Case Report

Intentional sodium nitrite ingestion with severe methemoglobinemia

V S Megha[1], Ritu Panchakshari[1], Pradeep Rangappa[2], Ipe Jacob[2], Karthik Rao[2], Satish Kumar Anumala[3]

From [1]Registrar, [2]Consultant, Department of Critical Care, [3]Consultant, Department of Hematology, Manipal Hospital, Bengaluru, Karnataka, India

ABSTRACT

Sodium nitrite ($NaNO_2$) is a commonly available chemical that can be fatal even in small amounts when ingested. It acts by oxidizing iron in hemoglobin, converting it from its ferrous to ferric state, known as methemoglobin. Methemoglobin cannot directly bind with oxygen, leading to decreased oxygen delivery and subsequent cyanosis, along with systemic effects such as hypotension, metabolic acidosis, hyperlactatemia, and coronary ischemia. Methemoglobinemia can be suspected when a patient presents with severe cyanosis despite normal oxygen saturation, is otherwise asymptomatic, and shows no improvement with supplemental oxygen. We present a case of a nineteen-year-old woman who was brought in with intentional ingestion of $NaNO_2$, with a subsequent serum methemoglobin level of 65%. The patient was treated with intravenous methylene blue, leading to restoration of normal methemoglobin levels within twenty-four hours. Severe methemoglobinemia can be fatal at high levels, but early clinical recognition and urgent initiation of its antidote, methylene blue, can rapidly reverse the condition. This case highlights the value of co-oximetry in the work-up of hypoxemia and cyanosis, and the need to suspect methemoglobinemia when cyanosis does not improve with supplemental oxygen.

Key words: Co-oximetry, Cyanosis, Methemoglobinemia, Methylene blue, Sodium nitrite, Suicide kit

Sodium nitrite ($NaNO_2$) poisoning is an uncommon cause of severe methemoglobinemia, and ingestion of as little as 1 g can be potentially fatal [1]. In a healthy physiological condition, the concentration of methemoglobin (methHb) does not exceed 1–2%. Values between 10% and 20% typically result in cyanosis, even though the patient may show no other symptoms. $NaNO_2$ thus causes chemical asphyxiation and impairs oxygen delivery, leading to injury of organs such as the heart, brain, and kidneys, which are highly dependent on oxygen. It is commonly marketed under the name "curing salt" and is used as a meat preservative due to its strong oxidizing properties [2]. There has been a global rise in suicide cases involving $NaNO_2$ ingestion, attributed to its promotion on online suicide forums that offer detailed guidance on its use, either alone or within a "suicide kit" with other medications such as anti-emetics and anti-histamines to prevent its side effects. Fatalities from $NaNO_2$ poisoning can be prevented with the timely administration of methylene blue [3,4].

The present case highlights the value of co-oximetry in evaluating peripheral cyanosis concomitant with normal peripheral oxygen saturation (SpO_2) and unresponsive to supplemental oxygen.

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CASE DESCRIPTION

A 19-year-old female, a medical laboratory technology student, with a medical history significant for previous suicide attempts, was brought to the emergency department by her parents with an alleged history of ingestion of 10 mL of $NaNO_2$ about 3 h back. She had taken this action based on advice from an online suicide advocacy website. She had complaints of multiple episodes of vomiting and generalized weakness.

On examination, she was conscious, with a heart rate of 140 beats/min, respiratory rate of 24 cycles/min, blood pressure of 106/60 mmHg, SpO_2 of 86% on room air and 98% with 15L/min oxygen through a non-rebreather mask. Examination showed extensive peripheral and circumoral cyanosis, with diffuse abdominal tenderness (Fig. 1).

Blood gases with co-oximetry showed mild metabolic acidosis with methHb 65.5% and lactate 6.3 mmol/L. There was global ST-segment depression on the electrocardiogram, but troponin I levels were normal (Fig. 2).

Gastric lavage was done, and methylene blue 1 mg/kg was given intravenously (IV) over 5 min, followed by Vitamin C 500 mg IV. In addition, she was resuscitated with IV fluid boluses and shifted to the intensive care unit (ICU). A 2 mg/kg dose of inj. Methylene blue IV

Correspondence to: Dr. Ipe Jacob, Department of Critical Care, Manipal Hospital, Bengaluru, Karnataka, India. E-mail: ipe.jacob@gmail.com

over 5 min was repeated after 1 h. Glucose-6-phosphate dehydrogenase (G6PD) levels were normal, while serum lactic dehydrogenase was slightly elevated.

She was cared for in the ICU with intermittent high-flow nasal oxygen and non-invasive positive pressure ventilation. MethHb level came down slightly to 56% after 2 h, hence, she was initiated on one cycle of plasma exchange with replacement volume of 1 L fresh frozen plasma and 2 L albumin (Fig. 3a). The discarded plasma from the patient was a chocolate brown color, suggestive of a high serum metHb level (Fig. 3b). MethHb levels had decreased to normal levels about 6 h after ICU admission. On day 2 of admission, she underwent a single session of hyperbaric oxygen therapy (HBOT) at 2 atmospheres absolute over 90 min. Following this, she had bilateral ear pain with fullness. As the methHb level had come down to 0.6%, further HBOT sessions were not required. On psychiatrist review, she was initiated on treatment for rapid cycling bipolar disorder, and discharged after another 3 days.

DISCUSSION

$NaNO_2$ is a readily available, colorless inorganic substance. It is commonly utilized as a food preservative, antimicrobial agent, and color-stabilizing agent in foods such as cheese and processed meats (including ham, bacon, and sausages), and fish. In addition, it serves as an industrial chemical and is used therapeutically to treat cyanide poisoning [5].

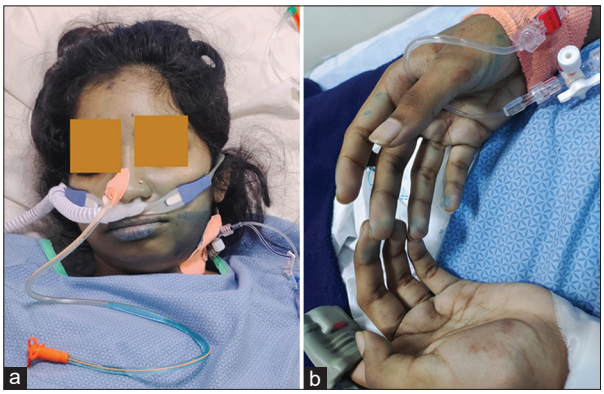

Figure 1: (a) Face showing circumoral cyanosis and nasogastric tube with bluish aspirate, (b) Peripheral cyanosis

$NaNO_2$ oxidizes heme iron by removing an electron and changing it from its ferrous (Fe^{2+}) form to the ferric (Fe^{3+}) form. Hemoglobin with iron in the ferric state is called methemoglobin and cannot bind directly with oxygen, resulting in cyanosis even when the individual shows no other significant symptoms, as in the present case. Due to these allosteric changes, methemoglobin binds fewer oxygen molecules more tightly, making it harder to release oxygen into tissues and causing a leftward shift in the oxygen dissociation curve.

Methemoglobinemia is characterised by a normal SpO_2, although the partial pressure of oxygen is low. Thus, a pulse oximeter may overestimate actual blood oxygen content, possibly leading to a false sense of security in treating patients with methemoglobinemia. Similarly, a falsely high SpO_2 may be seen in carboxyhemoglobinemia. This is because the pulse oximeter is unable to distinguish between oxyhemoglobin and methemoglobin [6]. Diagnosis of both methemoglobinemia and carboxyhemoglobinemia requires the use of co-oximetry, which uses different wavelengths of light to distinguish the various abnormal hemoglobin species.

In addition to impaired oxygen transport, nitrite acts as a strong vasodilator and may lead to systemic hypoxic changes such as coronary ischemia, with electrocardiographic changes of myocardial infarction, tachycardia, stroke due to hypotension, metabolic acidosis, and hyperlactatemia [7]. Myoglobin, a muscle protein, contains a heme subunit capable of binding a single oxygen molecule. In the presence of nitrites, myoglobin can undergo oxidation similar to hemoglobin, reducing its capacity to bind oxygen. This leads to muscular hypoxia and subsequent symptoms such as fatigue, weakness, and muscle cramps. Symptoms correlate with the serum levels of methHb (Table 1) [8].

Distinct signs like cyanosis that does not improve with supplemental oxygen, along with a discrepancy between SpO_2 readings and actual levels

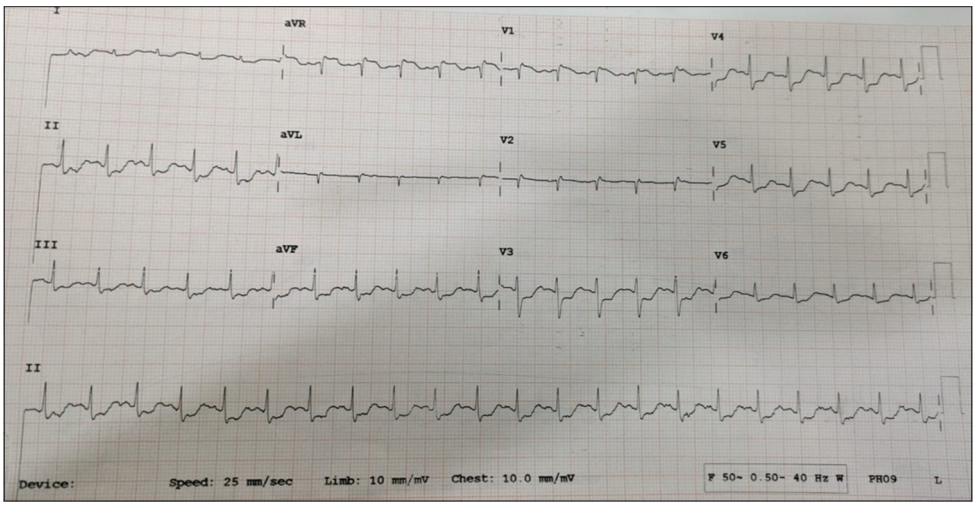

Figure 2: Electrocardiogram showing extensive ST depressions

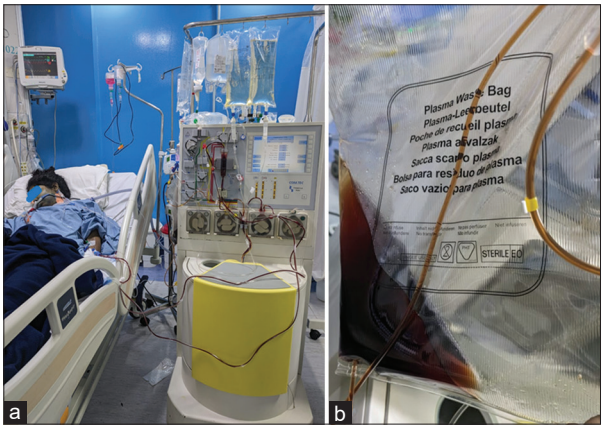

Figure 3: (a) Patient undergoing therapeutic plasma exchange through apheresis machine, (b) Chocolate brown appearance of discarded plasma extracted from patient

Table 1: Symptoms of methemoglobinemia with corresponding serum methemoglobin levels

Methemoglobin levels (%)	Symptoms
1–2	Normal
10–20	Cyanosis
30–40	Headache, fatigue, tachycardia, dizziness, weakness
60	Lethargy, convulsions, coma
>70	Lethal

(saturation gap), and chocolate-brown colored blood, can suggest methemoglobinemia [9]. When these clinical signs are present, treatment may be initiated without confirming methemoglobin levels.

Methylene blue is the primary antidote for treating severe methemoglobinemia. It works by inhibiting nitric oxide synthase and guanylate cyclase, and facilitates the conversion of methemoglobin back to functional hemoglobin, thereby restoring oxygen delivery to tissues. It is advised for patients with methemoglobin levels above 30%, those with risk factors like anemia, or those showing symptoms at any level. It is given at 1–2 mg/kg body weight as a single intravenous dose over 5 min. The maximum dose is 7 mg/kg, and doses higher than this may ironically lead to worsening methemoglobinemia or hemolysis. Smaller therapeutic doses can cause hemolysis in patients with G6PD deficiency; hence, the level should be checked before methylene blue injection [6]. For those with confirmed deficiency, Vitamin C 500 mg IV once daily is an alternative. This acts as an antioxidant and helps convert methemoglobin back to its reduced, oxygen-carrying state. However, its effectiveness in treating $NaNO_2$ poisoning remains under investigation and is still debated.

Clinical improvement often begins within minutes of starting methylene blue infusion, as seen in our patient, who showed visible recovery in skin color and a decrease in methemoglobin levels within 4 h post-treatment. Typically, methemoglobin levels drop substantially within 1–2 h after a single dose of methylene blue, although additional doses might be required.

Other treatment options include red blood cell transfusions or exchange transfusions to replace impaired hemoglobin, as well as HBOT [3,6]. Extracorporeal membrane oxygenation can also be considered as a supportive measure until organ recovery is complete.

CONCLUSION

$NaNO_2$ consumption with suicidal intent has been reported more frequently from Western countries, where it is advocated on online suicide forums. Reports from India are comparatively rare. Patients presenting with peripheral cyanosis for methemoglobinemia by co-oximetry, despite having normal SpO_2 and not improving with supplemental oxygen.

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