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Short paper / Article court

Carbon monoxide-related death in Southern Spain: a 7-year study

Étude sur 7 ans des décès dus au monoxyde de carbone en Espagne du sud

Mª Luisa Soria*, Rosario García-Repetto, Mª Paz Giménez, Carmen Jurado

National Institute of Toxicology and Forensic Sciences, Department of Seville Avda. Dr. Fedriani s/n 41015 Seville, Spain

Abstract – Introduction: Carbon monoxide (CO) is a colourless, odourless, tasteless toxic gas produced by incomplete combustion in fuel-burning devices such as motor vehicles, gas-powered furnaces, and portable generators. Exposure of humans to high concentrations of carbon monoxide can result in death, due to the formation of carboxyhemoglobine (COHb), which impairs the oxygen carrying capacity of the hemoglobin. The objective of this study was to determine the number of carbon monoxide-related deaths in forensic cases received in the Department of Seville of the Spanish National Institute of Toxicology from 2000 to 2006 (n = 515 cases). **Methods**: Carboxyhemoglobine levels were determined in blood using the normal procedure in our laboratory, consisting in a fourth derivative spectrophotometric method, using sodium dithionite as releasing agent. COHb levels were then measured after the saturation of blood with carbon monoxide. **Results**: In 415 of these cases (81%) carboxyhemoglobine was detected. In a 33% of the cases COHb was above 50% and in a 48% of the cases was below 50%. During the period studied males represented the big majority 72% of deceased people, presenting a 35% of the cases levels of COHb above a 50%. In a 26% of the cases the deceased was female with a 34% of the cases, which resulted in a COHb level above 50%, and in a 2% of the cases sex was not known. **Conclusions:** Our results indicate that improved population-based prevention measures, including educating the public about the dangers of CO exposure, are needed in order to avoid domestic accidental deaths.

Key words: Carbon monoxide, death, Spain

Résumé – Introduction : Le monoxyde de carbone est un gaz toxique incolore, inodore et sans goût issu de la combustion incomplète dans des dispositifs tels que moteurs de véhicules, chaudières à gaz et groupes électrogènes. L'exposition à de hautes concentrations de monoxyde de carbone peut se traduire, pour l'être humain, par un décès dû à la formation de carboxyhémoglobine (COHb) qui altère la capacité de l'hémoglobine à transporter l'oxygène. Cette étude a eu pour objectif de déterminer le nombre de décès dus au monoxyde de carbone parmi les cas recensés par la division de Séville de l'Institut National de la Toxicologie espagnol entre 2000 et 2006 (total de 515 cas). **Méthodes** : Les taux de HbCO dans le sang ont été déterminés via la procédure standard du laboratoire, à savoir une méthode spectrophotométrique de quatrième ordre, utilisant l'hydrosulfite de sodium comme agent révélateur. Les teneurs en COHb ont ainsi été mesurées après saturation du sang en monoxyde de carbone. **Résultats** : La carboxyhémoglobine a été détectée dans 415 cas (81 % du total). Dans 33 % des cas le taux de carboxyhémoglobine était supérieur à 50 % ; dans 48 % des cas il était inférieur à 50 %. Sur la période étudiée les hommes ont constitué la majorité des victimes (72 %) ; 35 % présentaient un taux de carboxyhémoglobine de plus de 50 %. Dans 26 % des cas les victimes étaient des femmes, avec pour 34 % un taux de carboxyhémoglobine de plus de 50 %. Pour 2 % des cas le sexe est indéterminé. **Conclusions** : Ces résultats montrent que de meilleures mesures de prévention auprès de la population, et notamment une éducation du public aux dangers de l'exposition au monoxyde de carbone, sont à mettre en œuvre pour éviter les accidents domestiques mortels.

Mots clés : Monoxyde de carbone, décès, Espagne

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1 Introduction

Carbon monoxide (CO) is a colourless, odourless, tasteless toxic gas produced by incomplete combustion in fuel-burning devices. The largest risk of exposure comes from the household environment.. Such exposures come from the inhalation of combustible fumes such as those produced by small gasoline engines, stoves, generators, lanterns, and gas ranges or by burning charcoal and wood. Carbon monoxide is usually in-

* Correspondence: Mª Luisa Soria, luisa.soria@mju.es

haled from an enclosed or confined space such as a garage, kitchen, basement, or workroom. The fire-related injuries and deaths result from a mixture of small particles of asphyxiant and irritant gases from the chemical breakdown of its burned sources such as furniture or other household items. Acute exposure from carbon monoxide poisoning can come from any fossil fuel. Chronic carbon monoxide exposure can come from tobacco smoke, automotive exhaust (truck drivers stuck in traffic), and occupational or industrial sources (steel foundries, paper mills, methylene chloride) [1, 2].

The binding of carbon monoxide to hemoglobine, producing carboxyhemoglobine, decreases the oxygen carrying capacity of blood and interferes with oxygen release at the tissue level; these two main mechanisms of action underlie the potentially toxic effects of carbon monoxide exposure. Carboxyhemoglobine levels below 10% are usually not associated with symptoms. At the higher carboxyhemoglobine saturation of 10–30%, neurological symptoms of carbon monoxide poisoning can occur. Dyspnea, increases in pulse and respiratory rates, and syncope are observed with continuous exposure, producing carboxyhemoglobine levels in excess of 30–50%. When carboxyhemoglobine levels are higher than 50%, coma, convulsions and cardiorespiratory arrest may occur and death may be related to carbon monoxide poisoning [3–5].

In Spain, as in most countries of the world, the real number of acute carbon monoxide poisoning is probably underestimated. It has been estimated that one-third of all cases of CO poisoning are undiagnosed. The true figures of CO poisoning are not known, since many non-lethal exposures go undetected. Despite environmental improvements introduced in the last few years, CO poisoning is frequent in our environment. From 2000 to 2006, in 515 cases of all the cases received in the Department of Seville of Spanish National Institute of Toxicology carbon monoxide poisoning was suspected.

2 Material and methods

On their arrival to the laboratory, all specimens were stored at 4°C until their determination. Our laboratory uses a spectrophotometric method for the determination of carboxyhemoglobine (COHb). All measurements were performed with a HP 8452A (Agillent Technlogies, Palo Alto CA) diode array spectrophotometer.

In this procedure hemoglobine is converted to its reduced form and the magnitude of the zero-order spectral shift of the reduced hemoglobine peak at 430 nm to the carboxyhemoglobine peak at 418 nm is determined by fourth-derivative spectrum analysis after CO saturation. Reducing reagent is prepared immediately before use (it is only stable for a few hours), as follows: 0.10 g of sodium dithionite (both from B.D.H. Chemicals Ltd., Poole, BH12 4NN, U.K.) are diluted to 40 mL of pH 8 Tris buffer [6]. Then add 20 µL of postmortem whole blood collecting, mix and allow standing for few minutes. Measure the forth-derivative spectrum between 390 and 450 nm is carried out in a diode array spectrophotometer [7].

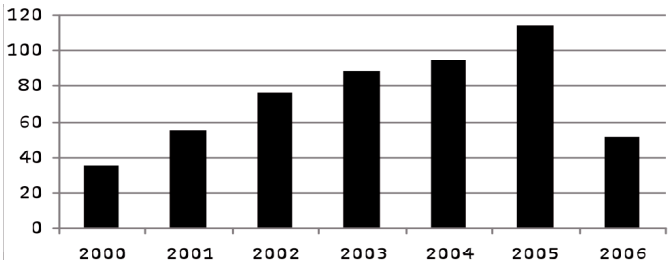

Fig. 1. Number of cases studied from 2000–2006.

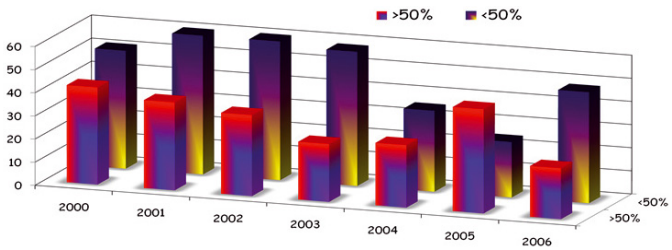

Fig. 2. Carboxihemoglobin levels distribution in analysed cases, assuming that a level higher than a 50% can be considered lethal to human beings.

3 Results

In the period studied, seven years, 515 cases were analysed in the Seville Department of the Spanish National Institute of Toxicology, and we detected carboxyhemoglobine in 415 of these cases (81%). Case distribution is shown in Figure 1. In a third part of the cases (33%) levels were above 50% of COHb and in a 48% the cases , were below this percentage. Finally, in 19% of the studied cases, carbon monoxide was not detected.

Males were involved in the majority of the cases (77%), finding high levels of carboxyhemoglobine in 35% of these cases. Similar proportion (34%) of carbon monoxide- related deaths were found in the females analysed.

During the period studied and with the exception of 2005, our laboratory analysed a higher proportion of cases in which carboxyhemoglobine levels were lower than 50%, than the number of cases in which these levels were higher than 50%. A saturation of hemoglobine with carbon monoxide of the 50% normally considered as the minimal to produce the death [3–5]. All these results are reflected in Figure 2.

4 Discussion and conclusions

The measurement of the concentration of present CO in the blood was realized, as it has been stated before, determining the percentage of saturation of the hemoglobine as carboxyhemoglobine. The spectrum of a compound or mixture of compounds may be mathematically differentiated to produce derivative spectra. Odd-numbered derivatives are of most use in determining the exact points of absorbance maximal of the original or zero-order spectrum and hence the

qualitative properties of the substance under investigation; even-numbered derivatives are helpful in quantitative determinations. The application of derivative spectroscopy to the measurement of carboxyhemoglobine is particularly useful. With fourth derivative, a result may be obtained within 15 min of receiving the sample and it is sufficiently sensitive to differentiate carboxyhemoglobine concentration in the blood of smokers and non-smokers [7, 8].

Along the studied period an increase is observed in the number of cases in which the carbon monoxide is involved (from a 6'5% of the cases in 2000 to 22% in 2005). However, we have observed a decrease to a 10% in 2006. Therefore, tendency in successive years cannot be predictable.

In 170 cases, death could be attributed to carbon monoxide poisoning due to the fact that carboxyhemoglobine levels were higher than 50%, being this hemoglobine saturation grade considered, by the majority of the authors, as the minimum capable of producing the death [3–5]. However, in 247 cases carbon monoxide presence could not justify the cause of the death. From the results exposed above we can conclude that in regard to the manner of death, throughout seven-year period studied, accidental death produced principally in fires was more frequent (37–44%), than suicides (20–31%).

It is also important to highlight that in those cases in which the victim was found completely carbonized, hemoglobine saturation percentages were, in a third of the cases studied, lower than those assumed to be minimum to produce the death. Furthermore, in some of these cases hemoglobine saturation percentages only corresponded to those found in light poisonings (lower than 30%) [3].

Although we have not sufficient information, both the children and the old men are the groups most capable of accidental poisonings; likewise, the winter period is the one that presents higher figures in this type of poisonings [9].

Finally, it seems to us very important to underline that to our knowledge and with the exception of the paper published by Dueñas *et al.* in 2001 [10], this is the first time that a retrospective study is published on the role played by CO poisoning in deaths occurred in Spain. Furthermore, there are also a few papers published in international journals in forensic toxicology on this matter.

References

1. Occupations Safety & Health Administration, US Department of Labor. Occupational safety and health guideline for carbon monoxide. Available at: http://osha.gov/SLTC/healthguidelines/carbonmonoxide/recognition.html. Consulted on March 14th 2007.
2. Kao L, Nanagas K. Carbon monoxide poisoning. Emerg Med Clin North Am. 2004; 22: 985-1018.
3. Sedda AF, Rossi G. Death scene evaluation in a case of fatal accidental carbon monoxide toxicity. Forensic Sci Int. 2006; 164: 164-167.
4. Gisbert JA. Monóxido de carbono. In: Villanueva E. Medicina Legal y Toxicología. Barcelona: Masson, 2005: 829-832.
5. Kunsman G, Levine B. Carbon monxide/Cyanide. In: Levine B. Principles of Forensic Toxicology. AACC Press, 2003: 327-340.
6. Park J, Worth HCJ. Carboxyhemoglobine Determination by second-derivative spectroscopy. Clin Chem. 1985; 31: 279-281.
7. Fukui Y, Matsubara M, Takahashi S, Matsubara K. A study of derivative spectrophotometry for the determination of carboxyhemoglobine in Blood. J Anal Toxicol. 1984; 8: 277-281.
8. Fukui Y, Matsubara M, Akane A. Determination of Carboxihemoglobine in heated samples. Sources of error and utility of derivative spectrophotometry. J Anal Toxicol. 1985; 5: 81-84.
9. Homer C, Engelhart D, Lavins E, Jenkings A. Carbon monoxide-related deaths in a metropolitan county in the USA: an 11-year study. Forensic Sci Int. 2005; 149(2-3): 159-165.
10. Dueñas-Laita A, Ruiz-Mambrilla M, Granda F, Cerd R, Martín-Escudero JC, Pérez-Castrillón JL, Díaz G. Epidemiology of Acute Carbon Monoxide Poisoning in a Spanish Region. Clin Toxicol. 2001; 39(1): 53-57.