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An Evaluation of the Autopsy Cases of Carbon Monoxide Poisoning in Trabzon Between 2009-2016

Trabzon'da 2009-2016 Yılları Arasında Otopsis Yapılan Karbon Monoksit Zehirlenmelerinin Değerlendirilmesi

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Abstract

Objective: Carbon monoxide related deaths, which are generally preventable accidents, and more common when compared with other toxic substance consumption, arouse public attention in our country.

Materials and Methods: In this study, the aim is to investigate different features of carbon monoxide poisoning related deaths autopsied in Trabzon in 8-year period of time and demonstrate medico-legal aspects of this issue.

Results: Our study consists of all deaths due to carbon monoxide poisoning and autopsied by Trabzon Morgue Department of the Council of Forensic Medicine of Turkey between 2009 and 2016. Records of a total of 7133 criminal cases who were autopsied between these years were examined and 215 cases who died due to CO poisoning were evaluated for age, sex, the month of the event occurred, origin, death time, CO source and carboxyhemoglobin (COHb) values. 215 criminal cases were constituting 3.01% of 7133 criminal cases who were autopsied within 8 years in Trabzon. 91 of the cases were (42.3%) female and 124 were (57.7%) male and the male/female case ratio was 1.4. Mean age of the cases was 48.8±27.1 years. 24.1% of deaths occurred in January, 74% at home. CO source was found to be charcoal in 55.3% of cases. Mean COHb level detected in cases was 54.9±17.6%.

Conclusion: Carbon monoxide poisoning is an important social problem in our country as in many developing countries. It is concluded that with their medicolegal experiences and suggestions, forensic medicine specialists can play an important role to manage carbon monoxide poisonings which are mainly preventable accidents and to help to increase social consciousness for carbon monoxide poisoning.

Keywords: Carbon Monoxide; Autopsy; Poisoning; Toxicology.

Özet

Amaç: Ülkemizde karbonmonoksit (CO) zehirlenmesine bağlı ölümlerin çoğunlukla önlenilebilir kazalar şeklinde olması ve diğer toksik madde alınımına bağlı ölümlere nazaran daha sık görülmesi, konunun gündemde kalmasını sağlamaktadır.

Gereç ve Yöntem: Bu çalışmada 8 yıllık süre içerisinde Trabzon'da otopsis yapılan CO zehirlenmesine bağlı meydana gelen ölüm olgularının çeşitli yönlerden incelenmesi ve konunun adli-tıbbi boyutunun ortaya konulması amaçlanmıştır.

Bulgular: Çalışmamız Adli Tıp Kurumu Trabzon Grup Başkanlığı Morg İhtisas Dairesi'nde 2009-2016 yılları arasında otopsis yapılan karbonmonoksit zehirlenmesine bağlı ölümlerin tamamını kapsamaktadır. Bu yıllar arasında otopsileri yapılan toplam 7133 adli olguya ait kayıtlar incelenmiş olup CO zehirlenmesi sonucu ölen 215 olgu yaş, cinsiyet, olayın meydana geldiği ay, orijin, ölüm süresi, CO kaynağı ve karboksihemoglobinin (COHb) değerleri açısından değerlendirilmiştir. 215 adli olgu Trabzon'da 8 yılda otopsis yapılan 7133 adli olgunun %3.01'ini oluşturmaktadır. Olguların 91'i (%42.3) kadın, 124'ü (%57.7) erkek, erkek/kadın oranı 1,4'dür. Yaş ortalaması 48.8±27.1'dir. Ölümlerin %24,1 Ocak ayında, %74'ü evlerde gerçekleşmiştir. Olguların %55.3'ünde CO kaynağı olarak soba kömürü bulunmuştur. Olgularda tespit edilen ortalama COHb düzeyi %54.9±17.6'dır.

Sonuç: CO zehirlenmeleri, birçok ülkede olduğu gibi ülkemizde de sosyal bir sorun oluşturmaktadır. Adli Tıp Uzmanlarının; büyük çoğunluğu önlenilebilir kazalar olan CO zehirlenmelerinin adli-tıbbi boyutunun ortaya konulmasında ve kamuoyunun bu konu ile ilgili olarak bilinçlendirilmesinde önemli katkıları olacağı kanaatindeyiz.

Anahtar Kelimeler: Karbonmonoksit; Otopsi; Zehirlenme; Toksikoloji.

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1. Introduction

Carbon monoxide (CO) is a product of the incomplete combustion of carbon compounds such as organic ma-

terials and hydrocarbons. It is colorless, tasteless, odorless, non-irritant and not easily detected by an exposed person (1). CO is toxic because its binding affinity for hemoglobin is 200-250 times higher than oxygen. Exposure to CO can be extremely detrimental to human health, and exposure to higher concentrations can result in death. The most common cause of CO poisoning in humans is breathing industrial smoke, smoke from fires, or automobile exhaust fumes, which is commonly the result of burning coal or wood in enclosed and improperly ventilated spaces or using insufficiently vented gas water heaters. Carbon monoxide poisoning can be either intentional or accidental (2-4). Carbon monoxide intoxication is the most common type of poisoning in our country and worldwide. It is shown to be one of the most important causes of death in countries such as the United States, Great Britain, France, Morocco, South Korea, and Israel (5-7).

The aim of the present study was to retrospectively investigate the epidemiology and forensic aspects related to CO poisoning, in cases with postmortem COHb analysis, from autopsies performed at the Morgue Department of Trabzon Branch of the Council of Forensic Medicine, between the years 2009 and 2016.

2. Materials and Methods

For this study, the autopsy records of the Morgue Department of the Trabzon Branch of the Council of Forensic Medicine in the period between January 2009 and December 2016 were reviewed. A total of 7133 autopsies had been performed and 215 (3.01%) of these involved CO poisoning. The cases were evaluated according to the following criteria: age, gender, year, month, season of death, occupation, source of CO, origin, location of exposure to CO, autopsy findings (lividity, lesions, coloration of blood and internal organs) and toxicological analysis results. The Statistical Package for Social Sciences (SPSS) version 13 was used in data analysis.

Table 1. Number of cases per year

Year	n	%
2009	23	10.7
2010	23	10.7
2011	37	17.2
2012	42	19.5
2013	24	11.2
2014	30	14.0
2015	23	10.7
2016	13	6.0

3. Results

From January 2009 to December 2016, a total of 7133 autopsies were performed; 215 (3.01%) of them were related to CO poisoning. The number of cases per year is presented in Table 1.

The mean age was 48.8 ± 27.1 years and the youngest and the oldest cases were 1 and 98 years of age, respectively. Males were involved in 57.7% (n=124) of the cases and the mean age of male cases was 47.7 ± 26.6 years, and females were involved in 42.3% (n=91) of them and the mean age of female cases was 50.2 ± 27.9 years. The male to female ratio was 1.4. The highest frequency of CO deaths was found in the >70 years age group (n = 59, 27.44%) (Fig. 1).

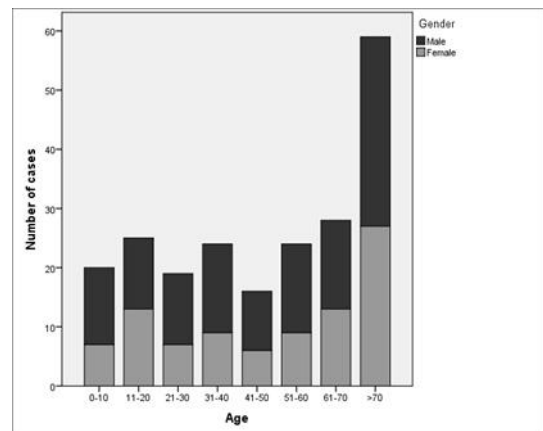


Figure 1. Age and gender distribution of CO poisoning.

The number of CO deaths was highest in 2012 with 42 cases (19.53%), followed by 2011 with 37 cases (17.21%). The lowest number of deaths occurred in 2016 with 13 cases (6.05%) (Fig.2).

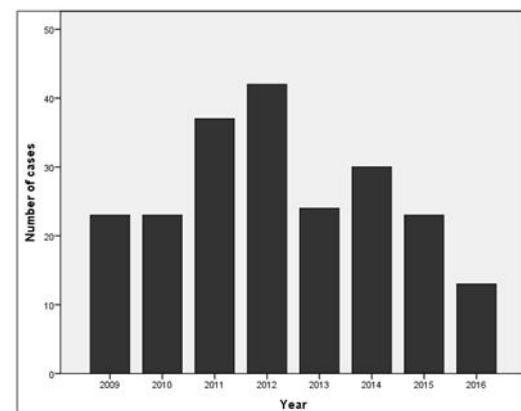


Figure 2. CO poisoning deaths according to the years.

The highest number of CO poisoning related deaths occurred in January (52 cases, 24.18%) and the lowest in July, August and October (Fig. 3)

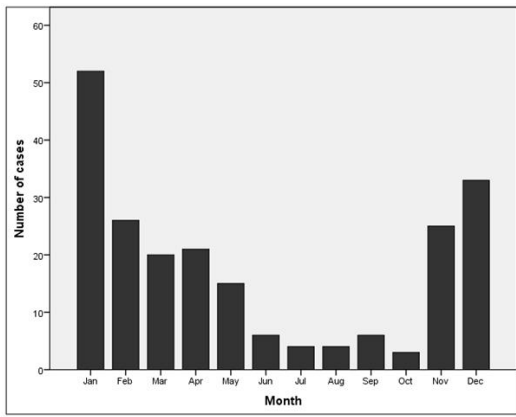


Figure 3. CO poisoning related deaths according to months.

The sources of CO were as follows: coal stoves (n = 119; 55.3%); fires (n=44; 20.5%); water heaters in baths (n=31; 14.4%), auto exhaust fumes (n=3 ,1.4%). In 18 cases (8.4%) there was no source of CO at the death scene. The origins of CO poisoning were as follows: unintentional (n = 213; 99.0%), homicide (n =1; 0.5%) and suicide (n=1, 0.5%). Most of the cases of CO poisoning occurred in the night (n=127, 59.1%). In addition, most of the cases of CO poisoning occurred at home and in the bathroom (Table 2). Furthermore; the cases of CO poisoning occurred in urban areas (n=117, 54.4%) rather than rural area (n=98, 45.6%).

Table 2. The locations where CO poisoning events occurred

Place	n	%
Home	159	74.0
Bathroom	30	14.0
In vehicle	6	2.8
Hotel room	4	1.9
Hut	4	1.9
Workplace	3	1.4
Tandoor well	2	0.9
Water well	1	0.5
Basement	1	0.5
Tunnel construction	1	0.5
Public bath	1	0.5
Hayloft	1	0.5
Mountain house	1	0.5
Total	215	100.0

According to toxicological analysis results, the mean COHb % in individuals with a COHb level who died due to CO poisoning was 54.9±17.6 %, and the lowest and

highest levels of COHb were 5% and 86%, respectively. The levels of carboxyhemoglobin in the blood are shown in Figure 4.

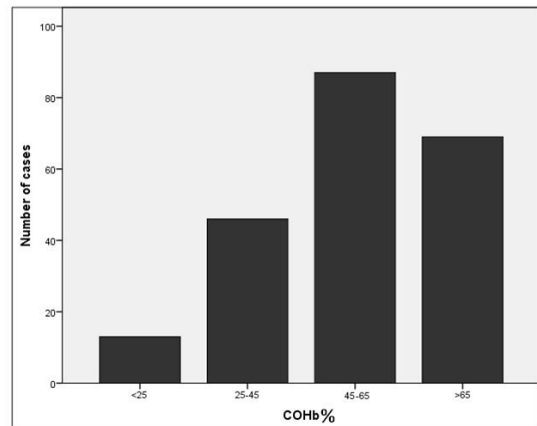


Figure 4. The level of COHb in blood.

We were able to detect alcohol in 10 cases (4.7%), and the lowest and highest blood alcohol level were 53 mg/dl and 577 mg/dl, respectively. Illegal drugs were found in 4 cases (1.8%). Marijuana was detected in 2 cases (0.9%), marijuana together with benzodiazepine in one case, and morphine in one case. Prescription drugs were found in 8 cases (3.7%). These prescription drugs were antidepressants and benzodiazepines. Antidepressants were found in 5 cases (2.32%), and antidepressants together with benzodiazepine in 3 cases (1.4%). In 192 cases (89.3%) alcohol and drugs couldn't be detected.

In 167 (77,7%) of the cases light red/pinkish death marks, in 45 of them macroscopically distinguishable dermal burns, in 31 (14,4%) soot-smoke smears on the surface of the skin, in 21 (9,7%) foam in/around the mouth and nostrils, in 5 (2,3%) superficial blunt trauma and in another 1 blunt trauma causing broken bones were determined in the external examinations. Decay signs were determined in the external examination of 2 (0.9%) cases.

In the internal examination intense hyperemia in internal organs and edema in parenchymal tissues was detected in 173 (80,5%) of the cases. In 39 cases (18,1%) the weight of each lung was more than 750 grams. In 36 (16,7%) cases there were soot and smoke smears in the upper and lower respiratory tracts, in 33 (15,3%) cases intense punctual bleeding in the mucosa and serosa and in 38 (17,7%) cases there were 4th degree burns causing carbonization in the internal organs.

4. Discussion

During the period between 2009 and 2016, the ratio of deaths due to CO poisoning in autopsied deaths in Trabzon was detected as 3.01% (n=215). The percent-

age of CO poisoning cases compared to the total number of autopsies performed was 3.8% in Bursa (8), 2.7% in İstanbul (9), 3.85% in Ankara (10), 1.28% in Aydın (11) and 1.99% in Adana (12). The deaths as a result of CO poisoning differ from region to region in Turkey. The climate characteristics and economical and social structures of the region affect the frequency of carbon monoxide poisoning cases. In the cities mentioned above, the winter months are hotter in Adana and Aydın. In the other cities, the winter months are colder in Bursa, İstanbul and Ankara. The coldest winter months are seen in Trabzon. Consequently, cold weather increases the usage of coal stoves and water heaters that are CO sources that increase the death rates. According to the other studies in different countries, Ait el Cadi et al. reported the rate of CO poisoning in autopsied deaths as 3.15% in Morocco (5), Nazari et al. found this ratio as 11.6% in Iran between the years 2003 and 2008 (13), and Liu et al. reported this ratio as 16.5% in China between the years 1999 and 2008 (14).

The mean age of the cases in this study was 48.8 ± 27.1 while it was 36.6 ± 21.9 years in İstanbul (15), 40.3 ± 21.8 years in Ankara (10), 60.3 ± 23.4 years in Aydın (11), 46.8 years in Bursa (8), 34 years in Morocco (5) and 42 ± 26 years in Portugal (16). In this study, the youngest and oldest cases were 0 and 98 years of age. The age of the cases ranged between 8 months and 98 years in İstanbul (15), 0-97 years in Adana (12) and 15-82 years in Edirne (17).

Most of the cases were observed in winter (72.55%) and in January (24.18%) and the lowest number was observed in summer (6.51%). Similar studies report that cases of death due to CO poisoning were most frequently encountered during winter (5,8,13,15-19).

In this study, all CO poisoning deaths were unintentional in manner. There were one homicide case and one suicide case. It was determined that a murder and a suicide determined in our study occurred during the same case from the legal documents which were drafted. The documents put forward that after injuring her mother with a shotgun, a female case burnt the house they were in and that both of them died in this fire. Since murder and suicide are rarely found together in cases related to carbon monoxide poisoning, these two cases were found to be extraordinary. In the other study; the frequency of accidental cases of CO poisoning in Morocco, Ankara, İzmir and Cleveland, Ohio in the United States were 93.5%, 98.3%, 91% and 69.0%, respectively (5,10,18,20). Furthermore; there has been a recent increase in suicide related CO poisoning. For example, there has been an increase in Taiwan in the annual number of deaths due to CO poisoning over the past 10 years, which may be associated with the increase in the number of suicides committed by

inhaling the fumes of burning charcoal (21,22). The burning of charcoal in enclosed spaces has been described as a particular method of suicide used by the Chinese, and it has rapidly increased as a method used in South Korea (23,24).

The CO poisonings were attributed to coal stoves for heating purposes (55.3%), water heaters used in shower systems (14.4%), house or building fires (20.5%), and exhaust gases of automobiles (1.4%). In a study conducted by Türkmen et al, the frequency of the causes of CO poisoning cases in Bursa were 48.5% for coal stoves and 28.3% for gas water heaters (19). The most common causes of CO poisoning in Ankara were coal stoves, gas water heaters, and fires. Furthermore; using a barbecue for cooking in an enclosed space caused 3.4% of CO poisoning cases, 2.3% were caused by exhaust gases, and one was caused by an explosion in a mine (10). CO poisoning accounted for 2.5% of the cases of fire-related deaths in İstanbul. Among the 33 cases included in the present study, the source of CO was fire for 23 (69.7%) and stoves for nine (27.3%) cases. One (3%) of the cases was an individual who committed suicide by inhaling bottled gas through a hose that he had inserted into his mouth (15). CO poisoning in the Aydın province occurred more frequently in association with fires. The absence of CO poisoning cases due to gas water heaters in Aydın can be attributed to the prevalent use of solar energy water heaters throughout much of the year (11).

In this study, the most common setting of CO poisoning was at home (74.0%). In other provinces in Turkey, for example, in Ankara, 90.8% of cases died in their homes (10). CO poisoning caused 15.4% of the deaths in bathrooms in Diyarbakır (25). In Bursa and Diyarbakır, 79.8% and 15.4% of CO poisoning cases occurred at homes and in bathrooms, respectively (19,25)

In the present study, the lowest and highest levels of carboxyhemoglobin content in the blood were 5% and 85%, respectively. The case whose carboxyhemoglobin was 5%, the woman case who was 63 years old and thought to be poisoned by the gas water heater while washing at home, was found unconscious in the bathroom and taken to the hospital in the same day. Because of the hyperbaric oxygen and intensive liquid replacement applied to her during her 1 day treatment in the coronary intensive care unit, the COHb measurement couldn't be made in the blood taken just before the first intervention. Therefore; the ratio of COHb at the moment of poisoning cannot be detected. The level of COHb was measured as 5% in postmortem blood. It is thought that this figure is related to the treatment which was applied. The prevalent ranges of carboxyhemoglobin levels observed in İstan-

bul, Ankara, Aydın and Bursa were 11-50%, 22.2-80.2%, 1.9-79.7% and 31-50% respectively (9,10,11,19).

In our study, routine toxicological analysis was carried out in all cases and alcohol was detected in 4.7% of the cases. Illicit drugs were detected in 4 cases (marijuana in 3 cases, morphine in one case), and prescription drugs were found in 8 cases (antidepressants in 5 cases, antidepressants together with benzodiazepine in 3 cases). In a study conducted by Cantürk et al., alcohol was detected in the blood of 26.9 % of the cases. The highest level of alcohol in the blood was 318 mg/dl (10). In a study conducted by Ruas et al. blood alcohol, prescription and illicit drug analyses were negative in all the CO intoxication cases (16). In fact, the substances have been related to an increased risk of CO related accidents, and to the ingestion of large quantities of drugs before CO-related suicide attempts (20,26), even though a study reported that the presence of drugs did not change the cause of death (20).

Light red/pinkish death marks which are one of the distinguishing external examination findings in CO poisoning were detected in three-quarters of the cases. The level of COHb was measured to be under 45% in 58 of the cases. The reason why characteristic death marks were not found elderly cases is believed to be that the COHb levels were low. In addition, the existence of some cardiac or hematological diseases about which data couldn't be collected within the scope of the study may have prevented the formation of lightly colored death marks. It was found that the formation of dermal burns in cases that died by being poisoned in a fire is compatible with the literature (15,16,26-28). Foam can be observed around the mouth and nose in CO poisoning. This was detected in 21 of the cases. Wooden roofs or heavy and stiff objects in the area where the fire takes place may fall on people either when they are alive or dead. Just as they may cause secondary trauma before death they may also cause the formation of postmortem artefacts. Within this scope superficial blunt trauma not causing breaks in bones was detected in 5 cases. In 1 case it was detected that the bone was broken in the postmortem period.

In 80.5% (n: 173) of the cases the common and intense hyperemia and edema found in the internal organs, serosas and mucosal tissues were compatible with CO poisoning findings. In addition, the intense punctual bleeding observed in 15.3% (n: 33) of the cases as a result of asphyxia just like hyperemia and edema. The edema resulting from the effect of CO poisoning causes dramatic changes especially in the parenchyma of the lungs. Another reason of weight increase of the lungs is intra-alveolar bleeding. In 18.1% (n: 39) of our cases both of the lungs weigh more than 750 grams. This weight in-

crease was found to be compatible with lung edema. Carbon monoxide is a poisonous gas which appears in the smoke forming as a result of the incomplete combustion of fuels containing carbon. This smoke accumulates in the lower and upper respiratory tracts of people whose respiration continue. In 16.7% (n: 36) of the cases there were macroscopically observable soot and smoke smears in the larynx, trachea and bronchus. When this finding is distinguishable especially in the lower respiratory tract it shows that the person was alive for some time in the smoke. It also incorporates hypoxic hypoxia into the causes of death in addition to the effects of CO. The internal organ burns detected in 17.7% (n: 38) of the cases are of 4th degree. The heat reaches the internal organs via the disintegrated burnt skin and causes carbonization. This can continue during the postmortem period. In compliance with external examination putrefaction and autolytic changes were detected in the internal organs of 0.9% (n: 2) of the cases. These findings indicate a natural process which occurs as a result of the prolongation of the post-mortem interval in corpses. The death times of these 2 cases are not certain and it is thought that about 48 hours passed since their deaths.

5. Conclusion

CO poisoning has been accepted to be one of the leading significant health problems. Accidental CO poisoning is a preventable condition. The community should be educated by governmental organizations, non-governmental organizations, schools, and private initiatives related to the dangers of heating living places with charcoal, gaseous and liquid fuels without the appropriate ventilation. Residential CO sensors should be made use of for the early detection of abnormal CO levels.

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