A Rare Case of Fatal Self-Poisoning With Sodium Nitrite: Autopsy and Toxicological Findings

A rare case of fatal self-poisoning with sodium nitrite: autopsy and toxicological findings.

Abstract

Fatal sodium nitrite poisonings are unusual in the forensic setting. Suicide by poisoning include drug overdose, the inhalation of toxic gasses, and poisoning from pesticides and chemical substances. Among these potentially deadly chemical substances is sodium nitrite, which is an inorganic compound made up of nitrous acid sodium salt. Sodium nitrite is used mostly in the food industry (as a preservative) and in medical field (as an antidote to cyanide poisoning), and if ingested in large enough amounts it can be fatal.

The ingestion or inhalation of sodium nitrite can cause severe methemoglobinemia, which is a metabolic disorder characterised by an inability of haemoglobin (which gets oxidised into methaemoglobin) to bind (and therefore carry) oxygen. Severe cases of this condition, if not treated, can be fatal.

We described a case of fatal self-poisoning with sodium nitrite; in particular, the paper focuses on the autoptic and toxicological investigations which enabled the correct diagnosis to be performed.

Keywords: self-poisoning; sodium nitrite; methemoglobinemia.

Introduction

Suicide is cause for significant concerns for public and social health worldwide. When a suicide occurs, the forensic pathologist is called to ascertain the modalities and the cause of death, and to exclude the involvement of a third party [1,2].

According to the World Health Organization [3], suicide is the 18th leading cause of death worldwide, and it accounts for 1.4% of all deaths. It occurs at all stages of life and it is the second leading cause of death among 15-29 years old globally. It is more common in people who are older and in males, with the highest rates occurring among older men mostly in European countries.

Methods of suicide may be categorized as non-violent (drugs and poisons) and violent (all other methods). In the United States, the most common method of suicide is firearms, which are used by 61% of the total male victims and by 36% of the total female victims. Poison is most commonly used by women, and it accounts for 29.3% of the total female victims in the United States [4]. In Europe, the most common methods of suicide for males are hanging, firearms, and falls; for females, these include hanging, poison, and falls [3].

In Italy, only a small percentage of suicides (~1.5% of all male suicides, ~3.8% of all female suicides) involves the ingestion of pesticides or other chemical substances [5-7]. Types of suicide by poisoning include drug overdose, the inhalation of toxic gasses, and poisoning from pesticides and chemical substances. Among these potentially deadly chemical substances is sodium nitrite, which is an inorganic compound made up of nitrous acid sodium salt. Sodium nitrite is used mostly in the food industry (as a preservative) and in medical field (as an antidote to cyanide poisoning), and if ingested in large enough amounts it can be fatal.

The ingestion or inhalation of sodium nitrite can cause severe methemoglobinemia, which is a metabolic disorder characterised by an inability of haemoglobin (which gets oxidised into methaemoglobin) to bind (and therefore carry) oxygen. Severe cases of this condition, if not treated, can be fatal.

The scientific literature contains descriptions of several cases of accidental sodium nitrite poisoning [8-12], but few cases of attempted suicides (only three of which were fatal) using this substance [13-19].

This paper describes a case of fatal self-poisoning with sodium nitrite; in particular, the paper focuses on the autoptic and toxicological investigations which enabled the correct diagnosis to be performed.

Case Report

The corpse of a 31-year-old male was found inside his family car, which was parked inside the garage of the apartment building in which he resided. During the first inspection, the corpse was found sitting on the front passenger seat (Fig. 1). Next to it were several items, among which were a precision scale, a bottle of water, a pack of plastic drinking glasses (one of which was outside the pack, and wet), and a plastic vial with 'Sodium Nitrite 99%' written on the label. No lesions were observed on the corpse.

The medical history of the victim reported that the man was being treated with sodium valproate for a depressive syndrome.

An autopsy was carried out to determine the cause of death. Subungual cyanosis of the hands and feet and blue-red livor mortis in several parts of the body were found during the external examination (Fig. 2A). The autopsy revealed a bilateral pulmonary oedema, subpleural petechiae and an intense visceral congestion (Fig. 2B). In the stomach, 250 cc of a brownish, gelatinous liquid were found.

The histological examinations revealed pulmonary oedema, congestion of the pulmonary capillaries, and intra-alveolar haemorrhage (Fig. 3A). Stretched, wavy cardiac myocytes and interstitial oedema were also found (Fig. 3B). No other pathological microscopic findings were found in the rest of the organs.

The toxicological analysis was carried out on blood samples collected from the femur and from the heart. The samples were screened for narcotic substances using the ultra-high-performance liquid chromatography–tandem mass spectrometry (UHPLC-MS/MS) technique with selected reaction monitoring (SRM); the same technique, but with multiple reaction monitoring (MRM), was used to screen the blood samples for medications and other xenobiotic substances with psychotropic or narcotic effects. To detect the presence of ethylic alcohol, the headspace gas chromatography-mass spectrometry (HS-GC-MS) technique was used.

The qualitative toxicological analyses were positive for benzodiazepines – specifically, for Alprazolam – and excluded the presence of alcohol, amphetamine-methamphetamine, 3,4-

methylenedioxy-methamphetamine, tetrahydrocannabinol, cocaine, opiates, methadone, barbiturates, neuroleptics, and tricyclic antidepressants.

The quantitative toxicological analyses for benzodiazepine and methaemoglobin revealed a methaemoglobin level of 73% and a concentration of 0.02 mg/l of Alprazolam.

Based on the medical history, on the findings of the first inspection, and on the results of the autopsy and the toxicology report, the death of the individual was attributed to sodium nitrite poisoning, which was presumed to have been diluted in water and ingested orally.

Discussion

Sodium nitrite is an inorganic compound made up of nitrous acid sodium salt; it is used mostly in the food industry, as a colouring substance and to suppress the growth of bacteria in food, especially in meat [16,18]. The reported serum nitrite level in adult patients who die due to voluntary ingestion of sodium nitrite is 0.55 mg/l [11,16]. Furthermore, while the lethal dose in adults is ~2.6 g [14,20], cases have been documented in which people survived after having ingested as much as 6 g of sodium nitrite [14,21].

The main toxic effect caused by the consumption of sodium nitrite is the onset of methemoglobinemia, a potentially fatal condition [14]. More specifically, methemoglobinemia causes a severe imbalance between exogenous oxidative stress and the mechanisms of haemoglobin oxidation reduction [15]. The outcome of this imbalance is that haemoglobin is oxidised into methaemoglobin at much higher rates than normal, with consequent hypoxia.

As a chemical agent, sodium nitrite oxidises the Fe^{2+} present in haemoglobin into Fe^{3+}, thus turning haemoglobin into methaemoglobin, which is incapable of binding and transporting oxygen [18,22]. Under physiological conditions, methaemoglobin is converted back into haemoglobin by NADH- and NADPH-methaemoglobin reductase, which maintain the concentration of methaemoglobin at < 1% [18,22,23]. After a significant exposure to or ingestion of sodium nitrite, the rate at which haemoglobin is oxidised into methaemoglobin surpasses the rate at which the reductase turns it back

into haemoglobin; thus, methaemoglobin accumulates inside the organism [18]. In turn, the increase in the concentration of methaemoglobin causes a reduction in the amount of oxygen that is delivered to the tissues; this effect can be graphically illustrated as a left-shifted oxygen dissociation curve [18]. The symptoms of acute intoxication by sodium nitrite appear 0.5-3 hours after the ingestion of at least 200-500 mg of this substance [8]. The susceptibility is variable, and the clinical effects are magnified by pre-existing cardiopulmonary diseases [17]. The first sign of methemoglobinemia is cyanosis [15], which, however, is a non-specific finding by itself. Then, as the concentration of methaemoglobin reaches 15-20%, blood discoloration and cyanosis occur [24]; when it reaches 30-40%, headaches, fatigue, tachycardia, weakness, and dizziness also appear; when it reaches > 70% it is typically lethal, even though the literature reports cases of survival with levels > 90% [14,15]. Sodium nitrite also causes vasodilation, which can cause hypotension, tachycardia, and hypoxia, which can be fatal [14]. Numerous authors have reported cases of severe methemoglobinemia which resulted in the death of the individuals who accidentally ingested sodium nitrite [11,12,15,16]. However, sodium nitrite is very rarely used as a mean to commit suicide, and very few such examples are reported in the literature [14-18].

Several papers have been written regarding what investigations should be carried out in the event of a suspected sodium nitrite intoxication of a person who, upon medical inspection, resulted having signs of methemoglobinemia, but there are almost no studies that describe the forensic approach that should be followed in cases in which a victim with no history of hospitalisation was suspected to have suffered a sodium nitrite intoxication.

In a recent article, Durão et al. [25] described a fatal case of sodium nitrite contained in a suicide kit ordered by the internet.

The case presented in this paper is one of the very first reports of self-poisoning via ingestion of sodium nitrite, the diagnosis for which was made post-mortem thanks to a systematic collection of circumstantial data and to exceptionally thorough autoptic, histological, and toxicological analyses.

The analysis of the circumstantial data (a precision scale, a bottle of water, a pack of plastic drinking glasses, and a plastic vial with 'Sodium Nitrite 99%' written on the label, all of which were found at the location where the corpse was discovered) quickly directed the investigations towards the hypothesis that the cause of death had been a sodium nitrite intoxication with the goal to commit suicide. Further confirming the self-poisoning hypothesis, no signs of trauma that could make a homicide plausible were found, and the anamnesis reported that the victim had been suffering from a major depressive disorder, the treatment for which had begun only a few days prior. Furthermore, the location in which the corpse was found – the victim's car, parked inside his garage – is a common location for suicides: typically, the choice of suicide method and location reflects the means at the disposal of the victim; in particular, the type of suicide method is based on motivations that reflect the personality of the victim [26,27]. Overall, a person is more likely to commit suicide inside his/her own house or car, since they have intrinsic emotional value.

To confirm the diagnostic hypothesis that the death of the individual had been caused by a voluntary ingestion of sodium nitrite, signs of methemoglobinemia were sought.

The autopsy, other than excluding signs of traumatic lesions, highlighted cyanosis of the extremities, which is a sign of methemoglobinemia. Furthermore, liquid material mixed with a non-dietary gelatinous/granular material was found inside the stomach, making it plausible that the victim had ingested sodium nitrite dissolved in water.

The (non-specific) histological exams showed stretched, wavy cardiac myocytes and interstitial oedema, very early signs of hypoxia [28] (developed after a severe case of methemoglobinemia).

Finally, the toxicological report was indispensable to confirm the cause of death, since it granted proof of the presence of a lethal concentration of methaemoglobin, compatible with the oral ingestion of 99% sodium nitrite.

In conclusion, we reported the diagnostic procedure we employed post-mortem on a subject who died due to methemoglobinemia cause by the intentional ingestion of sodium nitrite.

From a forensics point of view, an accurate collection of circumstantial data, followed by a thorough autopsy and toxicological investigation, is always essential when methemoglobinemia and the ingestion of sodium nitrite are suspected. In particular, a correct collection of circumstantial data can orient subsequent investigations towards the correct diagnostic hypothesis, while the autoptic and histological investigations can highlight indirect signs of methemoglobinemia and allow to identify the pathological mechanism that caused the death of the victim, as well as the means by which the substance was taken. Finally, the toxicological report is essential to determine if a high concentration of methaemoglobin (which accompanies the ingestion of sodium nitrite) is present.

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Figure Legends

Fig. 1: Scene of Death

A) The corpse was found inside his family car, which was parked inside the garage of the apartment building in which he resided. The cadaver was found sitting on the front passenger seat.

B-C) Next to corpse were a bottle of water, a pack of plastic drinking glasses (one of which was outside the pack, and wet), and a plastic vial with ‘Sodium Nitrite 99%’ written on the label.

Fig. 2: Autopsy findings

A) Blue-red livor mortis in several parts of the body were found during the external examination.

B) The autopsy revealed a bilateral pulmonary oedema, subpleural petechiae and an intense visceral congestion.

Fig. 3: Histological findings

A) Lung: samples: pulmonary oedema, congestion of the pulmonary capillaries, and intra-alveolar haemorrhage Hematoxylin-eosin x10.

B) Myocardial samples: stretched cardiac myocytes and interstitial oedema. Hematoxylin-eosin x20.