless, colorless and nonirritating gas, which binds to the hemoglobin molecule, displacing oxygen, and resulting in toxicity (1). CO poisoning from coal and gas heaters is a public health concern in many developing countries, including Turkey (1, 2). In Turkey, inadequate ventilation of domestic stoves and water heaters are the main causes of intoxication, unlike European countries or the USA (1). Other sources of carbon monoxide include faulty furnaces and engine exhaust, some of which are intentional poisonings.

Given the non-specific symptoms of CO poisoning, recognition of the disease becomes more difficult and subclinical exposures increase (3). Symptoms may include headache, dizziness, nausea, vomiting, disorientation and unconsciousness. Moreover, CO poisoning can cause immediate death, non-specific hypoxia-related neurological and cardiac manifestations, rhabdomyolysis and abnormal liver function (4, 5). Due to the hidden and mysterious nature of the

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disease, the clinical signs and symptoms of the exposure may easily be misdiagnosed in emergency departments.

Materials and Methods

We retrospectively evaluated "the" hospital police reports and medical records of 2417 pediatric and adult ED patients diagnosed with CO poisoning. All were admitted to Gazi University Hospital, Emergency Department between November 1999 and November 2009. CO poisoning was determined according to symptoms and CO levels. During this time period, 683.472 patients were admitted to our adult and pediatric EDs. Sources of exposure, seasonal variations and demographic characteristics of patients were analyzed.

Approval for the study was granted by the local research ethics committee. Statistical analysis was performed via SPSS for Windows (version 11.5, SPSS Inc., Chicago, IL). Descriptive statistics were expressed as mean±standard deviation for continuous variables. Categorical variables were shown with the number of cases and percentages and were evaluated using Pearson Chi-square test. Statistical significance was assumed for $p<0.05$.

Results

Data were collected by a retrospective review of a total of 2417 patients. Mean age of our patients was 29.07±18.02 years (min.=0, max.=96). Out of 2417 intoxicated patients, 1418 patients (58.7%) were female and 999 patients (41.3%) were male. According to official police reports and hospital records, no intentional (suicidal attempt) exposure to CO intoxication was reported, and major causes for intoxication were unsecured stoves and gas heaters. In our emergency department, patients over the age of 18 were considered adults, whereas patients under the age of 18 were regarded as children. According to this classification, 1708 patients (70.7%) were admitted to adult ED and 709 patients (29.3%) were admitted to pediatric ED.

Patients were divided into three groups according to their admission hours. The first group consisted of patients who were admitted between 8am and 4pm, the second group included admissions between 4pm and 12pm, and the last group's admissions were between 12pm and 8am. While most of the patients (n=938) presented between 4pm and 12pm (38.8%), 891 patients (36.9%) presented between 12pm and 8am, and 588 patients (24.3%) presented between 8am and 4pm.

There was a gradual increase in the annual numbers of patients presenting during the study period (Table 1). The year 2007 was the most affected year in terms of CO poisoning. Most of the exposures occurred in Winter months (57.1%). It was observed that January (21%) and the subsequent Winter months were the most dangerous periods for CO exposure; only 43 patients (1.8%) were admitted to ED during the summer months (Table 2).

According to ED admission hours, there was a statistically significant difference between male and female gender (p=0.016). Particularly in the 4pm-12pm period, admissions of female intoxicated patients increased compared to male admissions. There was no statistically significant difference between genders, according to seasonal admission ratios (p=0.302) (Table 3).

In terms of ED admission hours, there was no statistically significant difference between adult and pediatric populations (p=0.173).

Table 1. Distribution of CO intoxicated patients by years

Admission Year	n	Percent
1999	20	0.8%
2000	20	0.8%
2001	48	2.0%
2002	79	3.3%
2003	164	6.8%
2004	294	12.2%
2005	299	12.4%
2006	429	17.7%
2007	438	18.1%
2008	394	16.3%
2009	232	9.6%
Total	2417	100.0%

Table 2. Distribution of CO intoxicated patients by admission months and seasons

Variables	n	Percent
Admission Month		
January	510	21.1%
February	460	19.0%
March	309	12.8%
April	162	6.7%
May	93	3.8%
June	26	1.1%
July	7	0.3%
August	10	0.4%
September	19	0.8%
October	122	5.0%
November	290	12.0%
December	409	16.9%
Admission Season		
Winter	1379	57.1%
Spring	564	23.3%
Summer	43	1.8%
Autumn	431	17.8%
Total	2417	100.0%

However, during Spring months, pediatric admissions increased compared to adult patient admissions (p=0.013) (Table 4).

Discussion

Carbon monoxide poisoning still presents a common health problem in the United States and many other countries (1, 6, 7). Even though unintentional CO poisoning is a preventable health concern in many countries, the significance of this serious poisoning incidence is still increasing. The US Consumer Product Safety Commission categorized unintentional consumer product-related and non-fire-related CO deaths in 2007 as being associated with indoor heating

Table 3. Distribution of patients by admission hours, seasons and gender

Variables	Male n (%)	Female n (%)	p value
Admission Hours			**0.016**
8am - 4pm	253 (25.3%)	335 (23.6%)	0.337
4pm - 12pm	354 (35.4%)	584 (41.2%)	0.004
12pm - 8am	392 (39.2%)	499 (35.2%)	0.042
Admission Season			**0.302**
Winter	590 (59.1%)	789 (55.6%)	
Spring	215 (21.5%)	349 (24.6%)	
Summer	18 (1.8%)	25 (1.8%)	
Autumn	176 (17.6%)	255 (18.0%)	

Table 4. Distribution of patients by age groups, admission hours and seasons

Variables	Adult	Children	p value
Admission Hours			**0.173**
8am - 4pm	429 (25.1%)	159 (22.4%)	
4pm - 12pm	668 (39.1%)	270 (38.1%)	
12pm - 8am	611 (35.8%)	280 (39.5%)	
Admission Season			**0.032**
Winter	982 (57.5%)	397 (56.0%)	0.498
Spring	375 (22.0%)	189 (26.7%)	0.013
Summer	35 (2.0%)	8 (1.1%)	0.119
Autumn	316 (18.5%)	115 (16.2%)	0.182

systems (38%), engine-driven tools-related (38%) and other sources (charcoal grills, charcoal, ranges, ovens, water heaters, camp stoves) (25%) (8). In Turkey, the main cause of CO poisoning was unsecured gas heaters and domestic stoves. Akköse et al. (2) demonstrated in their Turkish population-based study that only one of 304 patients had a history of suicide attempt. In the retrospective study of Akbaba et al. (9), out of 491 poisoned patients, there was no reported case of intentional CO poisoning. Likewise, no case of suicidal attempt or engine-driven tools-related poisoning was observed in our study population.

According to Nazari et al. (10), non-fatal CO poisoning was higher in females than males, whereas actual fatalities were higher in males than females. In our study, the majority of the population consisted of female patients. Females tended to present at the hospital between 4pm and 8am, this finding might be due to neglect of symptoms in females during daytime. When the overall admissions are taken into consideration, increase in nighttime admissions (after 4pm) were observed. This might be due to frequent use of heating systems during nighttime.

In the retrospective study of Akköse et al. (2), the majority of CO poisoning cases occurred in the Winter months (64.6%). They associated this finding with the increased use of coal heaters in Winter and strong south-east winds. According to the study of Salameh et al., it was also reported that 79% of CO poisoned patients presented during Winter months (November- February) and 21% during the months of March-October. Similar to the literature, our study confirmed the increased ED visit rates in Winter months. Given the principal etiology of CO poisoning in our country, a marked decrease in ED visits in Summer months was observed. The overall number of ED visits in Summer months was found to be 43 (1.8% of total intoxicated patients). A study conducted on unintentional carbon monoxide poisonings in Iran, which covered a five-year period, also revealed that the highest frequency of both non-fatal poisonings and actual fatalities occurred in January (10). January accounted for the most dangerous month (21.1%) for CO poisoning in our study as well.

Moreover, this particular study demonstrated a gradual increase in the annual number of patients. As awareness of the disease increased, ED admission rates and the number of the treated patients increased as well. It is assumed that in the previous years, some of these patients might not have received proper treatment in our emergency department and therefore might have been misdiagnosed. In some countries, including Turkey, the actual incidence of CO poisoning is difficult to establish and many cases probably remain unrecognized (2, 11). The gradual increase rate might be due to widespread and uncontrolled use of different heating systems. Unchecked gas-fired combi boilers and inappropriate heating stoves facilitated carbon monoxide intoxication.

Furthermore, because CO poisoning has different impacts on different populations, the pediatric population should be carefully evaluated. Symptoms in pediatric patients are often nonspecific, such as nausea and vomiting, and can easily be misdiagnosed as a viral illness (12, 13). In our study, patients under the age of 18 represented 29.3% of the total study population. Adult presentations compassed majority of the patients (more than twofold). Pediatric population, who were intoxicated via carbon monoxide, usually diagnosed after their parents' presentations to the adult emergency department. Therefore, we have not found any statistically significant difference between adult and pediatric patients with regard to their admission hours. The reason might be simultaneous recognition of CO poisoning by family members.

Our study has several limitations. Two main limitations include lack of data about the symptoms of the patients and hyperbaric oxygen therapy. Due to the retrospective design of our study, we could not reach all of the data regarding the poisoned patients. The most important reason for this limitation originated from difficulties in recognition of CO poisoning in previous years at our ED. Therefore, the symptoms might have been underestimated and the poisoning might have been misdiagnosed as either common cold or vertigo. In addition, we do not have enough information about hyperbaric oxygen therapy status due to lack of data regarding the poisoned patients.

Conclusion

In many countries, CO poisoning accounts for one of the leading causes of preventable deaths. In our study population, CO exposure occurred mostly in Winter months and the annual ED visits increased gradually each year due to recognition of the disease by physicians and patients. Lack of awareness of the risks related to CO poisoning can significantly contribute to morbidity and mortality. Consequently, there is an increasing need to develop public education programs to raise awareness of CO poisoning. Educational efforts should aim at

patients, especially those who are in the highest risk group, including young, middle-aged, and elderly people together with others that reside at homes with old heating systems.

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Conflict of Interest

No conflict of interest was declared by the authors.

References

1. Keleş A, Demircan A, Kurtoğlu G. Carbon monoxide poisoning: How many patients do we miss? Eur J Emerg Med. 2008; 15: 154-7. [CrossRef]
2. Akköse Ş, Türkmen N, Bulut M, Akgöz S, İşçimen R, Eren B. An analysis of carbon monoxide poisoning cases in Bursa, Turkey. East Mediterr Health J. 2010; 16: 101-6.
3. Weaver LK. Clinical practice. Carbon monoxide poisoning. N Engl J Med. 2009; 360: 1217-25. [CrossRef]
4. Annane D, Chadda K, Gajdos P, Jars-Guincestre MC, Chevret S, Raphael JC. Hyperbaric oxygen therapy for acute domestic carbon monoxide poisoning: Two randomized controlled trials. Intensive Care Med. 2011; 37: 486-92.
5. Graber JM, Macdonald SC, Kass DE, Smith AE, Anderson HA. Carbon monoxide: The case for environmental public health surveillance. Public Health Rep. 2007; 122: 138-44.
6. Hampson NB, Weaver LK. Carbon monoxide poisoning: A new incidence for an old disease. Undersea Hyperb Med. 2007; 34: 163-8.
7. Salameh S, Amitai Y, Antopolsky M, Rott D, Stalnicowicz R. Carbon monoxide poisoning in Jerusalem: Epidemiology and risk factors. Clin Toxicol (Phila). 2009; 47: 137-41. [CrossRef]
8. Hnatov MV. Non-fire Carbon Monoxide Deaths Associated with the Use of Consumer Products - 2007 Annual Estimates. Bethesda, MD: US Consumer Product Safety Commission. Available at: http://www.cpsc.gov/library/foia/foia11/os/co10.pdf. Accessed May 31, 2011.
9. Akbaba M, Nazlican E, Demirhindi H, Sütoluk Z, Gökel Y. Etiological and demographical characteristics of acute adult poisoning in Adana, Turkey. Hum Exp Toxicol. 2007; 26: 401-6. [CrossRef]
10. Nazari J, Dianat I, Stedmon A. Unintentional carbon monoxide poisoning in Northwest Iran: A 5-year study. J Forensic Leg Med. 2010; 17: 388-91. [CrossRef]
11. Ait El Cadi M, Khabbal Y, Idrissi L. Carbon monoxide poisoning in Morocco during 1999-2007. J Forensic Leg Med. 2009; 16: 385-7. [CrossRef]
12. Baker MD, Henretig FM, Ludwig S. Carboxyhemoglobin levels in children with nonspecific flu-like symptoms. J Pediatr. 1988; 113: 501-4. [CrossRef]
13. Foster M, Goodwin SR, Williams C, Loeffler J. Recurrent acute life-threatening events and lactic acidosis caused by chronic carbon monoxide poisoning in an infant. Pediatrics. 1999; 104: e34. [CrossRef]