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Case Report

Delayed brain injury post carbon monoxide poisoning

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ARTICLE INFO

Article history:

Received 11 May 2020

Revised 15 July 2020

Accepted 17 July 2020

Keywords:

Globus pallidus

Carbon monoxide poisoning

Carboxyhemoglobin

Hyperbaric oxygen

Parieto-occipital lobe

Delayed neuropsychiatric sequelae

ABSTRACT

A 66-year-old male was found unresponsive and diagnosed with acute carbon monoxide poisoning, with pathognomonic findings on radiological imaging. During his first day's the patient underwent acute neurological deterioration; however, this was followed 2 weeks later with a subsequent improvement to near baseline. The improvement back to baseline was short-lived, and the patient quickly worsened and underwent neurological decompensation. These findings were consistent with delayed post hypoxic leukoencephalopathy, serious sequelae of carbon monoxide poisoning. This case report shows the importance of recognition of carbon monoxide toxicity and aims to improve accurate diagnosis of the sequelae that may follow using computed tomography and magnetic resonance imaging sequences, magnetic resonance spectroscopy in order to prevent or ameliorate further neurological decline.

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Introduction

Carbon monoxide is an odorless, tasteless, poisonous byproduct of partial combustion of fossil fuels that is a leading cause of brain injury and death due to suicidal attempts or accidental exposure. Its high morbidity and mortality are associated with impaired functioning of the red blood cells to transport oxygen to the tissues [1–4].

The survivors of the carbon monoxide toxicity present with white matter demyelination and necrosis of the Globus pallidus that further result in a range of clinical sequelae, for instance, reversible anoxic-ischemic encephalopathy or irreversible dementia. However, 1 rare underrecognized sequela is delayed posthypoxic leukoencephalopathy.

Delayed posthypoxic leukoencephalopathy, as a result of carbon monoxide poisoning, is characterized by initial hypoxic insult with a subsequent return to baseline or near baseline later followed by severe neurological deterioration or new neurological or psychiatric symptoms. The chronic stage includes progressive neurological decline [5,6].

Case presentation

A 66-year-old male with a previous medical history of hyperlipidemia arrived at the Emergency Room via ambulance after being found unresponsive for an indefinite amount of time in an auto-body shop adjacent to a car with the engine turned

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<https://doi.org/10.1016/j.radcr.2020.07.048>

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Fig. 1 – Noncontrast CT image through the brain shows a wedge-shaped hypodensity at the parieto-occipital region with loss of gray-white differentiation.

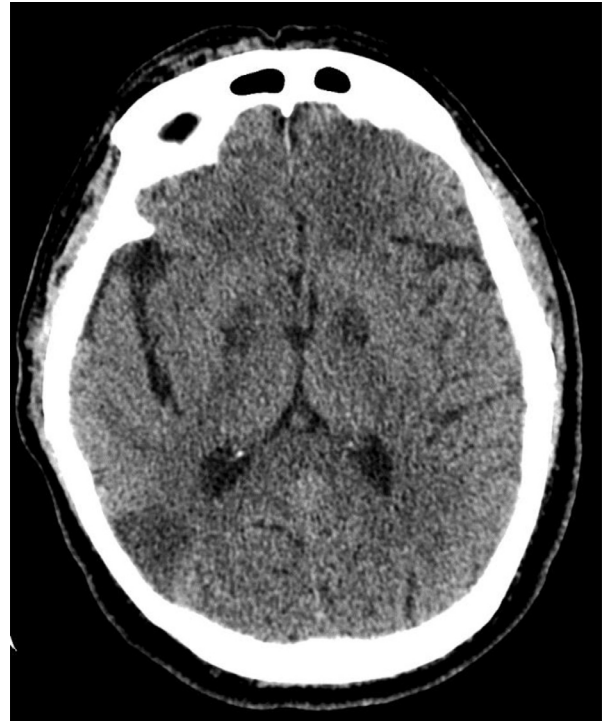


Fig. 2 – Noncontrast CT image through the brain shows a bilateral, symmetrical hypoattenuation of the Globus Pallidus and a stable hypodensity in the right parieto-occipital lobe.

on. His Glasgow Coma Score was 5, and physical examination noted a left-sided facial droop, reactive pupils, and grossly intact cranial nerves and deep tendon reflexes. In the Emergency Department, the patient was intubated, sedated with propofol, and placed under mechanical ventilation for airway protection before being transferred to the medical ward. Arterial Blood Gas results showed carboxyhemoglobin blood levels $>27\%$ when normal levels of carboxyhemoglobin for a non-smoker adult is 2%-3%, thus indicating carbon monoxide poisoning. This led to a concurrent diagnosis of acute hypoxic respiratory failure. The patient was not a candidate for hyperbaric oxygen therapy. The patient was febrile to a maximum temperature of 102°F . Initial chest radiograph revealed a left lower lobe consolidation. The laboratory values showed leukocytosis, bandemia, and lactic acidosis. The patient was treated empirically with vancomycin and zosyn for presumed aspiration pneumonia.

Electrocardiography revealed normal sinus rhythm, non-ST segment elevation myocardial infarction, and elevated troponins (2.47 ng/mL >3.89 ng/mL >4.16 ng/mL) likely secondary to carbon monoxide poisoning. The computed tomography (CT) of the brain on admission (Fig. 1) illustrated an acute ill-defined hypodensity in the right parieto-occipital region with loss of gray-white matter differentiation consistent with acute infarction in a watershed distribution.

On hospital day 2, the patient experienced decreased mental status and was less responsive. A repeat CT brain scan was performed. CT head without contrast (Fig. 2) revealed interval development of bilateral symmetrical Globus Pallidus hypodensities in the expected distribution associated with an

acute carbon monoxide poisoning. This was followed by clinical improvement with associated brief periods where he was able to communicate with his daughter.

On hospital day 12, patient mental status worsened, and he was no longer able to communicate with his daughter. Magnetic resonance imaging (MRI) of the head with and without contrast was obtained, revealing a 3 cm wedge-shaped focus on high FLAIR/T2 signal in the right parieto-occipital distribution, indicative of subacute infarction (Fig. 3). Further findings on FLAIR/T2 signal included bilateral symmetric rounded foci of increased signal in the Globus Pallidus, highly suggestive of carbon monoxide intoxication. A nonspecific patchy high FLAIR signal was acknowledged throughout the periventricular and subcortical white matter, which suggested an abnormal leptomeningeal enhancement.

During the patient's 4-week-long hospital stay, the patient continued to spike fevers and was appropriately managed with antibiotics. The patient was well saturated above 98% on 4L oxygen via nasal cannula and received pulmonary physiotherapy. Cardiology examination reported an ejection fraction of 65% and no hemodynamically significant stenosis on bilateral internal carotid arteries. The patient received consistent tube feeds for nutrition. The patient was eventually removed off sedation as his mental status gradually improved on week 2, yet he remained lethargic, and intermittently responded to vocal and tactile stimuli. During this time, we appreciated a delayed relapse in clinical-behavioral evaluation, after an initial recovery period. The patient presented with an akinetic-mute state, with psychomotor retardation, all of

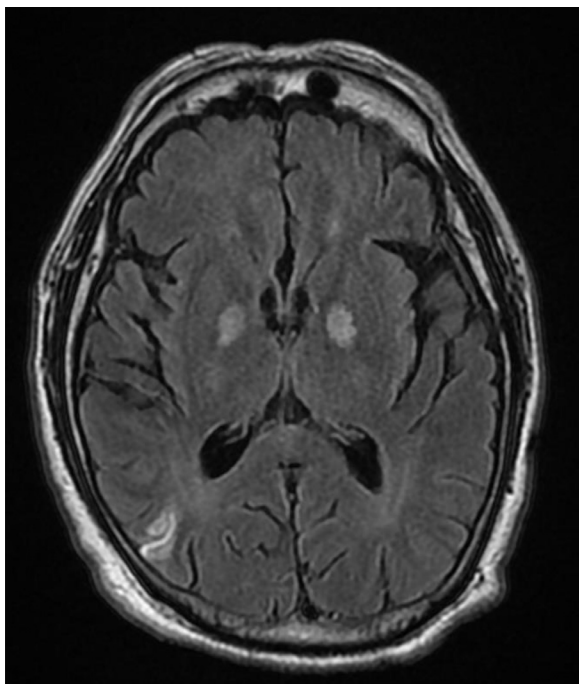


Fig. 3 – Axial MRI high FLAIR/T2 shows an abnormal increased signal of symmetrically rounded foci in the Globus Pallidus bilaterally.

which the patient's family acknowledged. He remained bed-bound and without orientation through the remainder of his hospitalization. On week 3, the patient was extubated and transferred to the medical floor. He continued to be somnolent, exhibited a decreased range of motion in all 4 extremities, and grimaces to painful stimuli. As a result of his progressive neurological decline, further investigations were completed to rule out underlying cerebral infections. A lumbar puncture was negative for Herpes Simplex virus, Lyme, and HIV. The cytology report was unremarkable. There was no evidence of infectious disease or vasculitis. The patient was transferred to a long-term care facility for closer monitoring and management of his care.

Four months later patient was readmitted due to COVID-19 infection complications. During that time, the patient's mental status had progressively declined – he was mute, nonverbal, quadriplegic, requiring mechanical ventilation, and tube feeds via a PEG tube.

In summary, our patient had an initial insult of carbon monoxide poisoning followed by a return to near baseline and further neurological deterioration consistent with a diagnosis of delayed posthypoxic leukoencephalopathy.

Discussion

Our brain tissue is particularly sensitive to carbon monoxide toxicity due to its highly deleterious effects. The common manifestation of carbon monoxide poisoning is bilateral damage to the basal ganglia and cerebral cortex. The typical patho-

logical variations generally comprise bleeding in the white matter, degeneration, necrosis of the bilateral Globus Pallidus, ventriculomegaly, progressive demyelination in the cerebral cortex, hypothalamus, hippocampus, and rarely cerebellar lesions [2,3]. The literature describes a marked difficulty in differentiation and diagnosis of disease. In this case, we focused on interpreting radiological findings with clinical evidence to support the unclear prognosis of acute carbon monoxide poisoning.

MRI provides reliable clinical-pathologic information on brain damage after carbon monoxide poisoning. The research on anoxic brain injury delineates various frequent changes in cerebral white matter. The investigation focuses on the observation of cerebral white matter changes that are frequently detected on MRI and are recognized as evidence for chronic symptoms [7–9].

In our case, we appreciate multiple nonspecific enhancements on MRI. Enhancement is depicted along the cerebral sulci bilaterally, as well as patchy high FLAIR throughout the periventricular and subcortical white matter. Although our imaging studies were limited in scope, the literature recommends employment of either Diffusion-Weighted Imaging (DWI) or Magnetic Resonance spectroscopy throughout the patient's hospitalization period to assess the continued cerebral white matter injury [10–12]. Such changes correlate with the progressive clinical decline in mental status and orientation [13].

The DWI allows us to quantitatively assess cerebral white matter damage [13]. DWI can demonstrate progressive pathologic changes in the early stage, allowing the prediction of chronic conditions. Characteristic cerebral white matter lesions include small necrotic foci, widespread necrosis with axonal destruction, and demyelination with preservation of axons in the deep white matter [14]. The latter characteristic is often appreciated in patients with delayed posthypoxic leukoencephalopathy also referred to as Grinker myelinopathy [1]. We now realize that carbon monoxide brain injury ignites a progressive process that can proceed for months [7]. The pathophysiological explanation for progressive white matter damage emphasizes the effect of ATP depletion, inflammatory response, lipid peroxidation, and microglial proliferation [15]. The clinical picture postcarbon monoxide cerebral injury is vague and infrequently includes delayed posthypoxic leukoencephalopathy, which is a rare neurological disease that usually occurs following cerebral hypotension [16]. Causes of delayed posthypoxic leukoencephalopathy include carbon monoxide poisoning, opioid overdose, or other anoxic triggers [2]. Formal epidemiological studies have not been conducted due to the rarity of the condition [15]. Delayed posthypoxic leukoencephalopathy is characterized by a parkinsonian like syndrome, which typically follows a biphasic course [16]. An initial period of mental decline is followed by a period of recovery to baseline. Subsequently, 2–4 weeks later, neurocognitive deterioration recurs. For one to be diagnosed with delayed posthypoxic leukoencephalopathy, the patient must be ≥ 18 years of age and have the following criteria, which our patient met, such as (1) neurological deterioration caused by an initial hypoxic event, (2) subsequent clinical improvement with a return to (prehypoxic event) baseline or near baseline, and (3) neurological relapse or

new neurological or psychiatric symptoms following clinical improvement [5,6]. Our patient had a brief lucid period where he began to communicate with his daughter, expressed good orientation (knew his age and current year), and followed commands. Shortly after, his mental status decompensated. This was followed by discharge to a long-term rehabilitation facility. During this chronic phase, our patient suffered a progressive neurological decline, which can be detected with cerebral CT or MRI. Due to COVID-19 considerations, the patient was unable to have this routine follow up. However, a physical exam showed decreased mental status, mutism, and quadriplegia. This case features most closely resemble the akinetic-mute form of phase 2 in delayed posthypoxic leukoencephalopathy. This form is clinically characterized by bizarre behavior, psychomotor retardation, and mutism. The imaging findings most essential for the diagnosis delayed posthypoxic leukoencephalopathy are the changes on T2-weighted and DWI-MRI [16].

Conclusion

Improved awareness of the neurological sequelae associated with carbon monoxide toxicity and its rare progressive disease is paramount. Delayed posthypoxic leukoencephalopathy is under-recognized due to its late manifestation. The employment of repeat cerebral MRI, CT, and Magnetic Resonance spectroscopy provides a diagnostic approach that can defend clinical symptomology and allow for accurate prognosis.

Consent

The patient and family provided verbal consent for publication of this case report and for any use of accompanying images.

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