Forensic Sci Med Pathol (2014) 10:97–102
DOI 10.1007/s12024-013-9495-6

CASE REPORT

Murder-suicide by carbon dioxide (CO_2) poisoning: a family case from Berlin, Germany

Julia Sautter · René Gapert · Michael Tsokos · Lars Oesterhelweg

Accepted: 11 September 2013 / Published online: 11 October 2013

Abstract This report demonstrates how carbon dioxide (CO_2) may be a potent weapon in murder-suicide, where the death scene offers virtually no clues as to the lethal modality and the autopsy findings are nonspecific. Four bodies were discovered in an apartment in midsummer 2012 in Berlin, Germany. The bodies were those of a father (a 69-year-old business consultant), his wife (aged 26-years), and two sons (aged 3 and 6 years, respectively). The police found the wife and two sons lying in their beds and the husband in a supine position on the floor with a plastic bag over his head tied loosely around his neck with a rope. A 500 g single-use CO_2 cylinder was standing on the floor. The container was almost empty and according to the label had been sold as a CO_2-fertilizer for aquarium plants. Two synthetic inhalation face masks and tubing were also found, which tested positive for the DNA of all four deceased family members. It is hypothesized that the husband placed an inhalation mask over the mouths and noses of his wife and children while they were sleeping. Inhalation of pure CO_2 ensured their rapid unconsciousness due to hypercapnia and severe anoxia. The rapid increase in CO_2 concentration would render a victim helpless, with no time to wake and defend themselves, or others. The proximate cause of death in all cases was attributed to CO_2 intoxication, based on the scene findings, the reconstructed sequence of events, the autopsy, and results of toxicological studies.

Keywords Forensic autopsy · Toxicology · Suicide · Homicide · Scene of crime investigation · Gas intoxication · Carbon dioxide · Pathology

J. Sautter · R. Gapert · M. Tsokos · L. Oesterhelweg
Institute of Legal Medicine and Forensic Sciences, Charité-University Medicine Berlin, Berlin, Germany

R. Gapert (✉)
Human Anatomy, UCD School of Medicine & Medical Science, Health Sciences Centre, University College Dublin, Belfield, Dublin 4, Ireland
e-mail: rene.gapert@ucd.ie

Introduction

Carbon dioxide (CO_2) is a colorless and odorless gas which has gained increased media and academic attention due to recent climate change and global warming issues. Despite its negative impact on the atmosphere, CO_2 has many useful and vital properties; e.g., CO_2 is used in fire extinguishers and plant fertilizers, as well as for saturation in foodstuffs. Pure CO_2 supports the photosynthesis in aquarium plants, creating a natural environment for fish.

High CO_2 concentrations lead to symptoms of intoxication because of the immediate toxic effect of the gas and the reduction in oxygen (O_2) levels [1, 2]. Among the first signs of CO_2 intoxication are tachypnea, tachyarrhythmia, restlessness, and anxiety. These are followed by neurological, with increasingly drowsiness, known as "CO_2 narcosis" [2–4].

It is almost impossible to detect the gas because of its colorless and odorless properties. Carbon dioxide accumulates in high concentrations at floor level in closed rooms as it is denser than oxygen (O_2) and nitrogen (N_2) [5].

Fatal CO_2 intoxication is rare at autopsy, and when seen are mostly due to accidents or suicides. However, these occurrences may be more common than previously thought, particularly when combined with other types of intoxication [6]. Carbon dioxide poisoning in homicides are extremely rare. The following case demonstrates the

use of CO_2 as the lethal tool in the murder-suicide of a family.

Case history

Four bodies of a family of five were discovered in their apartment during one of the hottest weeks of midsummer 2012 in Berlin, Germany. The bodies were those of a father (a 69-year-old business consultant), his wife (aged 26-years), and their two sons (aged 3 and 6 years respectively). The daughter, who was almost 1-year of age was not present. Two typed letters, both signed by the husband, were discovered inside the apartment. In the letters he stated that the reasons for the murder-suicide were business/financial problems, and he also explained what happened in the 36 h prior to the discovery of the bodies. He killed his wife first and then their two sons. He believed that his 1-year-old daughter had not yet developed a close familial bond and had decided to place her in a "Babyklappe" (baby hatch: permitting the anonymous deposition of an infant in a safe environment in cases were a parent cannot cope) of a hospital in Berlin. Finally, he committed suicide by CO_2 poisoning. Investigations discovered that a female infant had been deposited in a baby hatch in one of the Berlin hospitals a day before the bodies were found. A clinical forensic examination showed that the infant girl was healthy and without any injuries.

Crime scene

There was no evidence of a violent struggle at the crime scene. The wife and two sons were lying in their beds, covered with a duvet, with a single rose inside a vase close to the head of each individual (Fig. 1). External examination of the bodies at the scene did not reveal any obvious injuries or defensive marks. The bodies of both children showed early putrefaction, while the mother's body showed more pronounced putrefactive changes, particularly to the upper part of the body; however, rigor mortis was still relatively pronounced in the lower part of her body. The husband was discovered in a supine position on the floor, situated beside a provisional sleeping arrangement; his head was covered with a plastic bag, which was tied loosely around the neck with a rope (Fig. 2).

His head appeared cyanotic and the conjunctivae of the eyes showed evidence of occasional petechiae. The rest of the body did not reveal any signs of a violent struggle nor did it show signs of putrefaction. Postmortem lividity (livor mortis) was strongly developed and disappeared briefly when pressed. A 500 g single-use CO_2 cylinder was standing on the floor (Fig. 3). A "Sofortsektion" (immediate autopsy) of all four bodies was ordered by the state prosecutor.

Autopsy report

Atherosclerosis of the coronary arteries and a recent infarct of the left ventricular anterolateral papillary muscle were the only remarkable findings during the autopsy of the husband.

The autopsies of the mother and two sons showed remarkably advanced putrefaction in a short space of time. No further morphological changes were observed during the autopsies or following postmortem computed tomography (PMCT). Femoral vein blood samples were submitted for chemical–toxicological analyses and showed minimal levels of alcohol in the samples from the husband (0.3 ‰). Toxicological analyses of the mother and sons did not show the presence of any toxic substances.

Further investigations

Further investigations conducted by the "Landeskriminalamt" (LKA, State Office of Criminal Investigations) revealed the presence of a second 500 g single-use CO_2 cylinder in the bathroom. This bottle and the one found near the body of the husband were almost empty.

According to the labels, the containers were sold as CO_2-fertilizer for aquarium plants. However, the apartment did not contain an aquarium. On further inspection two synthetic inhalation face masks and tubing were found on top of a chest of drawers (Fig. 4). Analysis for DNA revealed a mixture of all four decedents on the masks. There was only a minor amount of the husband's profile discovered, with a single source trace of the youngest son's profile.

Cause of death

The cause of death in all four cases was CO_2 toxicity, after taking into consideration the scene findings, the reconstructed sequence of events, the autopsy, and outcome of toxicology.

Discussion

Many CO_2 accidents involve fermentation tanks, brewery and wine cellars, waste water tanks, sewage tanks, and other types of storage tanks, due to the release of CO_2 during the fermentation process and the resulting

Fig. 1 *Top* bodies of the two sons at the death scene. Note the putrefactive changes and the roses placed inside a small vase near the head of each child. *Bottom* body of the mother at the death scene. Note the advanced putrefactive changes and the rose placed inside a small vase near her head

Fig. 2 Body of the father at the death scene. The plastic bag and loose rope are clearly visible. Note the lack of putrefactive changes when compared to the bodies of the mother and two sons. The empty CO_2 container can be seen slightly obscured by the bed in the upper left corner of the image

Fig. 3 One of the two CO_2 containers discovered inside the apartment. This container was empty and discovered near the body of the father (see Fig. 2). The second empty bottle was discovered in the bathroom. Note the label which describes the contents and use (i.e., 500 g, CO_2 aquarium plant fertilizer)

accumulation of high concentrations of CO_2 at the bottom of these contained spaces [5–8].

Furthermore, accidental and suicidal deaths in connection with dry ice have also been reported [1, 9–12]. Dry ice is the solid phase of carbon dioxide, which changes at −78.5 °C, through sublimation at atmospheric pressure, into its gaseous state.

At 20 °C and a pressure of 55 bar CO_2 changes into its liquid state and can be stored in gas bottles [1, 13]. It is possible to determine the reduction of O_2 and the increase of CO_2 in the air inside a room/space by measuring the atmosphere at the scene or by conducting experimental measurements [1, 7–9, 12]. The "normal" atmospheric air contains a minimum CO_2 of 0.03–0.04 %, an O_2 content of approximately 21 % and an N_2 content of 78 %. The physiological partial pressure of CO_2 (pCO_2) inside the human body generally measures 35–45 mmHg, which roughly equals 4.5–5.8 vol% at normal pressure. Individuals with chronically increased pCO_2 levels may tolerate higher pCO_2 levels in their environment.

A pCO_2 of approximately 60–70 mmHg (7.7–9 vol% at normal pressure) is considered a pathological concentration. Carbon dioxide stimulates the circulation, respiration, and heart rate at slightly elevated pCO_2 values (<10 vol%); i.e., blood pressure increases, tachypnea, dyspnea, tachycardia, and tachyarrhythmia commence. Neurological changes can be observed at levels above 10 vol%; restlessness, headaches, and anxiety are commonly reported, followed by numbing effects such as clouded awareness, reduced excitability, and increased paralysis. Carbon dioxide levels above 10–20 vol% pCO_2 result in seizures, coma, and finally death [2–4].

The cerebral circulation has a limited self-protection mechanism, the autoregulation mechanism It acts by increasing cerebral blood circulation during hypoxia and

Fig. 4 Two inhalation face masks discovered on a table in the apartment. Mixed DNA traces of all four family members were recovered from the masks

hypercapnia through direct myogenic effects without nervous stimulation, while it decreases the circulation during hypocapnia [14]. Circulation is increased to ensure that enough oxygen reaches the brain in cases of low oxygen and high CO_2 blood concentrations; however the mechanism fails when pCO_2 levels are too high. The inhalation of a gas mixture high in CO_2 concentration leads to a lowering of the intracellular O_2 concentration within a few seconds. This is called hyperacute anoxia, which is also commonly found in hanging [15, 16]. Severe anoxia leads to a breakdown of cognitive functions, unconsciousness, and after a few minutes, irreversible brain damage [3].

The mechanism of CO_2 intoxication in the cases described in this paper is not fully known, and had to be reconstructed from the findings at the scene and during background research conducted by investigating officers. An example of the effective use of 100 % concentrations of CO_2 is the euthanization of laboratory animals, where quick-acting and painless methods with minimal stress are required [17]. Other quick-acting and painless methods of suicide using anesthetic/narcotic agents have been reported previously and are almost exclusively linked to the medical professions [18].

It is hypothesized that the husband caught his wife and children off guard while they were sleeping, slipping the inhalation mask over the mouth and nose of each sleeping individual in turn. The inhaled pure CO_2 would ensure unconsciousness within a few seconds due to hypercapnia and severe anoxia. The rapid increase of CO_2 concentrations in the brain would render the victim helpless, probably leaving the victim no time to wake and defend themselves, or others.

Within a few minutes irreversible brain damage would have affected the brain stem and in particular the respiratory and circulatory centers, leading to respiratory arrest. It is also possible that significant cardiac arrhythmia and/or respiratory acidosis with severe clinical symptoms may have accelerated the fatal outcomes.

The circumstances of the father's death seemed puzzling considering the presence of occasional conjunctival petechiae. It is hypothesized that he filled the bag with CO_2 remnants from the container and then pulled the bag over his head, tightening it with the rope. There may not have been enough CO_2 left in the container and he may have suffocated by his own exhaled CO_2., in addition to the effects of pressure on the neck. This scenario could explain the petechiae.

Carbon dioxide is virtually impossible to detect during autopsy or by toxicological analysis. Kettner et al. [5] reported on the rapid and elaborate extraction of CO_2 content in the lungs of the victim using QMS 421 C (quadrupole mass spectrometer) in an accidental CO_2-related death inside a fermentation tank. The analysis demonstrated an increased CO_2 concentration and decreased O_2 concentration; however, the diagnostic value decreases with increased body decomposition [5]. Opinions on the diagnostic value of postmortem CO_2 analysis vary. The scientific literature reports that postmortem CO_2 concentrations are always raised and can therefore not be interpreted correctly [1].

The role of the forensic pathologist in the aftermath of a mass disaster with high levels of atmospheric CO_2 has been well documented by Wagner et al. [19]. The case described by Wagner et al. illustrates how whole villages succumbed to a gaseous cloud of CO_2 released from a lake. The positions of the victims suggested that they experienced a rapid loss of consciousness and died carrying out their daily routines.

Key Points

1. Carbon dioxide is vital for living organisms but highly toxic in raised concentrations. This paper reports the use of CO_2 as a potent weapon in a murder-suicide case, where the death scene offered virtually no clues as to a lethal modality and the autopsies were nonspecific.
2. Evidence of CO_2 intoxication during autopsy and toxicological analysis is almost impossible to obtain if such intoxication is not suspected and the body is in an advanced state of decomposition.
3. Pure CO_2 in large quantities is relatively inexpensive and freely available to the general population.
4. The forensic pathologist should consider CO_2 poisoning as a possible cause of death if the cause of death is unclear. Information gathered from the death scene during the investigative process is crucial in providing indicators of possible CO_2 poisoning.

Acknowledgments Dr. René Gapert's stay at the Institute of Legal Medicine and Forensic Sciences in Berlin was supported by a DAAD Research Scholarship (Deutscher Akademischer Austausch Dienst—German Academic Exchange Service Research Grant A/12/74773). The authors would like to thank Alison Gapert for her help with the preparation of this manuscript.

References

1. Dunford JV, Lucas J, Vent N, Clark RF, Cantrell FL. Asphyxiation due to dry ice in a walk-in freezer. J Emerg Med. 2009;36(4):353–6.
2. Langford NJ. Carbon dioxide poisoning. Toxicol Rev. 2005; 24(4):229–35.
3. Brinkmann B, Madea B. Handbuch Gerichtliche Medizin, band 1. Berlin, Heidelberg: Springer; 2004. p. 706–10.
4. Schwarz C, Oberbauer R. Säure-Basenhaushalt. Education. 2007;1:21–38.

5. Kettner M, Ramsthaler F, Juhnke C, Bux R, Schmidt P. A fatal case of CO_2 intoxication in a fermentation tank. J Forensic Sci. 2013;58(2):556–8.
6. Williams HI. Carbon dioxide poisoning: report of eight cases, with two deaths. Br Med J. 1958;2(5103):1012–4.
7. Sato H, Tanaka T, Kasai K, Kita T. Autopsy case of drowning caused by accidental carbon dioxide intoxication in a hold tank. J UOEH. 2009;31(4):353–8.
8. Dedouit F, Tournel G, Robert AB, Dutrieux P, Hédouin V, Gosset D. An apple a day does not always keep the doctor away. J Forensic Sci. 2008;53(6):1434–6.
9. Norimine E, Ishizawa F, Honsa K, Uemura S. Suicide case of carbon dioxide poisoning using dry ice. Chudoku Kenkyu. 2009;22(2):121–4.
10. Srisont S, Chirachariyavej T, Peonim AV. A carbon dioxide fatality from dry ice. J Forensic Sci. 2009;54(4):961–2.
11. Gill JR, Ely SF, Hua Z. Environmental gas displacement: three accidental deaths in the workplace. Am J Forensic Med Pathol. 2002;23(1):26–30.
12. Yamazaki M, Islam MN, Ogura Y, Honda K, Tsuchihashi H, Nishioka H. An autopsy case of carbon dioxide intoxication. Nihon Hoigaku Zasshi. 1997;51(6):446–51.
13. Marquardt H, Schäfer SG. Lehrbuch der Toxikologie. Auflage. Stuttgart: Wissenschaftliche Verlagsgesellschaft mbH; 2004.
14. Henßge C. Beweisthema todesursächliche/lebensgefährliche Halskompression: pathophysiologische Aspekte der interpretation. In: Brinkmann B, Püschel K, editors. Ersticken: Fortschritte in der Beweisführung. Festschrift für Werner Janssen. Berlin: Springer; 1990. p. 3–13.
15. Gilbert JD, Jensen L, Byard RW. Further observations on the speed of death in hanging. J Forensic Sci. 2008;53:1204–5.
16. Sauvageau A, Boghossian E. Classification of asphyxia: the need for standardization. J Forensic Sci. 2010;55:1259–67.
17. Donovan J, Brown P. Euthanasia. Curr Protoc Neurosci. 2005. doi:10.1002/0471142301.nsa04hs33.
18. Hayashi T, Buschmann C, Riesselmann B, Roscher S, Tsokos M. Circumstantial and toxicological features of deaths from self-administered intravenous anesthetic/narcotic agents. Forensic Sci Med Pathol. 2013;9:138–44.
19. Wagner GN, Clark MA, Koenigsberg EJ, Decata SJ. Medical evaluation of the victims of the 1986 Lake Nyos disaster. J Forensic Sci. 1988;33:899–909.