International Journal of Biology and Life Sciences
ISSN: 2957-9511 | Vol. 9, No. 2, 2025

Toxic Encephalopathy Induced by Diquat Poisoning: A Case Series of Three Patients

Zihan Liu, Yabin Jiang *

Department of Emergency, The First Affiliated Hospital, Jinan University, Guangzhou Guangdong, 510000, China
*** Corresponding author:** Yabin Jiang (Email: 13392692121@163.com)

Abstract: Diquat is the third most widely used herbicidal biocide globally, following glyphosate and paraquat, with toxicity lower than paraquat. In the United States, diquat poisoning is predominantly linked to occupational exposure (8%–44%), with a low mortality rate (<1%–3%). In China, however, diquat use has increased only recently, following the ban on paraquat, leading to limited awareness and a significantly higher fatality rate compared to developed countries. Diquat primarily affects the liver and kidneys, but it can also damage the central nervous and respiratory systems. We report three cases admitted to our hospital, each involving severe central nervous system injury following accidental diquat ingestion. These patients exhibited characteristic clinical and imaging findings associated with diquat-induced brain injury. This case series provides valuable insights and may guide prevention and management strategies for similar poisoning cases in the future.

Keywords: Diquat Poisoning; Toxic Encephalopathy; Clinical Features; Imaging Features.

1. Introduction

Case summary: Our hospital admitted three patients (one male and two females, aged 18 to 25) with toxic encephalopathy resulting from acute diquat poisoning. Each patient had ingested a large quantity of diquat aqueous solution (20% concentration) following a period of behavioral and emotional instability. All patients sought treatment at a local hospital within 24 hours of ingestion. Initial symptoms included nausea, vomiting, abdominal pain, a burning sensation in the throat and behind the sternum, and limb weakness. As the disease progressed, all three developed varying degrees of dyspnea, hypoxemia, coma, and multiple organ dysfunction syndrome. Despite intensive treatment, only one patient survived, while the other two succumbed to their conditions. [1] [2]

Case 1: Patient A, a previously healthy male, developed nausea, vomiting, limb weakness, and green-tinted vomitus half an hour after ingesting 100 ml of diquat. He presented to a local hospital one hour later and received emergency gastric lavage, gastric protection, fluid replacement, diuresis, and other supportive treatments. He was transferred to our emergency department five hours post-ingestion. Initial laboratory test results and urine diquat concentration are provided in Table 1. On the second day of hospitalization, the patient exhibited restlessness, dizziness, oral mucosal ulcers, and a decrease in peripheral blood oxygen saturation. By the third day, he remained agitated, with slurred speech and in a shallow coma; peripheral oxygen saturation dropped to 80%. He was intubated, placed on a ventilator, and sedated, as brain damage was suspected. An emergency CT scan revealed reduced density and swelling in the bilateral insula, thalamus, cerebellar hemispheres, and midbrain-pons-medulla regions, suggestive of toxic encephalopathy. CT images are provided in Table 2. By the seventh day, the patient was alert, able to open his eyes spontaneously, showed limb flexion in response to pain, had a strong cough reflex, spontaneous breathing, and an oxygenation index >300. The endotracheal tube was successfully removed, and the urine diquat concentration was 53.9 μg/L. He was then transferred to a rehabilitation hospital for further care. Follow-up two months later confirmed that he had been discharged and was living a normal life. Treatment included supportive measures such as gastric lavage, catharsis, intracranial pressure reduction, blood purification, anti-inflammation, antioxidant therapy, free radical scavenging, ventilator-assisted respiration, and organ protection.

Case 2: Patient B, a previously healthy 22-year-old female, developed abdominal pain, distension, nausea, and watery vomitus shortly after ingesting approximately 200 ml of diquat. She was treated at a local hospital within four hours, receiving gastric lavage, fluid replacement, and gastric protection, before being transferred to our emergency department. Initial lab results and urine diquat concentration are provided in Table 1. On her second day of hospitalization, she became drowsy, displayed minimal response to painful stimuli, showed sluggish light reflexes, developed tachypnea, and had a blood oxygen saturation of 88%. She was intubated and placed on a ventilator. On the third day, a cranial CT revealed symmetrical low-density lesions in the bilateral basal ganglia, thalamus, and pons, consistent with toxic encephalopathy. She underwent external ventricular drainage in the surgical department. By the fourth day, she fell into a deep coma, and repeat CT showed significant brain swelling and herniation. Due to her poor prognosis, her family elected to discontinue treatment, and she was discharged. Follow-up confirmed her passing. Imaging findings are detailed in Table 2. Treatment was similar to that in Case 1.

Case 3: Patient C, an 18-year-old previously healthy female, vomited with greenish vomitus and briefly fainted ten minutes after ingesting around 200 ml of diquat. She arrived at a local hospital within 30 minutes, where she received gastric lavage with 1500 ml of water and gastric protection, before being transferred to our emergency department three hours after ingestion. Upon admission, she reported a burning sensation in her mouth and displayed confusion, drowsiness, and non-cooperation during neurological examination. Initial lab results and urine diquat concentration are available in Table 1. By the second day, her respiratory rate was 26 breaths per minute with peripheral oxygen saturation at 90%, leading

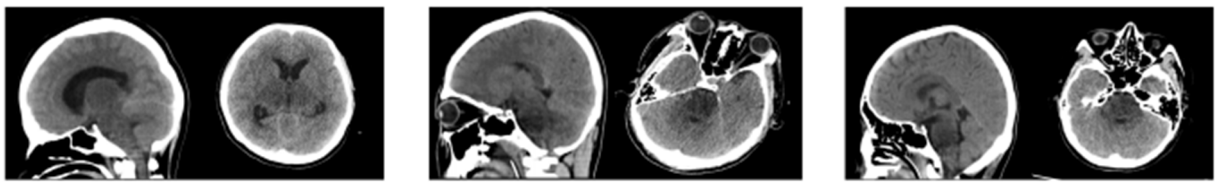
to intubation and ventilator support. On the third day, a head and chest CT showed diffuse swelling and low density in the brainstem and bilateral thalamus, suggestive of toxic encephalopathy, along with diffuse exudative lung lesions and bilateral pleural effusions. She was treated with mannitol, anti-infection therapy, and prone ventilation. By the fifth day, she developed multiple organ failure and increased infection markers. On the seventh day, in a continued deep coma, she tested positive for *Klebsiella pneumoniae* in alveolar lavage fluid. Treatment with polymyxin B, imipenem, and fluconazole was initiated, along with mannitol for dehydration. On the tenth day, her family opted to discontinue further treatment, and follow-up confirmed her passing. Imaging findings are shown in Table 2. Treatment was consistent with Case 1.

2. Attachment

Table 1. Initial laboratory test results and urine diquat concentration

Name	A	B	C
age	25	22	18
gender	male	female	female
Dosage ml	100	200	200
Ending	survival	die	die
Urea mmol/L	4.71	3.64	4.31
CREA umol/L	96.2	54.4	54.3
Total bilirubin umol/L	29.3	9.9	22.5
Alanine aminotransferase U/L	63	11	9
Creatine kinase CK U/L	86	123	74
Lactic acid mmol/L	1.7	4	1.5
Myoglobin ng/ml	10.3	>1200	17.9
WBC x10^9/L	35.22	12.6	17.37
NEUT%	85.7	87.4	90.25
HGB g/L	199	134	132.9
PLTx10^9/L	463	227.3	265.6
PCT ng/ml	0.381	0.01	0.015
Troponin I	<0.02	0.19	<0.02
D-dimer ug/ml	0.616	0.777	0.979
Urine diquat concentration ug/L	10954.5	54236.2	222574.6

Table 2. Brain CT images



3. Discussion

Toxic encephalopathy resulting from diquat poisoning is a severe condition with rapid progression and typically poor prognosis, often accompanied by high mortality[3] . In this case series, all patients succumbed to the effects of diquat poisoning after ingesting doses exceeding 100 ml. Animal studies indicate that the median lethal dose of oral diquat ranges from 30 to 400 mg/kg, with a fatal dose for adults estimated at 6 to 12 g[4] . his suggests that diquat poisoning is closely associated with central nervous system (CNS) damage. Mai et al. reviewed 11 cases of acute diquat poisoning, finding that all fatalities (6 out of 11) involved CNS complications[5] . Another report describes a 21-year-old male who ingested 100 ml of diquat (20 g/100 ml), with CT and MRI confirming acute pontine demyelination[6] .

In this series, patients who accidentally ingested diquat suffered from liver, kidney, and lung damage, accompanied by severe central nervous system involvement. Early neurological symptoms, including irritability, dizziness, headache, mental fatigue, and impaired consciousness, indicated the presence of toxic encephalopathy. Brain CT imaging revealed abnormalities primarily as symmetrical density reduction in the bilateral cerebellar hemispheres, pons, thalamus, and basal ganglia, along with varying degrees of brain tissue swelling. There was diffuse density reduction in the brainstem, signaling damage and swelling in this area. CT findings showed that the midbrain and pons were the most commonly affected regions, consistent with previous reports [7] . Diquat may penetrate the blood-brain barrier through a specific, yet unidentified, mechanism, resulting in direct damage to brain cells and neural tissue[2] . The midbrain and pons are critical components of the brainstem, which is essential for sustaining life. In this case series, respiratory

failure and altered consciousness emerged during disease progression, likely due to brainstem edema, depression of the respiratory center, and damage to the reticular activating system. This may be related to diquat's neurotoxicity, as it redistributes within the body and accumulates in the brainstem [8].

Currently, the specific mechanism of neurological damage caused by diquat remains unclear, though it is thought to primarily involve the activation of oxidative stress. Diquat has a high redox potential, making it more effective than other herbicides at generating reactive oxygen species (ROS) during redox cycling, which increases its neurotoxic effects [1] . Diquat mediates the redox cycle in cytochrome P450 reductase-expressing cells, contributing to ROS production through lipid peroxidation and reduced coenzyme II (NADPH), resulting in a substantial release of ROS. Protective substances like glutathione are overwhelmed by the excessive ROS, ultimately leading to oxidative stress-induced cellular damage[9] [10] . Some studies have also implicated nitrification stress in diquat-induced neurotoxicity, as reactive nitrogen species (RNS) can contribute to neuronal damage. In rat models of diquat poisoning, pretreatment with NG-nitro-L-arginine methyl ester (L-NAME), a non-selective nitric oxide synthase inhibitor, was shown to reduce neurotoxic effects[11] .

Additional research has revealed that diquat induces mitochondrial genome instability in endothelial cells, leading to the accumulation of Z-DNA. This activates Z-DNA binding protein 1 (ZBP1), which interacts with receptor-interacting protein kinase 3 (RIPK3), ultimately initiating RIPK3-dependent necroptosis and ferritin-related signaling cascades [12]. Moreover, diquat significantly reduces the activity of dopaminergic neurons, promoting their degeneration and damaging specific brain regions. Given that dopamine neurons are primarily located in the midbrain, this may also explain the pattern of brainstem damage observed in these cases[13] .

As for treatment, there is currently no specific antidote for diquat poisoning. Treatment principles focus on rapidly removing unabsorbed toxins, promoting the elimination of absorbed toxins, utilizing blood purification therapies, administering antioxidants, providing mechanical ventilation, and supportive care[1] [3] . Some studies have indicated that vitamin K may offer partial protection against diquat-induced organ damage [12].

4. Conclusion

In conclusion, diquat poisoning complicated by toxic encephalopathy generally involves a substantial toxic dose and progresses rapidly, which adversely affects patient recovery and psychological outcomes. In the clinical management of diquat poisoning, careful observation of neurological symptoms, early imaging assessments, prompt detection, and timely, appropriate treatment are essential. This analysis provides new insights into diagnosis and treatment and may offer valuable guidance in managing similar cases.

References

[1] Chen Yang, Liu Hao, Dong Xuesong. Research progress on the poisoning mechanism and treatment of diquat[J]. Journal of Clinical Emergency Medicine, 2021, 22(7): 496-502.

[2] Jia-Ning Zhou, Yuan-Qiang Lu. Lethal diquat poisoning manifests as acute central nervous system injury and circulatory failure: A retrospective cohort study of 50 cases[J]. EClinicalMedicine, 2022, 52: 101609.

[3] Liang Xiaoli, Hu Xiaomin, Gong Yang, et al. Analysis of risk factors for death in 40 patients with diquat poisoning from 2016 to 2018[J]. Journal of Clinical Emergency Medicine, 2019, 20(5): 366-370+375.

[4] Vanholder R, Colardyn F, De Reuck J, et al. Diquat intoxication: report of two cases and review of the literature[J]. The American Journal of Medicine, 1981, 70(6): 1267-1271.

[5] Mccarthy LG, Speth C P. Diquat intoxication[J]. Annals of Emergency Medicine, 1983, 12(6): 394-396.

[6] Xing J, Chu Z, Han D, et al. Lethal diquat poisoning manifesting as central pontine myelinolysis and acute kidney injury: A case report and literature review[J]. The Journal of International Medical Research, 2020, 48(7) :30006052094 3824.

[7] SechiI GP, Agnetti V, PireddaI M, et al. Acute and persistent parkinsonism after use of diquat[J]. Neurology, 1992, 42(1): 261-263.

[8] Fu Linqing, Ye Meiping, Wang Zhengge, et al. A case report and imaging analysis of diquat toxic encephalopathy[J]. Chinese Journal of CT and MRI, 2023, 21(6): 187-188.

[9] Magalhaes N, Carvalho F, Dinis-Oliveira R. Human and experimental toxicology of diquat poisoning: Toxicokinetics, mechanisms of toxicity, clinical features, and treatment[J]. Human & Experimental Toxicology, 2018, 37(11): 1131-1160.

[10] Fussell K C, Udasin R G, Gray J P, et al. Redox cycling and increased oxygen utilization contribute to diquat-induced oxidative stress and cytotoxicity in Chinese hamster ovary cells overexpressing NADPH-cytochrome P450 reductase[J]. Free Radical Biology & Medicine, 2011, 50(7): 874-882.

[11] Park A, Koh H C. NF-κB/mTOR-mediated autophagy can regulate diquat-induced apoptosis[J]. Archives of Toxicology, 2019, 93(5): 1239-1253.

[12] Lai K, Wang J, Lin S, et al. Sensing of mitochondrial DNA by ZBP1 promotes RIPK3-mediated necroptosis and ferroptosis in response to diquat poisoning[J]. Cell Death and Differentiation, 2024, 31(5): 635- 650.

[13] Kanthasamy A, Jin H, Anantharam V, et al. Emerging neurotoxic mechanisms in environmental factors-induced neurodegeneration[J]. NeuroToxicology, 2012, 33(4): 833-837.

[14] Leng Junling, Zou Xiaodong, Li Yang, et al. A case report of a patient poisoned by a large dose of diquat[J]. Chinese Journal of Health Emergency Electronics, 2017, 3(5): 317-318.

[15] Liang Xiaoli, Hu Xiaomin, Gong Yang, et al. Analysis of risk factors for death in 40 patients with diquat poisoning from 2016 to 2018[J]. Journal of Clinical Emergency Medicine, 2019, 20 (5): 366-370+375.