

Methanol-Induced Bilateral Optic Neuropathy: An Ever-Presenting Challenge to the Healthcare System

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Case Report

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ABSTRACT:

Methanol is a highly toxic alcohol that can cause severe metabolic acidosis, leading to multi-organ failure and permanent blindness. Despite its seriousness, methanol poisoning remains a significant challenge, particularly in resource-limited settings due to inadequate acute care facilities and the unavailability of specific antidotes. We report the case of a 27-year-old female who presented with nausea, vomiting, and altered consciousness 12 hours after alcohol consumption. Initial investigations revealed high anion gap metabolic acidosis unresponsive to bicarbonate therapy and fluids, which was corrected following a Sustained Low-Efficiency Dialysis (SLED) session. Despite metabolic correction, the patient developed sudden bilateral vision loss 48 hours after admission. Magnetic resonance imaging (MRI) of the brain revealed hemorrhagic necrosis in the basal ganglia. Although high-dose intravenous methylprednisolone followed by oral steroids and vitamin supplementation were initiated, the patient had persistent visual impairment. Neurological and ophthalmological evaluations confirmed methanol-induced optic neuropathy. This case highlights the potential for delayed ocular toxicity even after acidosis correction and underscores the critical importance of early recognition and timely intervention in methanol poisoning. Improved access to antidotes and multidisciplinary care are essential to prevent irreversible complications.

Key words: Methanol toxicity, Optic neuropathy, Methylprednisolone, Visual outcome

INTRODUCTION:

Methanol is a colorless and lethal alcohol that is widely used in numerous industries as a solvent, fuel and insecticide. They are highly toxic if inhaled, swallowed or absorbed through the skin. Of all these possibilities, ingestion is the most dangerous as even 10 mL of pure methanol is sufficient to cause severe poisoning and permanent blindness.¹ A prevalent symptom of methanol intoxication is ocular toxicity, which can culminate in total blindness or impaired vision.² Methanol's effect causes acute bilateral optic disc oedema and subsequent optic atrophy.^{3,4} Methanol poisoning usually leads to immediate, rather than long-term, harm to the body. It manifests as symptoms related to the digestive system such as gastrointestinal issues, depression of the central nervous system, confusion, coma, cardiac and respiratory arrest, and severe metabolic acidosis. The latter is the main cause of death in such cases.^{5,6} The mortality rate associated with methanol poisoning varies from 8% to 23%,⁷ and survivors frequently experience permanent vision impairment in 15-40% of cases.⁸⁻¹⁰ Social and cultural factors in Bangladesh contribute to the underreporting of methanol poisoning cases, with patients postponing medical help due to legal concerns.

CASE REPORT:

A 27-year-old female without any past medical illness presented to the Department of Acute Medicine and High Dependency Unit with complaints of nausea, vomiting, and altered level of consciousness for 12 h. On query, she had consumed a significant amount of alcohol 12 h before admission. She did not give any history of fever, headache, convulsions or head trauma. Clinical examination revealed that the patient was tachypneic, with stable hemodynamics. She was drowsy with a Glasgow Coma Scale score of E3V4M6, bilaterally

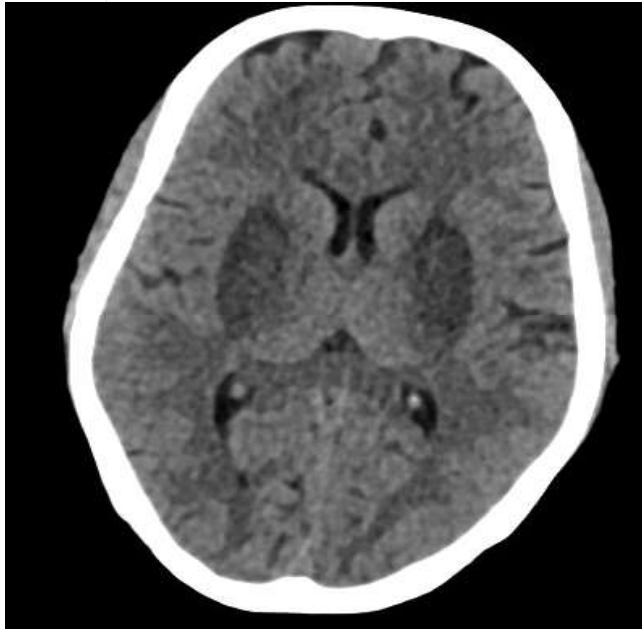


Fig-1: Bilateral symmetrical ill-defined hypodensities involving basal ganglia and subcortical white matter of both frontal lobes

equally dilated (4 mm) pupils reacting to light, normal deep tendon reflexes, and bilateral flexor plantar responses. Immediate arterial blood gas analysis (ABG) showed severe high anion gap metabolic acidosis: pH 6.77 (normal range, 7.35 to 7.45), PCO_2 of 17.2 mmHg (normal range, 35 to 45 mmHg), bicarbonate level of 4.3 mmol/L (normal range, 21 to 25 mmol/L), anion gap of 25 mmol/L (normal range, 8 to 18 mmol/L), and lactic acid level of 1.9 mmol/L (normal range, 0.60 to 2.20 mmol/L), that was not corrected by intravenous sodium bicarbonate and adequate fluid resuscitation. The acidosis persisted, and metabolic acidosis was corrected after a Sustained Low-Efficiency Dialysis (SLED) session. Considering the diagnosis of methanol poisoning, intravenous folate and high-dose vitamin B administration were initiated. Blood methanol levels could not be measured because of the lack of equipment at our hospital. Antidotes for fomepizole and ethanol were unavailable. However, she developed sudden vision loss after 48 hours. Clinical examination revealed a bilaterally equally dilated (6 mm) pupil that did not react to light on normal fundoscopy, and visual acuity was reduced to hand motion. Consultations were obtained from the Neurology Department. A non-contrast computed tomography (CT) scan of the head was done, and it revealed bilateral symmetrical

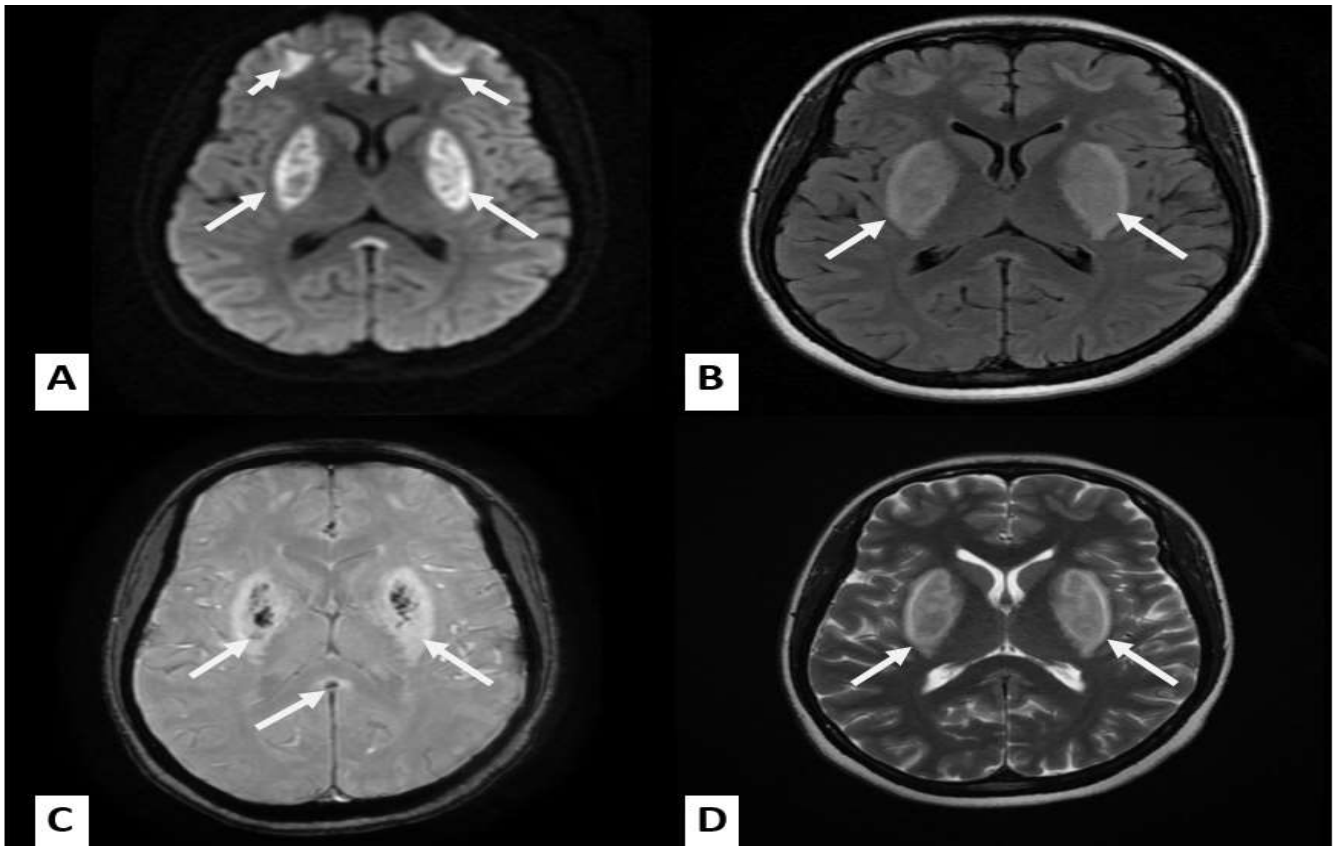


Fig-2: MRI brain showed bilateral symmetrical signal abnormality in basal ganglia and subcortical white matter of frontal lobes displaying diffusion restriction in (A) DWI image (B) Axial T2 Flair (D) Axial T2, *Petechial hemorrhage is seen in the lesions of basal ganglia in (C) Axial SWI. Tiny acute lacunar infarcts are seen in cortex and periventricular region of both cerebral hemispheres. Acute infarct is also seen in right temporal lobe and splenium of corpus callosum

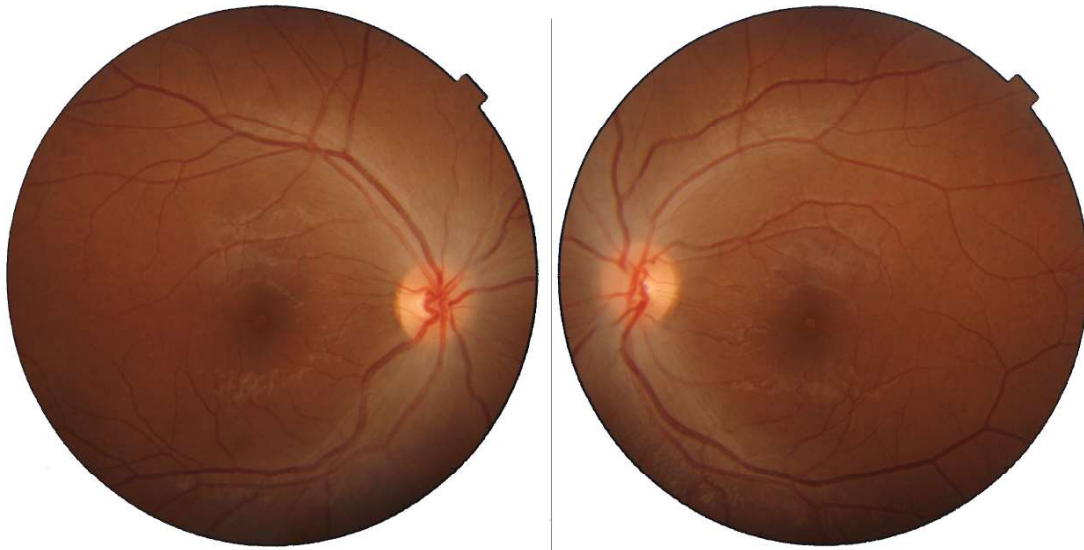


Fig-3: Color fundus photograph - revealed normal findings

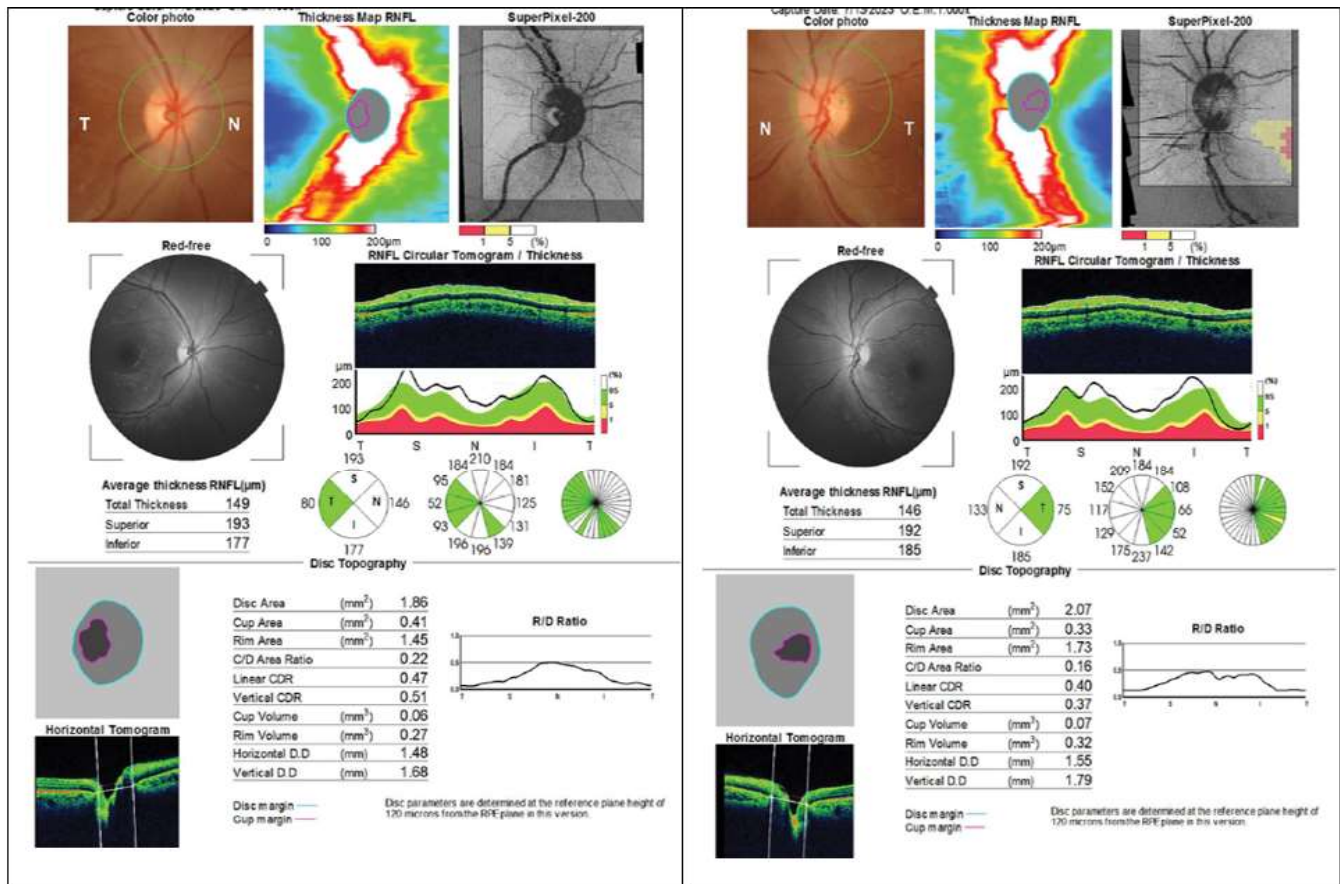


Fig-4: Optical Coherence Tomography (OCT) - revealed normal findings

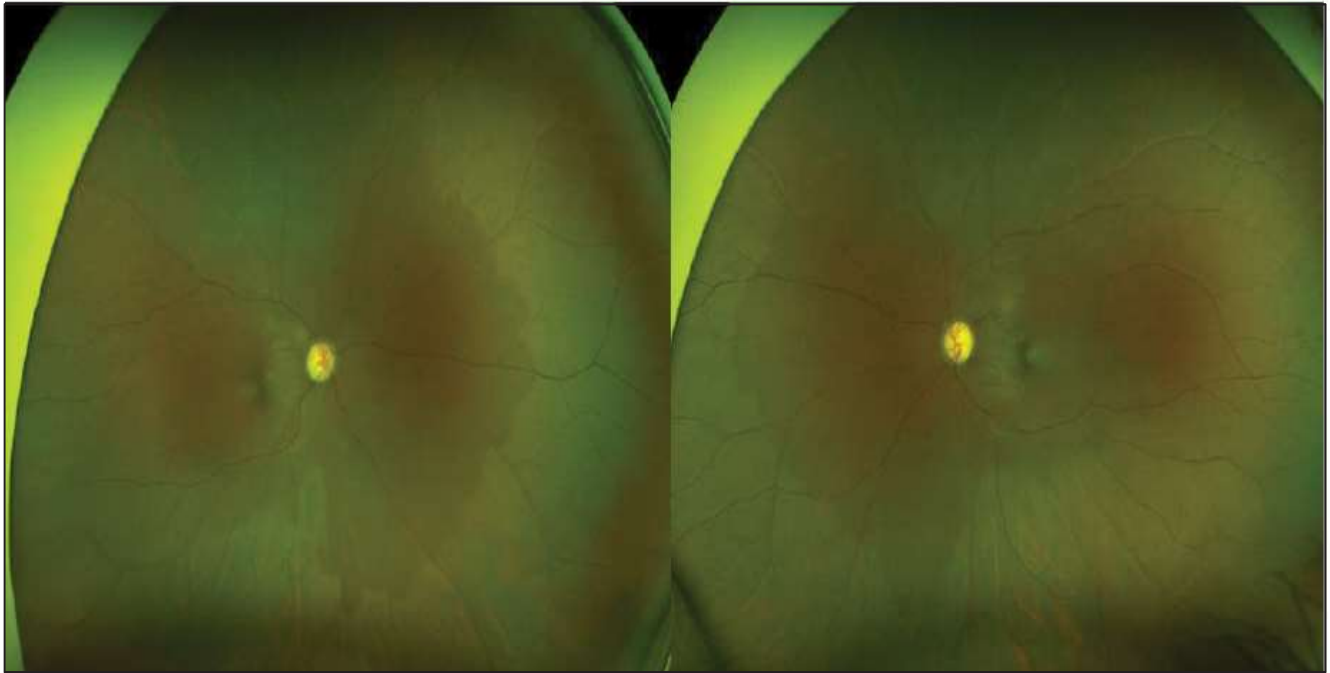


Fig-5: Color fundus photograph - revealed bilateral optic atrophy

ill-defined hypodensities involving basal ganglia and subcortical white matter of both frontal lobes. (Fig-1) Brain magnetic resonance imaging revealed bilateral symmetrical diffusion restriction in the basal ganglia and subcortical white matter of the frontal lobes, hemorrhage in the basal ganglia lesions, acute infarct in the right temporal lobe and splenium of the corpus callosum, and tiny acute lacunar infarcts in the cortex and periventricular region of both cerebral hemispheres. Features favor acute methanol toxicity with hemorrhagic necrosis in the basal ganglia. (Fig-2 A, B, C, D)

The patient was prescribed intravenous methylprednisolone 1000 mg once daily for five consecutive days and continued with oral prednisone at a dose of 1 mg/kg, oral folate 10 mg three times, and thiamine 100 mg daily. Consultations were obtained from the Ophthalmology Department. Color fundus photography (CFP) (Fig-3) and optical Coherence Tomography (OCT) were performed, and the results were normal. (Fig-4) 5 days later, the patient was discharged from the hospital in stable condition. Her sensorium recovered completely at the time of discharge, but her vision was finger-counting at 1 ft. Steroid tapering was advised. During the subsequent visit for two months, her eyesight did not improve, and finger counting reduced only light perception. After 4 months, fundoscopic examination revealed bilateral optic atrophy (Fig-5).

DISCUSSION:

Optic neuropathy due to methanol is a diagnostic challenge, and we present the clinical manifestations, management protocol, and outcomes of a patient with methanol intoxication who was treated in the Acute Medicine and HDU Department at a tertiary-level hospital. We must thoroughly investigate any

potential history of methanol exposure, since it can occur via numerous pathways.⁶ Another specific group of symptoms includes central nervous system depression, metabolic abnormalities and visual impairments.¹¹ The presence of metabolic acidosis denoted by an elevated anion gap and a heightened osmolar gap, despite the absence of a clinical history, reinforces the diagnosis.¹² In the above patient, the clinical history and the laboratory findings helped in reaching the diagnosis. When toxic alcohol levels are unavailable or do not fall within the 30- to 85-hour half-life range, diagnosis becomes difficult.^{2,13} As in our case, blood toxic alcohol examinations were not routinely performed at our center. In developing countries with poor regulation of liquor production and distribution, methanol is often the primary suspected toxic agent in patients with a history of local alcoholic beverage consumption. Supportive examinations were performed to confirm this diagnosis. Brain imaging typically reveals hyperintense T2 signals and involvement of the bilateral putamen, although normal brain images can still be obtained.

Methanol toxicity has the greatest effect on the putamen, basal ganglia, subcortical white matter of the brain and optic nerves. In this case, bilateral putaminal necrosis was observed on the brain magnetic resonance imaging (MRI). On certain occasions, patients may only exhibit visual symptoms, which can complicate diagnosis. It is important to note that visual problems can arise 4–48 h after methanol exposure.² In our case, ophthalmological symptoms became evident two days after exposure. Methanol ocular and central nervous system toxicity develops through a combination of metabolic acidosis and formic acid, which damages the optic nerve and leads to histotoxic hypoxia.¹⁴ Ocular toxicity may present in a range of

manifestations from blurred vision to complete blindness in cases of significant poisoning.¹³ Loss of vision may take place inconsistently. The most commonly encountered signs include optic disc pallor, papilledema, central scotoma, hyperemia and afferent pupillary defects.

Optical Coherence Tomography (OCT) is a noninvasive imaging modality that facilitates high-resolution examination of the retinal nerve fiber layer (RNFL). In experimental studies of toxic optic neuropathy, methanol caused immediate nerve fiber edema and persistent nerve fiber shrinkage. As in methanol poisoning, B12 deficiency can diminish nerve fiber findings on OCT. OCT may reveal peripapillary nerve fiber swelling in conjunction with the accumulation of intraretinal fluid.¹⁵ Previous studies have suggested that individuals with methanol-induced optic neuropathy may experience a reduction in RNFL thickness, even years subsequent to the initial acute episode.¹⁶ In the present case, there was an initial presentation of normal RNFL thickness.

The diagram offers a comprehensive schematic representation of the methanol metabolic pathway, supplemented by the resultant indicators and relevant interventions.

Treatment options for methanol-intoxicated patients include intravenous sodium bicarbonate and folic acid. Protocols indicate that an antidote, ideally fomepizole as opposed to ethanol, should be administered once the serum methanol concentration reaches or exceeds 15 mg/day. The initiation of hemodialysis along with an antidote should be initiated when the serum methanol concentration is at or above 50 mg/day.⁸ We could not give fomepizole due to resource constraints. Hemodialysis is an effective intervention for methanol intoxication that facilitates the correction of acidosis and elimination of methanol from the bloodstream. Coma, seizures, initial manifestations of visual impairment, severe metabolic acidosis with arterial blood pH levels below 7.14, an anion gap of more than 18 mmol/L and elevated serum methanol concentrations collectively justify the necessity of hemodialysis.¹⁷ Bicarbonate administration and hemodialysis were adequate for the management of metabolic acidosis in this case, as our patient fulfilled these criteria. Treatment regimens including ethanol, fomepizole, folic acid, sodium bicarbonate, and hemodialysis prevent formic acid formation and further toxicity but do not remove established ocular inflammation, which is the classical mode of presentation in

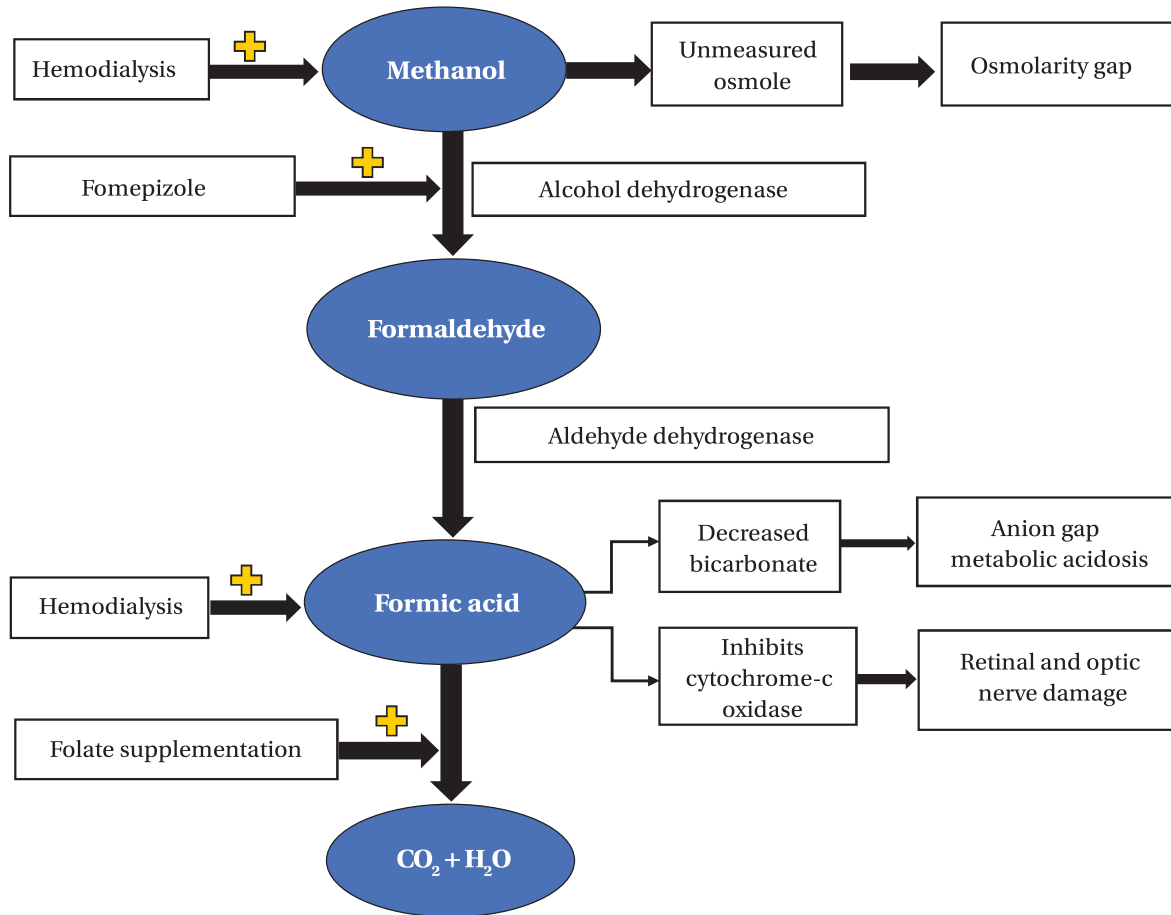


Diagram: Comprehensive schematic representation of methanol metabolic pathway

acute methanol poisoning cases.¹⁸ A trial was conducted where intravenous methylprednisolone was administered for a duration of three days, followed by oral prednisolone. This treatment led to a notable enhancement in visual acuity in all patients, with the exception of one individual.¹⁸ The importance of folic acid supplementation cannot be overstated, as folic acid is required as a cofactor for the enzyme that breaks down formic acid.¹⁸ Similarly, bicarbonate administration can significantly improve metabolic acidosis and prevent nerve damage due to formic acid.¹⁹ To prevent permanent blindness in cases of methanol-induced optic neuropathy, intravenous steroid therapy is necessary. This is because it reduces inflammation of the retina and swelling of the optic nerve.²⁰ It was found that most patients who received methylprednisolone and neuroprotectants showed enhanced visual acuity within six days after being exposed to the treatment. Additional treatment alternatives have been investigated, such as erythropoietin and antioxidants, which function as neuroprotective agents. In this case, the patient received the same initial treatment, including intravenous methylprednisolone 1000 mg once daily for 5 days followed by oral prednisolone for 14 days. Early presentation and prompt initiation of therapy did not appear to influence visual recovery significantly. In contrast, another study identified visual sequelae in patients with prolonged metabolic acidosis.²¹ In this case, it took 12 hours from exposure to the first therapy. The outcome was unfavorable, even if the starting treatment schedule was somewhat similar and the admission severity was identical. Although the role of metabolic acidosis should not be underestimated, it emphasizes the importance of closely monitoring all patients with toxic optic neuropathy. Commencing therapeutic intervention at the earliest opportunity is crucial, as evidence indicates that efficacy is lost even after a duration of six days. In our case, no significant visual improvement was noted despite the correction for metabolic acidosis and steroid therapy.

CONCLUSION:

Methanol-induced optic neuropathy is a serious complication that is often irreversible and poses significant challenges in terms of its diagnosis and management. Not only do early interventions, such as high-dose intravenous methylprednisolone and hemodialysis, have a poor prognosis for vision recovery in these cases, but the prognosis worsens with delayed treatment. This case emphasizes the crucial role of early recognition and management and the necessity to perform visual electrophysiological tests to prevent irreversible neurological damage and decrease long-term visual disability associated with such poisoning. Improved access to antidotes such as fomepizole or ethanol and timely metabolic correction are essential for improving patient outcomes. This case also highlights the importance of improved awareness and access to appropriate healthcare systems in resource-limited areas for the management of methanol toxicity to minimize the associated morbidity and mortality.

Conflict of Interest: The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

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Ethical Compliance: Informed consent was obtained from the patient for publication of the case details and images. As this was a case report, ethical review and approval by an institutional ethics committee were not required.

Author Contributions: Sadat MI and Nizhu L were involved in the conception and design of the case report. Ahmad J and Anam AM were involved in the acquisition of data and clinical management of the patient. Sadat MI and Nizhu L contributed to drafting the manuscript. All authors have reviewed and approved the final manuscript.

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