MRI and clinical manifestations of delayed encephalopathy after carbon monoxide poisoning

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Abstract: To explore the relationship between the clinical manifestations and functional magnetic resonance images (MRI) of delayed encephalopathy after carbon monoxide intoxication. Six patients received the MRI were diagnosed with delayed encephalopathy after carbon monoxide (CO) poisoning. Clinical manifestations were observed in each patient. MRI revealed multiple lesions. The majority of the lesions were located in the globus pallidus, sub cortical white matter, and basal ganglia. The cognitive injury, akinetic mutism, fecal and uroclepsia, forced crying, forced laughing and extra pyramidal syndromes such as chorea and parkinsonism were manifested in clinic. Cognitive impairment improved greatly while involuntary movements only improved slightly after several months. Meanwhile brain MRI suggested remarkable improvement. Neuroimaging directly correlated with the clinical manifestations

Keyword: Carbon monoxide, delayed encephalopathy, MRI, subcortial white matter.

INTRODUCTION

Acute carbon monoxide (CO) poisoning may lead to hypoxic encephalopathy at varying degree, including disorientation, disorder, coma, or even death (Raub *et al*., 2000). Delayed encephalopathy after acute monoxide poisoning (DEACMP) is a complication with carbon monoxide (CO) poisoning (Choi., 1983). There were 0.2% to 40% patients with CO poisoning present with delayed-onset neurological symptoms, including mental deterioration, gait disturbance, or sphincter incontinence, even experiencing a pseudo recovery period (lucid interval) ranging from 2 days to 40 days (Chang *et al*., 1992). Several reports have detected notable changes in the neuroimaging findings, time course of recovery, and long-term prognosis in delayed encephalopathy (Hsiao, Kuo and Huang, 2004; Lin *et al*., 2009) The potential pathological lesion is supposed to be the diffuse demyelination of the cerebral white matter (leukoencephalopathy); and mechanisms of underlying delayed encephalopathy in men and even in laboratory animal, are not fully understood (Kim *et al*., 2003). In China, acute CO poisoning is of clinical concern, but the data on delayed encephalopathy are still lacking (Hu *et al*., 2011). The study aims at understanding the link between brain neuroimaging results and the clinical manifestations of DEACMP in the Chinese population.

MATERIALS AND METHODS

Twelve patients were retrospectively reviewed (ages 60 to 78 years) who were diagnosed with delayed encephalopathy after acute CO poisoning between March 2009 and February 2010 in the Second Hospital of Zhengzhou. All of the patients experienced CO poisoning due to incorrect use of coal stoves in their homes. Patients were diagnosed with DEACMP based on the following criteria: (1) patients had a clear history of acute CO poisoning, exhibiting distinct neuropsychological symptoms, (2) patients experienced a distinct pseudo precovery period, or "lucid interval" (14~40 days); (3) recurrence of symptoms after lucid interval. We excluded six patients who did not maintain regular follow-ups. Therefore, only six patients conformed to the study. The participants were consisted of three male patients men and three female patients, with a mean age of 70±8 years and a range of 60-78 years. All patients experienced prominent neurological dysfunctions in the acute stage and were treated with high flow of O_2 or hyperbaric oxygen therapy. All patients responded positively to the treatment within 0.5-3 days, but subsequently developed delayed encephalopathy. Magnetic Resonance Imaging (MRI) occurred 25-95 days after CO exposure. MRI was conducted by using a 3,0-The MRI was made from axial T2-weighted fast spin-echo (TR/TE, 4500/120.4, ETL32), axial fluid-attenuated inversion recovery (FLAIR) (TR/TE/TI, 9500/146/2350) and sagittal T1-weighted fast spin-echo (TR/TE, 2395.9/8.4, ETL, 9) sequences. Diffuse weighted images (DWI) and apparent diffusion coefficient (ADC) maps were produced from the axial plane by using a single-shot spin-echo echo-planar imaging sequence with the following parameters: TR/TE/NEX of 6000/68/1, a 128_128 matrix, a 24_24-cm field of view and a 6-mm section thickness with a 1 mm gap. Diffusion gradients were applied along three orthogonal directions (x, y and z axes) with two b values

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(0 and 1000 s/mm^2). Iterative nonlinear least-squares fit of a monoexponential decay was used to produce a trace ADC map, which was written on an IDL platform.

Clinical symptoms and MRI results were carefully observed for each patient. All patients received monthly follow-ups in the outpatient clinic by one of the authors (Xiahong Wang) for up to six months.

RESULTS

Clinical manifestations

The main clinical features of acute CO poisoning included neurological dysfunctions and deep or semi-coma. Neurological dysfunctions included: (1) cognitive impairment; (2) apathy; (3) akinetic mutism; (4) chorea; (5) confusion; (6) fecal and urine incontinence; (7) reduced speech; (8) difficulty swallowing; (9) dystonia; (10) forced crying and forced laughing; (11) parkinsonism. Neurological dysfunctions for each patient returned to baseline between 12 hours and 3 days after onset. However, other symptoms persisted between 14 to 40 days after the first acute episode. Table 1 outlines the clinical manifestations in the acute stage and delayed phase, as well as the correlating neuroimaging results.

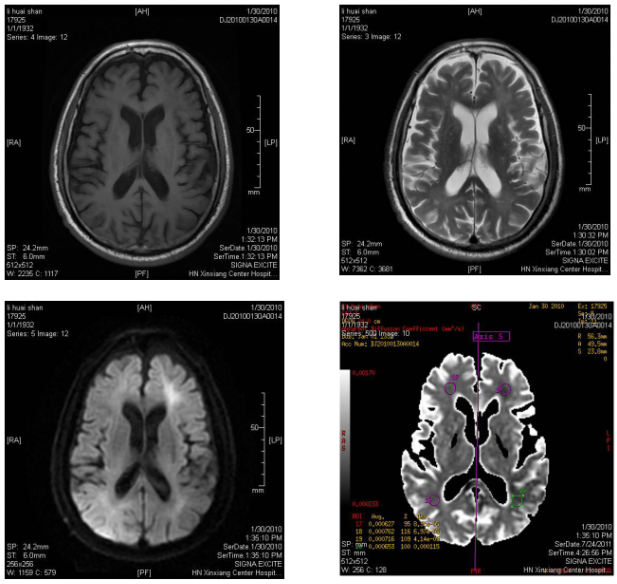

Fig. 1: Brain MRI of a 78-year-old man with delayed encephalopathy after CO intoxication. The brain MRI was obtained five days subsequent to diagnosis of delayed encephalopathy after CO intoxication. T1 weighted images show symmetric lesions of the lateral ventricular side as well as low intensity centrum semio vale lessons. T2 weighted images and DWI reveal hyper intense lesions.

Clinical follow-ups

All patients had clinical follow-ups for the first there months after acute CO poisoning diagnosis. Cognitive dysfunction was the first symptom to improve during the follow-up period. Other improved symptoms included: chorea, stiffing, fecal and urine incontinence and difficulty swallowing.

Brain neuroimaging findings

Brain MRI was performed during the first week of neurological symptoms, as shown in fig. 1. T1 weighted images revealed multiple low intensity lessons on while hyperintenseive lesions were seen on T2 weighted images. DWI also detected hyperintenseive lesions, mainly in the sub cortical white matter (sub cortical white matter, SWM) and basal ganglia (basal ganglia, BG), and also in the globus pallid us (globus pallid us, GP), lateral ventricular thalamus and in the centrum semio vale. Five patients exhibited symmetric lesions in the SWM, while only one patient had asymmetric lesions.

DISCUSSION

Carbon monoxide poisoning is the major reason that causes lethal intoxication all over the world. Carbon monoxide is readily absorbed along the blood circulation blood-stream from the lungs, in which it is tightly combined with hemoglobin (Hb) and it is hardly reversible, known as carboxyhemoglobin (COHb). COHb in the blood decreases the capacity of oxygen carry, reduces the availability of oxygen to body tissues, resulting in histanoxia. This is especially harmful to the brain (Raub *et al*., 2000).

Neurological manifestations of acute CO poisoning include disorientation, confusion, cogwheel rigidity, opisthotonic posturing, extremity flaccidity or spasticity, extensor plantar response, and coma. Patients with moderate CO poisoning should be received treatment with 100% oxygen at normal barometric pressure (NBO2). Hyperbaric oxygen is highly recommended for patients in comatose, patients without consciousness during exposure and patients in abnormal neuropsychological manifestations (Mathieu, Mathieu-Nolf and Wattel, 1996).

The most detrimental effect of CO poisoning is the development of DEACMP. The occurrence of delayed encephalopathy is related to the age, severity of initial anoxia, early ambulation, and emotional stress (Cocito *et al*., 2005). Some patients experience a lucid interval, a period of peseduo recovery between acute CO poisoning and the onset of DEACMP symptoms, which has a mean of 22 days. DEACMP is caused by progressive demyelination from the deep cerebral white matter due to CO poisoning (Weaver, 2009) Brain damage caused by chronic neurological symptoms after CO poisoning has been rigorously investigated by using neuroimaging (Chu, 2004).

This study observes the clinical course and MRI changes in six patients with DEACMP. Patients exhibited clinical manifestations include cognitive impairment, apathy,

Table 1: Summary of clinical manifestations and brain of MRI of six patients with delayed encephalopathy after carbon monoxide intoxication

Patient/ sex	Onset (year)	Duration of Symptoms (days)	Duration of Pseudo recovery (days)	Clinical Manifestations	Lesion Location (in brain)
1/F	74	2	14	Cognitive impairment, reduced speech, apathy, chorea	Bilateral thalamus, bilateral lateral-ventricular area, the left centrum semiovale
2/M	78	1	15	Cognitive impairment, confusion, fecal and urine incontinence	Bilateral lateral-ventricular area and centrum semiovale
3/M	60	0.5	14	Cognitive impairment, reduced speech, slow movement, dystonia, urine incontinence	Diffuse white matter
4/F	76	0.3	14	Cognitive impairment, difficulty swallowing, fecal and urine incontinence	Bilateral lateral-ventricular area, centrum semiovale
5/F	60	3	16	Cognitive impairment, slow movement, dystonia, urine incontinence	Bilateral lateral-ventricular area, centrum semiovale.
6/M	72	1	40	Akinetic mutism, cognitive impairment, forced crying and forced laughing, fecal and urine incontinence, difficulty swallowing, dystonia	Bilateral basal ganglia, bilateral lateral-ventricular area, bilateral centrum semiovale and bilateral occipital

akinetic mutism, chorea, confusion, fecal and urine incontinence, reduced speech, difficulty swallowing, dystonia, forced crying and forced laughing and parkinsonism (Hsiao, Kuo and Huang, 2004). All patients in this study experienced improvement in clinical features, particularly in cognitive dysfunctions. Other improved symptoms included: chorea, stiffing, fecal and urine incontinence, and difficulty swallowing. Despite marked improvement in most symptoms, some clinical manifestation persisted for long durations. In this study, characteristic findings from MRI included small necrotic foci and demyelinating changes in the cerebral white matter and golbus pallid us. Brain MRI further revealed lesions in the SWM and BG, as well as in the globus pallid us, lateral ventricular thalamus and the centrum semio vale. The lesions were symmetric in five patients and asymmetric in one patient. Therefore, the underlying pathologic lesion is thought to be diffuse demyelination of the cerebral white matter (leukoencephalopathy) The potential pathological lesion is supposed to be the diffuse demyelination of the cerebral white matter (leukoencephalopathy). Further, the degree of metabolic acidosis and systemic hypotension is related to the size of white matter lesions.

In this study, improved neuroimaging results correlated with clinical improvement. Specifically, improved cognitive functioning correlated with changes in the sub cortical white matter to show reversible demyelination, rather than an irreversible necrosis. Cognitive dysfunction improved rapidly, while the dystonia was slow to improve, often persisting for more than six months. White matter lesions, therefore, recovered better than globus pallid us lesions. We can conclude that the clinical manifestations and brain MRI results are positively correlated in delayed encephalopathy after CO intoxication.

DISCLOSURES

The authors declare that there are no conflicts of interest.

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