Medical Findings and Toxicological Analysis in Infant Death by Balloon Gas Asphyxia

Journal of Analytical Toxicology, 2017;41:347–349
doi: 10.1093/jat/bkx006
Advance Access Publication Date: 7 February 2017
Case Report

Case Report

Medical Findings and Toxicological Analysis in Infant Death by Balloon Gas Asphyxia: A Case Report

Eva Cuypers[1,*], Elien Rosier[1], Sara Loix[1], Wim Develter[2], Wouter Van Den Bogaert[2], Joke Wuestenbergs[2], Wim Van de Voorde[2], and Jan Tytgat[1]

[1]KU Leuven Toxicology and Pharmacology, Campus Gasthuisberg, Onderwijs en Navorsing 2, Herestraat 49, PO box 922, 3000 Leuven, Belgium, and [2]KU Leuven, Imaging and Pathology Department, Division Forensic Biomedical Sciences, University of Leuven (KU Leuven), Campus Sint-Rafaël, Kapucijnenvoer 33, 3000 Leuven, Belgium

*Author to whom correspondence should be addressed. Email: eva.cuypers@kuleuven.be

Abstract

In recent years, the increasing number of asphyxiation cases due to helium inhalation is remarkable. All described cases in the literature where diagnosed as suicide. In this article, however, we describe a triple infant homicide in which helium, as balloon gas, was administered to three young children after sedation causing asphyxiation and death through the medical findings and toxicological analysis. During autopsy, in addition to standard toxicological samples, gas samples from lungs as well as lung tissue itself were directly collected into headspace vials. Besides routine toxicological analysis, which revealed toxic levels of doxylamine, qualitative analysis on gas and lung samples was performed using headspace gas chromatography-mass spectrometry. As carrier gas, the commonly used helium was replaced by nitrogen. In gas samples from lungs of all three children, no helium was found. Nevertheless, lung tissue samples were found positive on helium. Therefore, sedation followed by asphyxia due to helium inhalation can strongly be assumed as the cause of death of all three children.

Introduction

Last decade, several cases of death due to asphyxiation with helium are described in literature (1–3). Since helium is easily available in commercial balloon gas tanks and detailed how-to Internet suicide literature can easily be found, the number of suicide cases is increasing the last years. Despite the lack of direct toxicity, inhaled helium quickly displaces oxygen, leading to almost immediate unconsciousness and death by asphyxia probably in minutes. Although helium is color- and odorless, leaving hardly any postmortem evidence, which makes it a possible murder weapon, all described cases found today are suicide-related. In this article, we describe medical findings and toxicological analysis in which helium, as balloon gas, was purposely administered to three young children after sedation causing asphyxiation and death.

Case History

Three young children of 2-, 4- and 6-year old were found dead in bed in sleeping position. In the same bedroom, several balloon-gas bottles connected by a tube to a plastic bag were found. Besides some homeopathic medication, an empty blister pack of doxylamine was found. Considering the scene, it was assumed that asphyxia causing balloon-gas was administered to the children, possibly after sedating them.

Medicolegal Investigation

The father of the children received a phone call at work from his oldest 11-year-old son that his mother had fallen. He called the emergency department and alarmed his neighbors. They found the two oldest children waiting outside. The mother was lying unconscious in her bedroom and the three youngest children were sleeping upstairs, but apparently they were death. Thorough resuscitation was unsuccessful.

Six helium containers were recovered in the children's room. All containers were connected to plastic bags with plastic tubes. Suicide notes and empty doxylamine blisters were found in the kitchen. A bloody syringe and empty Lidoject (lidocaine) containers were lying next to the unconscious mother.

All three children were found in their bedroom in sleeping position. A pinkish fluid was flowing from nose and mouth cavity. The youngest child had a 'mushroom of foam' around the mouth. The external examination of the corpses showed no signs of violence.

Postmortem total body CT was performed before the internal autopsy and revealed no specific pathological or clinical relevant information.

Internal autopsies revealed unspecific signs of asphyxia including discrete conjunctival petechiae, asphyxial petechial hemorrhages on the heart surface (Tardieu spots) and expansion of the lungs. Also congestion of parenchymatous organs and cerebral edema was observed, which was confirmed microscopically. One child had mild gastric content aspiration and the youngest child had lung edema. No other relevant histopathological findings were observed.

Toxicological Analysis

Collection of blood, urine, gas and lung samples

Peripheral and heart blood samples were collected in tubes containing sodium fluoride. Urine samples were collected in plastic containers. Brain samples were immediately stored in headspace vials. Lung gas samples were collected during autopsy, as previously described by Auwaerter *et al.* (4), by placing the lung in a plastic closed container filled with water and piercing the lung with metal needles. Lung gas samples were directly collected in vials completely filled with water. Afterwards, lung tissue samples were taken and immediately stored in airtight 20 mL headspace vials. Air from autopsy room was collected in headspace vials as a control sample.

Instrumental analysis of gas and lung samples

Headspace sampling was carried out using a SPME fiber DVB/CAR/PDMS (50/30 μm, 24Ga, Supelco, USA). Gas analysis was performed on a Agilent model 6,890 N series GC, in combination with an Agilent 5975B MSD MS using a VF-5 MS (30 × 0.25 mm i.d., 0.25 μm) + 5 m EZ-Guard column; injector temperature 100°C; oven temperature 120°C isothermal, nitrogen was used as carrier gas instead of the commonly used helium at flow rate of 1.0 mL/min. The following ions were detected in selected ion monitoring: *m/z* 4 (helium), 16 (methane), 40 (argon), 44 (carbon dioxide). Gas from balloon-gas bottles found at the scene was used as standard. As a blank control, room samples were taken during autopsy. As a positive reference, helium from a gas cylinder was injected into a headspace vial.

Screening of drugs and medicines in blood

A general tox-screening on 450 drugs and medicines is carried out according our previous publication (5).

Doxylamine confirmation in blood and urine

For the preparation of urine samples, 100 μL LC–MS grade acetonitrile was slowly added to 100 μL urine while vortexing. After centrifugation (10 min, 1,000 × *g*), the supernatant was diluted with 300 μL water. To prepare whole blood samples, 200 μL acetonitrile was dropped to 100 μL blood while vortexing. After centrifugation, the supernatant was diluted with 700 μL water. Five microliter was injected into the LC–MS-MS. LC–MS-MS analysis was carried out using a UFLC Shimadzu system consisting of a LC-20ADXR pump, a SIL-20ACXR autosampler, a DGU-20A3 degasser and a CTO-20 A oven (Shimadzu Prominence, Antwerpen, Belgium) in combination with a 3,200 QTRAP and Analyst software (ABSciex, Halle, Belgium). The Turbo V ion source equipped with electrospray ionization probe used following settings: gas 1: nitrogen, 40 psi; gas 2: nitrogen, 70 psi; ion-spray voltage: 5,500 V; ion-source temperature: 500°C; curtain gas: nitrogen, 20 psi. The mass spectrometer was operated in positive multiple reaction monitoring mode considering three transitions for doxylamine: 271.3/167.1 (CE: 45 V), 271.3/182.1 (CE: 23 V) and 271.3/139.1 (CE: 89 V). Declustering Potential was set at 23 V, Entrance Potential at 4 V. The Acquity C18 column (1.7 μm particle size, 2.1 mm × 50 mm), fitted with a guard frit of 0.2 μm, was purchased from Waters (Zellik, Belgium). The flow rate was 0.5 mL/min. The autosampler temperature was set at 15°C, the column oven at 45°C. Gradient elution was performed using 10 mM ammonium bicarbonate at pH 9.0 (solvent A) and MeOH (solvent B): 0–2 min: 25–90%B; 2–3.5 min: 90%B; 3.5–4 min: 90-25%B; 4–6 min: 25%B. Doxylamine was quantified with matrix-matched calibration curves ranging from 50 to 7,000 ng/mL urine and whole blood.

Results and Discussion

Autopsy was unsatisfactory pointing out the cause of death. It is known that asphyxia with helium leaves almost no signs of asphyxia whatsoever. In addition, the 'classic' signs of asphyxia at autopsy, such as multiple conjunctival petechiae and asphyxial petechial hemorrhages on the heart surface, are highly unreliable indicators (6). Pulmonary edema, an often encountered indication of hypoxic death, was observed. Nevertheless, this is a non-specific phenomenon with little diagnostic significance since it is found in a variety of fatal conditions (6). Therefore, toxicological analysis proving the presence of helium in the lungs is indispensable in all cases in which helium-induced asphyxia is suspected.

In GC–MS analysis, blank air samples were taken during autopsy. As a positive reference, helium from a gas cylinder was injected into and headspace vial. In Figure 1, GC–MS spectrum of selected ion 4 (helium) from blank, reference and lung tissue sample is shown.

GC–MS analysis was done on peripheral as well as heart blood, brain and lung tissue samples. As shown in Figure 2, lung tissue contains the highest amount of helium followed by brain and heart blood. Only trace amounts of helium was found in peripheral blood. Samples of all three children showed comparable chromatogram ratios.

As described by Musshoff *et al.* (3) using nitrogen as carrier gas, a negative peak appeared at the expected helium retention time, which also can be observed in the present cases. Analysis of gas lighter than the carrier chromatographic gas can lead to saturation of the mass spectrometer (pumps are not efficient enough to pump these gases out from the MS) causing a decrease of sensitivity sufficient to cancel the acquisition. So hydrogen is recommended as carrier gas if available. However, the presented analysis method is proven to be sensitive enough to solve the case. Moreover, the standard and easy sampling method was sufficient to detect helium in blood, brain and lung tissue. The special,

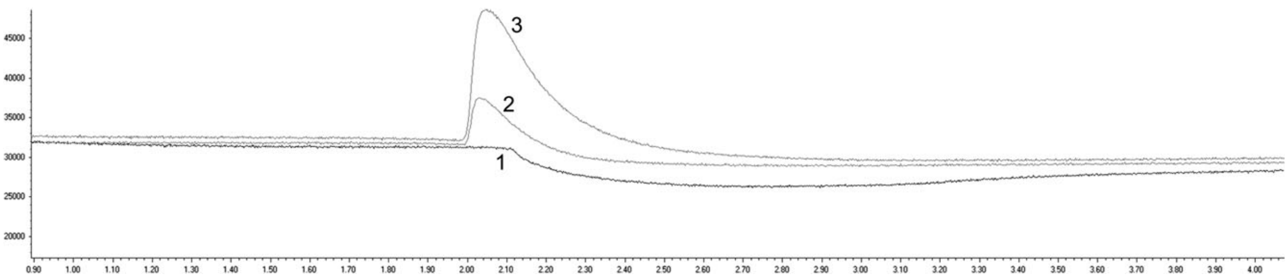

Figure 1. GC–MS chromatogram of selected ion 4 of blank (1), lung tissue (2) and helium reference (3).

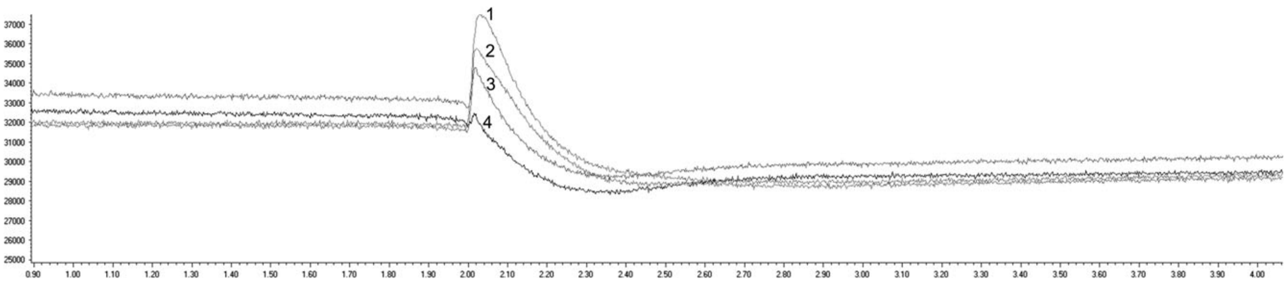

Figure 2. GC–MS chromatogram of selected ion 4 of lung tissue (1), brain (2), heart blood (3) and peripheral blood (4).

sophisticated method previously described by Auwaerter *et al.* (4), using a plastic box filled with water, was carried out during autopsy. Also lung tissue samples were collected in headspace vials. Remarkably, helium was only detected in the lung tissue samples. These findings might be explained by the previous described observation that small helium molecules can pass through plastics (7). Our findings indicate that sophisticated sampling methods are not necessary since helium can be detected in fast taken and well preserved lung tissue samples. As shown in Figure 2, lung tissue samples are the most suitable samples to investigate suspected asphyxia due to helium. Also brain tissue or heart blood can be used when lung tissue is not available.

In the general tox-screening, doxylamine was detected in blood as well as urine of the three children. Blood and urine analysis of the mother revealed the presence of doxylamine as well as lidocaine.

In all three children, doxylamine concentrations in blood exceeded 7,000 ng/mL. This blood concentration is, even in adults, described to be lethal (8). Since stomach content was not available for toxicological analysis, stomach doxylamine concentrations could not be measured. Nevertheless, since it can be assumed that the sedative was given shortly before death, one should take into consideration that postmortem redistribution from stomach is possible. The fact that helium was found in lung tissue of all three children and thus respiration can be assumed at the time of helium administration, we can conclude that postmortem redistribution is very likely. Therefore, sedation followed by asphyxia due to helium inhalation can strongly be assumed as the cause of death of all three children.

Ethical standards

All performed experiments comply with the current Belgian ethical standards.

References

1. Gallagher, K.E., Smith, D.M., Mellen, P.F. (2003) Suicidal asphyxiation by using pure helium gas: case report, review, and discussion of the influence of the internet. *The American Journal of Forensic Medicine and Pathology: Official Publication of the National Association of Medical Examiners*, **24**, 361–366.
2. Grassberger, M., Krauskopf, A. (2007) Suicidal asphyxiation with helium: report of three cases. *Wiener klinische Wochenschrift*, **119**, 323–325.
3. Musshoff, F., Hagemeier, L., Kirschbaum, K., Madea, B. (2012) Two cases of suicide by asphyxiation due to helium and argon. *Forensic Science International*, **223**, e27–30.
4. Auwaerter, V., Perdekamp, M.G., Kempf, J., Schmidt, U., Weinmann, W., Pollak, S. (2007) Toxicological analysis after asphyxial suicide with helium and a plastic bag. *Forensic Science International*, **170**, 139–141.
5. Verplaetse, R., Decabooter, S., Cuypers, E., Tytgat, J. (2013) Screening of urine and blood using limited sample preparation and information dependent acquisition with LC-MS/MS as alternative for immunoassays in forensic toxicology. *Journal of Forensic Toxicology and Pharmacology*, **2**, 1–8.
6. Saukko, P., Knight, B. (eds). *Knight's Forensic Pathology*, 3rd edition. Edwards Arnold Publishers: London, UK, 2004.
7. Galletti, P.M., Snider, M.T., Silbert-Aiden, D. (1966) Gas permeability of plastic membranes for artificial lungs. *Medical Research Engineering*, **5**, 20–3.
8. Regenthal, R., Krueger, M., Koeppel, C., Preiss, R. (1999) Drug levels: therapeutic and toxic serum/plasma concentrations of common drugs. *Journal of Clinical Monitoring and Computing*, **15**, 529–544.