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CASE REPORT

PATHOLOGY/BIOLOGY; TOXICOLOGY

Lubomir Straka,[1] M.D., Ph.D.; Frantisek Novomesky,[1] M.D., Ph.D.; Anton Gavel,[2] M.D.; Juraj Mlynar,[3] Ing., C.Sc.; and Petr Hejna,[4] M.D., Ph.D.

Suicidal Nitrogen Inhalation by use of Scuba Full-Face Diving Mask

ABSTRACT: A 29-year-old man was found dead lying on the bed in a hotel room in a famous Slovak mountain resort. He had a full-face diving mask on his face, connected through a diving breath regulator to a valve of an industrial (nondiving) high-pressure tank containing pure 100% nitrogen. The breath regulator (open-circuit type) used allowed inhalation of nitrogen without addition of open air, and the full-face diving mask assured aspiration of the gas even during the time of unconsciousness. At autopsy, we found the typical signs of suffocation. Toxicological analysis revealed 94.7% content of nitrogen in alveolar air. Following the completion of the police investigation, the manner of death was classified as a suicide. Within the medico-legal literature, there has been only one similar case of suicidal nitrogen inhalation described (1).

KEYWORDS: forensic science, forensic pathology, suicide, nitrogen, nitrogen asphyxiation, gaseous suffocation, full-face diving mask, sudden sniffing death, analysis of alveolar air

Nitrogen (N_2) as a separate gas element was discovered in 1772 independently by D. *Rutherford* and *H. Cavendish.* Later, *A. Lavoisier* declared nitrogen as the principle component of Earth's atmosphere. Nitrogen is physiologically an inert, nontoxic gas, not involved in human metabolism. In water and soils, nitrogen can be found in the form of nitrates and nitrites. In the human body, nitrogen is a constituent element of amino acids and thus of proteins and nucleic acids (DNA and RNA).

Nitrogen, like argon, methane, propane, and carbon dioxide, is considered to be a simple asphyxiate gas. It may displace oxygen from the inhaled air causing a life-threatening condition. Reduction in atmospheric oxygen to less than 25% of normal value can lead to rapid unconsciousness and death in minutes.

In this paper, we report on the analysis of a suicide of a 29-year-old man committed by inhalation of 100% nitrogen. In the medico-legal literature, there has been only one similar case of suicide by inhalation of nitrogen described (1).

[1]Institute of Forensic Medicine and Medicolegal Expertises, Jessenius Faculty of Medicine, Comenius University, University Hospital, Kollarova 2, 036 01 Martin, Slovak Republic.
[2]Department of Forensic Medicine, Health Care Surveillance Authority, Banicka 803, 058 01 Poprad, Slovak Republic.
[3]Department of Forensic Medicine, Health Care Surveillance Authority, Antolska 11, 845 45 Bratislava, Slovak Republic.
[4]Institute of Forensic Medicine, Faculty of Medicine, Charles University, Sokolská 581, 500 05 Hradec Kralove, Czech Republic.1

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Case Report

Case History

A 29-year-old student from Germany was found dead in a hotel room on the last day of his 3-day biking tour at a mountain resort. According to hotel staff, he had been unaccompanied, he was only in obligatory contact with the reception desk and was last seen in the evening several hours prior to his death. His undressed body was found by a cleaning staff lying on a bed in the supine position with his upper arms extended sideways (Fig. 1).

There was a full-face diving mask (CRESSI-SUB, Genoa, Italy) found on the face of the victim, being snugly sealed by rubber straps (Fig. 2). The glass of the full-face mask was covered with tiny droplets of the condensed vapor on the inner side. The full-face diving mask was connected with a second stage of standard open-circuit scuba (self-contained underwater breathing apparatus, NOAA) diving regulator (Seemann-Sub, Germany). The 2nd stage of the above-mentioned regulator was connected via a flexible medium-pressure rubber hose with the 1st stage of the scuba breathing system used. Finally, the 1st stage of the regulator was firmly screwed into the orifice of a valve of a high-pressure industrial gas tank (inner capacity 6 L, remaining pressure 87 bars; Lübke, Germany), filled with pure nitrogen. Both regulators were in the open position.

There was also a notebook, tourist map, navigational instruments, wallet (with credit cards and a large amount of cash), and a cellular phone on the table besides the body. In the lobby of the room was a mountain bike. The police investigator, after consultation with a public prosecutor and forensic expert, asked for a medico-legal autopsy of the deceased (Fig. 3).

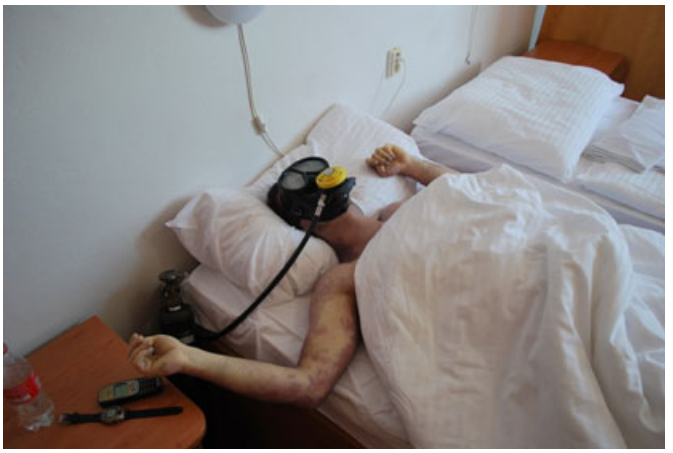

FIG. 1—*The body of deceased with a diving full-face mask fixed on the face.*

FIG. 2—*Diving full-face mask tightly fixed on the face.*

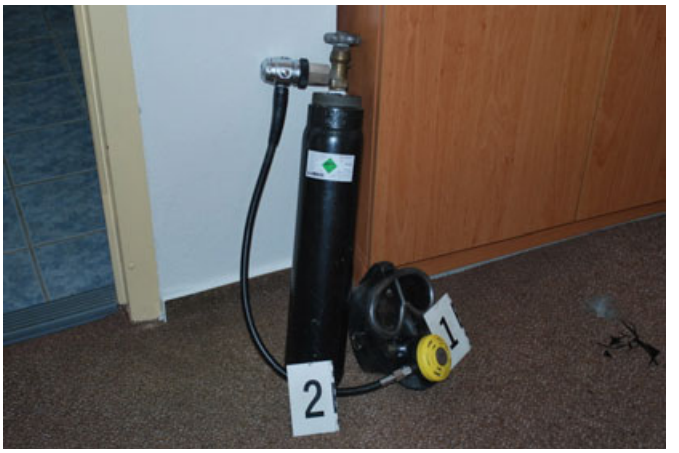

FIG. 3—*Diving mask connected to a high-pressure tank.*

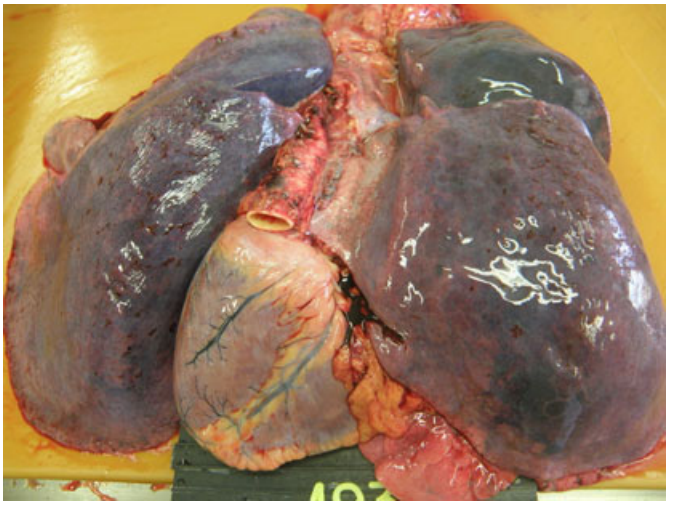

FIG. 4—*Tiny hemorrhagic foci on the pleura of both lung lobes.*

Autopsy Findings

The male deceased was 183 cm tall and weighed 90 kg. On external examination, there was intensive postmortem lividity, hyperemia and pin-point hemorrhages, and multiple petechiae on the skin of the shoulders. There was no evidence of trauma.

The internal examination revealed the following findings: the brain of the deceased was swollen with dilatation and congestion of blood vessels in the leptomeninges. Both lungs were enlarged, congested, and edematous (left lung weight 750 g; right lung weight 950 g). Tiny hemorrhagic foci were found on the pleura of both lungs (Fig. 4). There was a pinkish mucous froth in the airways. The heart was excessively dilated, and the muscular walls were flaccid, with a total loss of tonus. The abdominal organs were congested, and the liver was slightly enlarged (1670 g) without, however, visible morphological changes. The blood within the whole body was dark red and fluid. The reminder of autopsy was unremarkable.

Microscopic Findings

Microscopy of the lungs revealed diffuse foci of intra-alveolar hemorrhagic edema, together with acute emphysema of alveoli and passive congestion of septal vasculature. A microscopic examination of the brain revealed pericellular and perivascular edema with passive congestion of the capillaries. The microscopic structure of the other parenchymatous organs was found to be normal and appropriate to the age of the deceased. All the organs were congested due to terminal circulation failure.

Toxicological Analyses

Samples of blood, urine, brain, lungs, suprarenal gland, and adipose tissue were investigated using screening (thin layer chromatography; immunochromatographic assay) and specific methods (gas chromatography with head-space injection; gas chromatography with mass selective detector). Analyses were focused on drugs, drugs of abuse, ethyl alcohol, and other volatile compounds.

Alcohol and volatile compounds in blood and drugs testing resulted in negative findings.

Isolation of the alveolar air from the lungs to special plastic bags (2–4) was performed immediately after isolation of the lung samples at the autopsy. Analysis of the air isolated from both lungs was performed separately, in a specialized accredited testing laboratory, focused to nitrogen, oxygen, and carbon oxide

determination and quantification. The analysis of basic instrumental conditions (accredited method) included the following:

Method: gas chromatography
Column(s): a system of six molecular sieve-based packed columns and four valves in combination
Temperature: 60°C, isothermal chromatography
Carrier gas: helium, purity 5.0
Detector: TCD
Injection volume: 1000 μL and 250 μL, respectively
Expanded uncertainty of measurement (% of the determined concentrations): 1% for nitrogen; 3% for oxygen; 10% for carbon oxide.

The results were as follows:

Right lung: nitrogen—91.0% (v/v), oxygen—8.51% (v/v), carbon oxide—0.49% (v/v).
Left lung: nitrogen—94.7% (v/v), oxygen—4.71% (v/v), carbon oxide—0.59% (v/v).
Postmortem toxicology revealed nitrogen in both the lungs at extreme levels.

Following the completion of laboratory examination and autopsy, the cause of death was attributed to nitrogen asphyxiation. Further investigation provided by the German police revealed that the deceased man had made suicidal declarations in the past and that the diving equipment was his own. Furthermore, his close relatives confirmed suicidal ideations of the deceased; however, an apparent reason remained unclear. Following the completion of the police investigation (both German and Slovak), the manner of death was classified as a suicide.

Discussion

In the medico-legal practice, lethal episodes of breathing gas mixtures with a low percentage of oxygen (or even no oxygen in the mixture at all) should appear in situations as follows:

- Autoerotic maneuvers, where the lack of oxygen stimulates the libido of the subject (5–7).
- Accidental entrance of the subject to places with low-oxygen atmosphere (corroded steel tanks, tunnels, mines) or places where the oxygen was partly/totally displaced by another nontoxic gas (laboratories, volcanic fumaroles; 8–13).
- Deep diving, when the diver in the process of decompression by mistake switches and starts to breathe a low-oxygen gas mixture (bottom mix; 14–16).
- Suicidal attempts where the subject voluntarily breathes inert gas (e.g., nitrogen, helium, propane–butane mixture) from a separate container (5,17–22).

Nitrogen inhalation fatalities are very rare. From the described cases, most are accidents (8,10,13,23). Accidental nitrogen asphyxiation causes about eight deaths per year in the U.S.A. (23), which is asserted to be the highest number of intoxications than by any other industrial gas. In 1981, shortly before the launch of the first space shuttle mission, two technicians lost consciousness, and one of them died after they entered the orbiter aft compartment, which was pressurized with pure nitrogen as a precaution against fire (8). A laboratory assistant died in Scotland in 1999, apparently from nitrogen asphyxiation, after entering the basement storage room where liquid nitrogen had spilled (10). A similar case was referred to by Kernbach-Wighton (13). In similar episodes of collapse, suffocation and death may be encountered where workers enter ship cargo spaces or when cleaning or inspecting fuel tanks of ships, as some industrial tanks contain high concentrations of nitrogen (11). Deliberate nitrogen asphyxiation is also viewed by some as a more humane way to end human life (24). Nevertheless, execution by nitrogen asphyxiation is not used by any nation in the world. Suicidal nitrogen inhalation is an extremely rare event. There has been only one case published in the medico-legal literature (1). In the case mentioned, 50-year-old man committed suicide with a do-it-yourself suicide device: homemade breathing tent constructed from a plastic milk crate covered with a clear plastic shower curtain sealed with the duct tape. The tent was connected by the tube to a valve on a large cylinder of industrial nitrogen gas.

If pure nitrogen is being breathed, the alveolar oxygen content from the previously breathed air decreases very fast. Mathematically speaking, breathing of pure nitrogen leads to the situation where an even less number of oxygen molecules pass through alveolar-capillary membranes in the lungs; thus, the capillary blood is less saturated by oxygen. After a few breaths, the alveolar spaces become completely filled with pure nitrogen, and hence, the fatal asphyxia of the victim develops.

Deaths from suffocating gases are caused not by the toxic nature of the gases, but rather by displacement of oxygen from the breathed gas mix (e.g., atmospheric air; 11,12,18–20,25–27). Determination of the cause of death in such cases is enhanced by knowledge of the circumstances surrounding the death (5,8–10,12,17–20). There are no specific findings at autopsy, save for the signs of suffocation, and deep asphyxia. Thus, it is not the inert gas itself, but a lack of oxygen that kills.

While analyzing the presented case, the authors were convicted that the above-mentioned information concerning the effects of pure nitrogen breathing as a way to end one's life was available to the deceased. The hypothesis of suicide in the case reported seems to be confirmed by the following facts:

- Use of the full-face diving mask, fixed in the occipital region of the head by three rubber straps (spider), thus providing continual inhalation of the pure nitrogen even after loss of consciousness of the victim (no mouthpiece on the diving regulator used),
- No evidence of sexual paraphilia at the place of death (no pornographic materials, no erotic devices, adverse achievement from interrogation of the cell phone and the notebook, no signs of spermatism, his nakedness is explainable by high ambient temperature in the hotel room (detected at the time of examination at the place),
- Demonstrative, organized placement of his personal property (money, credit cards, passport, documents, etc.) on the table in the hotel room,
- Suicidal ideations and declarations of the deceased, confirmed later by his close relatives.

The unanswered question still remains concerning the use of a scuba diving regulator, which suggests some knowledge of the victim concerning scuba(self-contained underwater breathing apparatus) diving. This probability was not confirmed by the authors, even with close cooperation with police authorities of both the countries involved in the case. However, if the victim had even basic scuba diving training (the scuba gear was his own), he was thoroughly informed about the effects of nitrogen, which is a gas treated very seriously due to its narcotic effects in elevated pressure (14,28,29) even in recreational diving practice.

The authors did not find any information concerning a case of nitrogen sniffing in the literature; however, there are several cases of death due to other breathing gases (suicide, autoerotic maneuvers) in the literature (5–7,17–22).

The presented case seems to be remarkable for several reasons:

- An unusual and literally curious way of nitrogen asphyxiation via scuba diving equipment (full-face mask.
- The manner of the suicide indicating long-term planning (knowledge of nitrogen effects and also of diving gear).
- Nonspecific autopsy finding, confirmed by special alveolar air analysis.
- The open unresolved question why a German citizen chose a Slovak mountain resort (where there was no possibility to dive), very far from his home, to commit suicide by a rather bizarre and complicated way.

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Additional information and reprint requests:
Lubomir Straka, M.D., Ph.D.
Institute of Forensic Medicine and Medicolegal Expertise
Jessenius Faculty of Medicine
Comenius University
University Hospital
036 59 Martin
Slovak Republic
E-mail: lubomir.straka@unm.sk