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Herbicide-Induced Methemoglobinemia Presenting with Cyanosis and Hypoxemia: A Rare Case Report

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Abstract: ***Methemoglobinemia, a rare condition characterized by the presence of methaemoglobin in the blood, can result from exposure to certain chemicals, including herbicides. Methemoglobinemia occurs when red blood cells (RBCs) contain methaemoglobin at levels higher than 1%. Methaemoglobin results from the presence of iron in the oxidized ferric form (Fe3+) instead of the usual reduced ferrous form (Fe2+). This results in a decreased availability of oxygen to the tissues. This condition can be congenital or acquired. We present a case of a 47-year-old male patient with no significant past medical history, who presented to the hospital with high-grade fever, weakness, cyanosis, and hypoxemia following recent herbicide exposure.***

Keywords: Methemoglobinemia, Hemoglobin, Cyanosis, Hypoxemia, Herbicide, , Oxidizing Agents, Co-oximetry, Methylene Blue

1. Introduction

Methemoglobinemia is a rare but serious condition where elevated methemoglobin levels impair oxygen delivery to tissues. It can be congenital or acquired, often due to exposure to drugs or chemicals. Herbicide-induced methemoglobinemia is particularly uncommon. This report presents a 45- year-old male with cyanosis and hypoxemia after accidental herbicide ingestion. Despite supplemental oxygen, low oxygen saturation persisted, and elevated methemoglobin levels were confirmed. Prompt treatment with intravenous methylene blue led to rapid symptom improvement. This case underscores the need for awareness and prompt management of methemoglobinemia, especially with herbicide exposure.

2. Case Report

The patient, a 47-year- old male, arrived at the hospital with complaints of persistent high-grade fever and weakness. Upon examination, he exhibited evident cyanosis, with low peripheral saturations indicative of poor oxygenation. Two days prior, the patient had been exposed to herbicide during agricultural work. Despite his symptoms, the patient remained hemodynamically stable, albeit with peripheral saturations of 70% and a notable central-peripheral saturations mismatch. Also patient had a negative family history of methemoglobinemia, Arterial blood gas analysis (ABG) on presentation revealed a pH of 7.44, PO2 of 70 mmHg, and PCO2 of 30 mmHg, indicating respiratory alkalosis. The presence of collar dark blue coloration further confirmed the clinical suspicion of cyanosis. A toxicology report was promptly sent to confirm herbicide exposure. Laboratory investigations revealed a normal haemoglobin level of 14 g/dL and total leukocyte count of 14,000/µL, but thrombocytopenia was noted with a platelet count of 3.38 × 10^5/µL. Renal function tests showed elevated urea (33 mg/dL) and creatinine (1.45 mg/dL), warranting close monitoring, A CT chest scan was performed later to assess pulmonary involvement.

3. Discussion: Definition

Methemoglobinemia is a blood disorder in which an abnormal amount of methemoglobin—a form of hemoglobin—is produced. Hemoglobin is the protein in red blood cells that carries and releases oxygen to body tissues. Methemoglobin is hemoglobin in which the iron in the heme group is in the ferric (Fe3+) state, not the usual ferrous (Fe2+) state of normal hemoglobin. This change makes methemoglobin unable to bind oxygen effectively, leading to decreased oxygen delivery to tissues and resulting in symptoms such as cyanosis and hypoxemia.

Pathology

Normally, methemoglobin is present in the blood at very low levels (less than 1%), as it is continuously reduced back to hemoglobin by enzymatic pathways, primarily the NADH-dependent cytochrome b5 reductase system. In methemoglobinemia, either due to genetic defects or exposure to oxidizing agents, this balance is disrupted, leading to elevated methemoglobin levels.

Clinical Manifestations

The clinical manifestations of methemoglobinemia are primarily related to the reduced oxygen-carrying capacity of blood and vary depending on the level of methemoglobin present: 0-10% Methemoglobin: Usually asymptomatic or mild symptoms. 10-20% Methemoglobin: Cyanosis (bluish discoloration of the skin and mucous membranes) without significant symptoms. 20-30% Methemoglobin: Symptoms

such as headache, fatigue, dizziness, and exertional dyspnea.30-50% Methemoglobin: More severe symptoms including dyspnea, confusion, tachycardia, and chest pain. 50-70% Methemoglobin: Severe symptoms like arrhythmias, metabolic acidosis, seizures, and coma. >70% Methemoglobin: Life- threatening symptoms, potentially leadingto death.

4. Diagnosis

Typically, diagnosis is made from the history,typical clinical manifestations, and toxicologyreport, ABG, colour of Blood, Etc.

5. Treatment

Treatment options, including the administration of methylene blue, were thoroughly discussed with the patient's attenders. The mechanism of action and potential complications associated with methylene blue were explained in detail. Following methylene blue transfusion, the patient's saturations improved significantly 78% to 94%, and complaints of cyanosis were alleviated. Subsequent ABG demonstrated normalization of pH (7.35) and improvement in oxygenation parameters. The patient was initiated on piperacillin- tazobactam antibiotic therapy, vitamin C injection, and supportive care to address any underlying infection and oxidative stress. Upon stabilization, the patientwas discharged with close follow-up arranged.

Diagnostic Difficulties

- Non – specific symptoms.
- Cyanosis that does not improve with oxygentherapy
- Pulse oximeters may show oxygen saturation levels around 85% regardless of actual oxygenation status, which can be misleading. This discrepancy is due to the pulse oximeter's inability to differentiate between oxyhemoglobin and methemoglobin accurately.
- Symptoms and signs of methemoglobinemia can overlap with other conditions like carbon monoxide poisoning, anemia, and various cardiac or respiratory disorders, complicatingthe differential diagnosis.
- Patients may not always recall or disclose exposure to potential oxidizing agents (e.g., certain medications, chemicals), making it difficult to link symptoms to methemoglobinemia.

6. Conclusion

This case underscores the importance of considering herbicide exposure in patients presenting with cyanosis and hypoxemia, especially in agricultural settings. Prompt recognition and appropriate management, including methylene blue administration, can lead to favorable outcomes and prevent potential complications. Further research is warranted to better understand the pathophysiology and optimal management strategies for herbicide- induced methemoglobinemia

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