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Nitrous Oxide-Associated Rhabdomyolysis With Acute Kidney Injury Requiring Hemodialysis

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Abstract

Nitrous oxide (N_2O) is increasingly abused for its euphoric effects, yet its potential for severe medical toxicity remains underrecognized. This case report describes a 22-year-old male who developed severe rhabdomyolysis and acute kidney injury (AKI) following chronic nitrous oxide abuse. Upon admission, the patient exhibited significant muscle edema and a profoundly elevated creatine kinase level exceeding 45,000 U/L. The clinical course was complicated by progressive renal failure, necessitating intensive care management and hemodialysis. This report details the patient's clinical presentation, the association between N_2O exposure and severe muscle injury, and successful treatment outcomes following cessation of the substance and aggressive supportive care. By highlighting this rare but serious complication, we aim to bridge the current knowledge gap regarding N_2O toxicity. This case underscores the importance of considering nitrous oxide abuse in the differential diagnosis of unexplained rhabdomyolysis, particularly in young patients, and highlights the necessity for clinical vigilance, early recognition, and timely intervention to mitigate the risk of irreversible renal damage.

Categories: Internal Medicine, Nephrology
Keywords: acute kidney injury, myoglobinuria, nitrous oxide, rhabdomyolysis, substance abuse

Introduction

Rhabdomyolysis is a serious condition in which skeletal muscle fibers break down and release intracellular contents, including myoglobin, creatine kinase, potassium, and phosphate, into the circulation [1]. These substances can cause significant systemic complications, most notably AKI and electrolyte disturbances and, in severe cases, cardiac arrhythmias and death [1,2]. Rhabdomyolysis is frequently attributed to trauma, prolonged immobilization, and certain medications, but substance-induced rhabdomyolysis, particularly from illicit drugs, is an increasingly common and often underrecognized cause [1]. Recognizing this trend is essential for prompt diagnosis and targeted management.

Nitrous oxide (N_2O), commonly known as "laughing gas", is a colorless, non-flammable gas traditionally used for its anesthetic and analgesic properties in medical and dental settings [3,4]. In recent years, it has also become a popular recreational drug because of its rapid onset of euphoria, dissociation, and short-lived psychoactive effects [3]. It is often inhaled from balloons or cartridges ("whippets"), and its use is particularly widespread among adolescents and young adults because of its accessibility, low cost, and perceived safety.

Despite this benign reputation, chronic or high-dose N_2O use is well documented to cause toxicity through inactivation of vitamin B_{12} (cobalamin), including functional B_{12} deficiency, myeloneuropathy with subacute combined degeneration, and hematologic abnormalities [3,5,6]. Cognitive impairment and thromboembolic events have also been reported [7, 8]. In contrast, the association between N_2O use and rhabdomyolysis is far less established and is currently supported mainly by isolated case reports. Proposed mechanisms, including prolonged immobility with pressure-related muscle ischemia, hypoxia, and neuromuscular injury, remain largely speculative. As recreational use continues to rise globally, clarifying this less recognized complication is clinically important. We report a case of severe N_2O-associated rhabdomyolysis with dialysis-requiring AKI.

Case Presentation

A 22-year-old man with a history of anxiety and polysubstance use disorder presented to the emergency department shortly after discharge from an opioid rehabilitation facility, complaining of bilateral lower extremity weakness and numbness. He reported a recent, marked escalation in recreational N_2O use, consuming approximately one liter per session, during which he remained immobile for prolonged periods.

On examination, he was alert but in visible discomfort. The right thenar eminence was tense and edematous, and the left gluteal and proximal thigh regions were markedly enlarged compared with the

contralateral side. Serial examinations and compartment pressure measurements showed no evidence of compartment syndrome, and no surgical intervention was required. Urine drug screen was positive only for marijuana. Random urine creatinine was elevated at 322.86 mg/dL (Table *1*). Admission serum creatinine was 1.83 mg/dL and rose progressively over the following days. Given the severity of the presentation and the risk of worsening kidney function, the patient was admitted to the intensive care unit (ICU).

Component	Result
Amphetamine	Negative
Barbiturates	Negative
Benzodiazepines	Negative
Buprenorphine	Negative
Cocaine	Negative
Fentanyl	Negative
Marijuana	Positive
Methadone	Negative
Opiates	Negative
Oxycodone	Negative
Phencyclidine	Negative
Creatinine (mg/dL)	322.86

TABLE 1: Admission urine drug screen results

Serum creatine kinase (CK) exceeded 45,000 U/L (more than 200 times the upper limit of normal), confirming muscle injury. Initial blood urea nitrogen (BUN) and creatinine levels were only mildly elevated relative to the CK (Table *2*), a pattern that can be seen early in rhabdomyolysis-associated AKI [2]. Urinalysis showed dark urine with pigmented granular casts and no red blood cells, consistent with acute tubular necrosis (ATN) secondary to myoglobinuria.

Labs	Normal levels (nL)	Patient levels at admission	Patient levels on day 11	Patient levels at 1-week post-discharge
Serum creatinine (sCr)	0.7-1.3 mg/dL	1.83 mg/dL	14.10 mg/dL	1.80 mg/dL
Blood urea nitrogen (BUN)	7-20 mg/dL	16 mg/dL	56 mg/dL	14 mg/dL
Potassium (K+)	3.5 to 5.2 mmol/L	3.7 mmol/L	3.9 mmol/L	4.2 mmol/L
Creatine kinase (CK)	22-198 unit/L	> 45,000 unit/L	N/A	N/A

TABLE 2: Patient serum lab report

This table summarizes key laboratory findings for the patient at admission, peak, and post-discharge, including serum creatinine, blood urea nitrogen, potassium, and creatine kinase levels compared to normal ranges.

Cross-sectional imaging defined the extent and distribution of muscle injury. A non-contrast computed tomography (CT) scan of the right hand showed soft tissue expansion of the thenar and palmar regions adjacent to the first metacarpal, consistent with localized edema and inflammatory fluid collection (Figure *1*). CT of the pelvis and lower extremities showed profound asymmetric edema of the left gluteal and proximal thigh muscles, with diffuse hypodensity and complete obliteration of the normal intermuscular fat planes (Figure *2*). Magnetic resonance imaging (MRI) of the lumbar spine and paraspinal soft tissues showed marked hyperintensity within the deep paraspinal and proximal gluteal musculature, confirming severe acute intramuscular edema (Figure *3*). Together, these findings demonstrated multifocal muscle injury

consistent with pressure-related ischemia during prolonged immobilization.

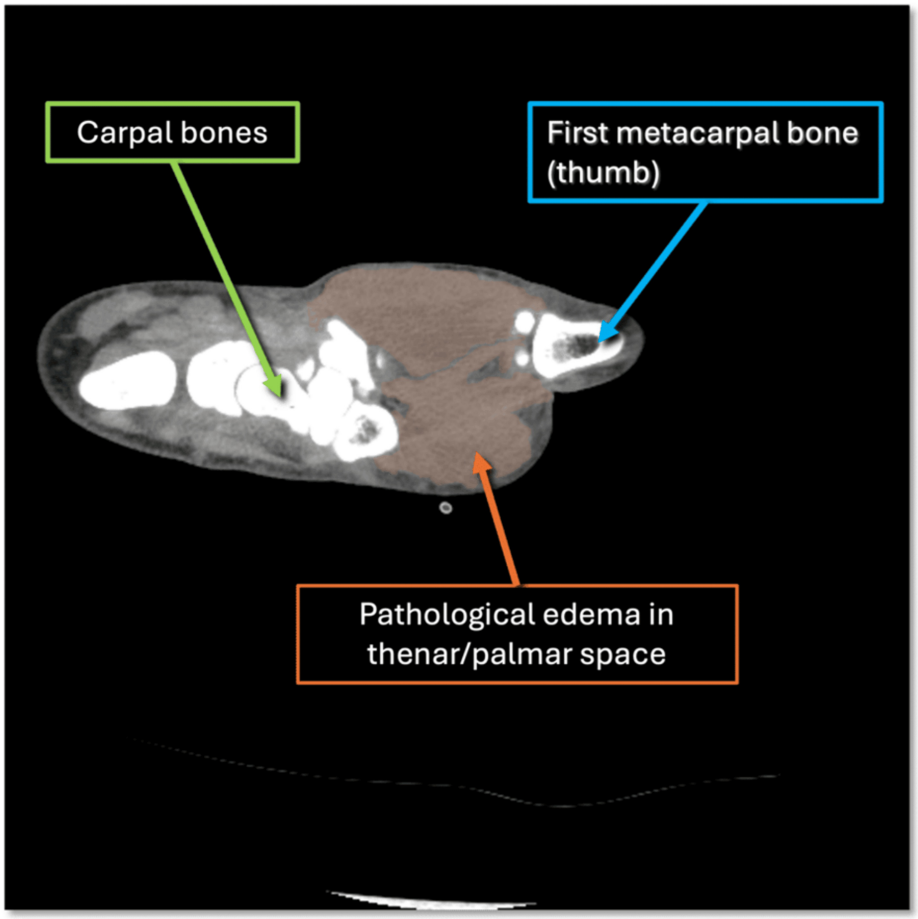


FIGURE 1: Non-contrast axial CT of the hand demonstrating soft-tissue expansion in the thenar and palmar regions



FIGURE 2: Non-contrast axial CT of the pelvis and bilateral lower extremities

Axial view at the level of the hip joints demonstrates profound, asymmetric soft-tissue pathology. There is marked enlargement and diffuse hypodensity involving the left gluteal and proximal thigh musculature (right side of image) compared to the normal contralateral side. The normal intermuscular fat planes are completely obliterated, accompanied by subtle reticulation in the overlying subcutaneous tissue. These findings are characteristic of severe unilateral muscle edema.

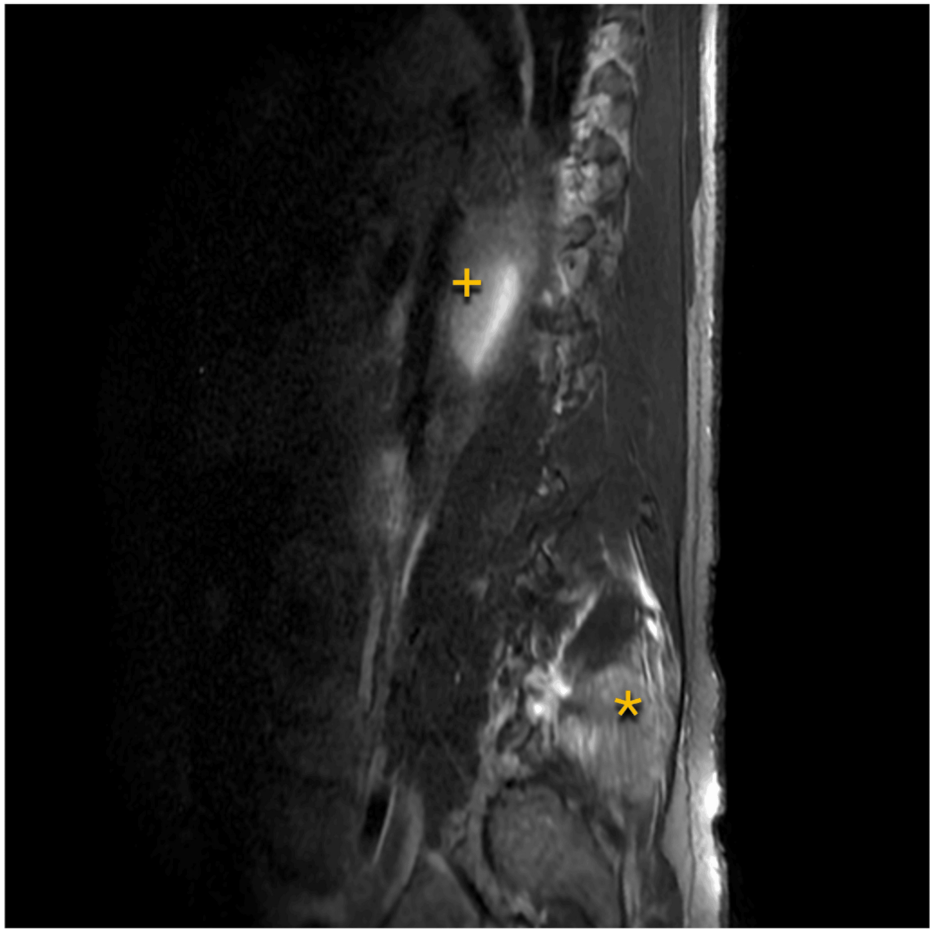


FIGURE 3: Sagittal MRI view of the lumbar spine and paraspinal soft tissues

Parasagittal fluid-sensitive imaging demonstrates prominent regions of high signal intensity (hyperintensity) highlighting acute tissue pathology. A well-demarcated area of superior fluid tracking is indicated by the yellow plus sign (+). The larger, inferior region of intense hyperintensity, marked by the yellow asterisk (*), represents severe, acute intramuscular edema involving the deep paraspinal and proximal gluteal musculature.

Despite aggressive intravenous fluid resuscitation and supportive care, renal function continued to deteriorate, and the patient became anuric. Initially, muscle rest and fluid management appeared to mitigate the initial muscle injury, as evidenced by a downward trend in creatine kinase (CK) levels (Figure *4*), but the overwhelming injury to the kidneys proved to be unresponsive to simple fluid resuscitation. Serum creatinine rose from 1.83 mg/dL at admission to a peak of 14.10 mg/dL on hospital day 11 (Figure *5*). Renal replacement therapy was initiated via a tunneled hemodialysis catheter (PermCath) on hospital day 11. He also received high-dose vitamin B_{12} to counteract N_2O-induced cobalamin inactivation, methocarbamol for muscle spasms, and gabapentin for neuropathic pain. The patient remained abstinent from N_2O throughout hospitalization.

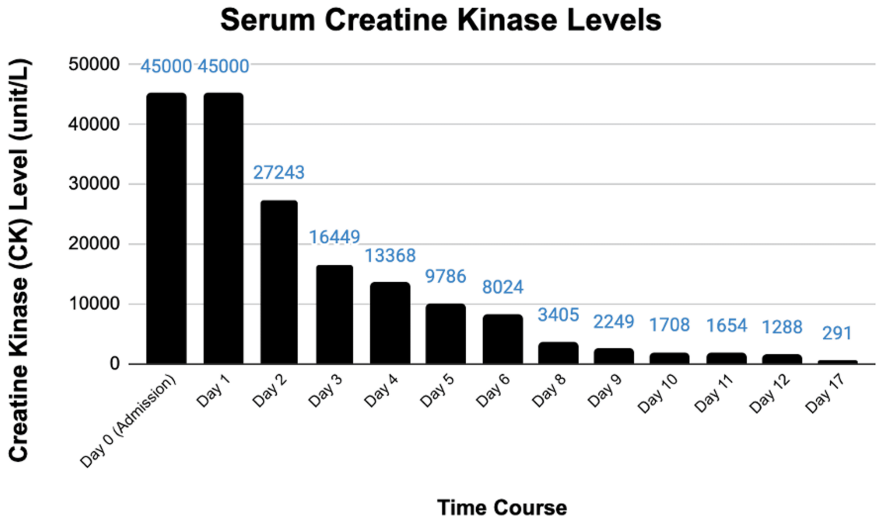


FIGURE 4: Time course of serum creatine kinase (CK) levels in a patient with nitrous oxide (N_2O) abuse-associated rhabdomyolysis

Serum CK levels remained elevated at admission (45,000 U/L) before progressively declining to 291 U/L right before discharge. The downward trend suggests improvement in skeletal muscle injury with supportive care, including rest and intravenous fluid resuscitation. Despite biochemical improvement in rhabdomyolysis, the patient developed progressive acute kidney injury, ultimately requiring hemodialysis on hospital day 11.

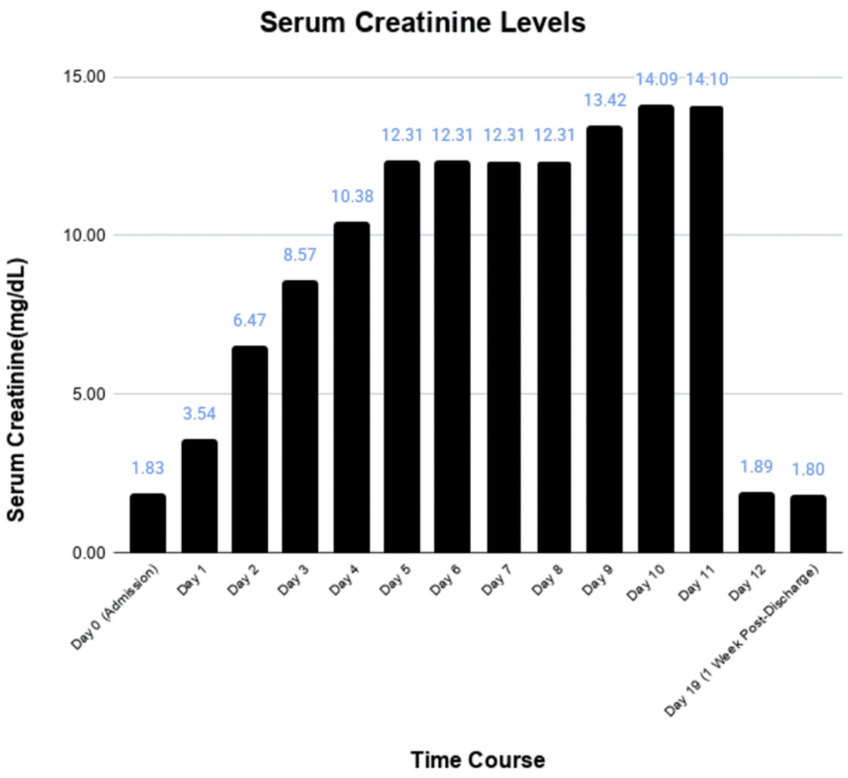


FIGURE 5: Time course of serum creatinine (Cr) levels in nitrous oxide (N_2O) abuse-associated rhabdomyolysis

The graph demonstrates a notable increase in serum creatinine from admission (1.83 mg/dL) to peak levels on day 11 (14.10 mg/dL), at which hemodialysis and supportive care were initiated to manage severe acute kidney injury and associated uremia (normal levels of serum creatinine (nL sCr) = 0.7-1.3 mg/dL). Post-discharge creatinine decline indicates a potential treatment option for N_2O-induced rhabdomyolysis and acute kidney injury.

After inpatient hemodialysis, renal function improved. Serum creatinine was 1.89 mg/dL at discharge and 1.80 mg/dL at one-week outpatient follow-up (Figure *5*), and dialysis was discontinued with the catheter removed. The patient had substantial renal recovery with dialysis independence, although creatinine remained elevated. Further renal and neurologic evaluation was not pursued, as the patient declined further management after the one-week follow-up.

Discussion

The intersection of N_2O misuse and rhabdomyolysis presents a diagnostic challenge. Functional B_{12} deficiency and subsequent myeloneuropathy are well-documented consequences of chronic N_2O exposure [5,6], but severe skeletal muscle breakdown is rarely reported and poorly characterized [9]. The pathophysiology is likely multifactorial. Prolonged immobilization during intoxication can cause muscle compression and ischemic injury, a recognized cause of rhabdomyolysis [10,11]. Hypoxia from inhaling undiluted gas and a direct toxic effect of N_2O on muscle are possible additional contributors, but these remain hypotheses. The asymmetric, pressure-point distribution of edema in our patient (thenar, gluteal, and paraspinal regions) favors immobility as the main mechanism, although we cannot exclude other contributors.

Drug- and alcohol-related causes account for a substantial proportion of non-traumatic rhabdomyolysis in adults [11,12], but N_2O-specific epidemiologic data are sparse, which makes individual case reports valuable. The classic triad of myalgia, weakness, and tea-colored urine is present in fewer than 10% of patients, and more than half of patients do not report muscle pain or weakness at presentation [12]. This diagnostic difficulty is compounded in young, otherwise healthy patients who may be reluctant to disclose substance use. A CK above 5000 U/L is a commonly cited threshold associated with a markedly increased risk of AKI [12,13]; our patient's CK was more than nine times higher.

An estimated 10% to 40% of patients with severe rhabdomyolysis develop AKI, and rhabdomyolysis accounts for up to 15% of cases of acute renal failure [12,13]. Our patient required ICU care and hemodialysis but

regained dialysis independence after N_2O cessation, fluid resuscitation, and renal replacement therapy, which suggests that renal injury in this setting can be at least partly reversible. His discharge and follow-up creatinine values (1.89 and 1.80 mg/dL) indicate residual impairment, so longer follow-up is needed. Whether vitamin B_{12} affected the muscle or renal course cannot be determined from a single case; it was given to treat the underlying N_2O-related cobalamin inactivation. This case also shows that the absence of trauma or extreme exertion should not preclude evaluation for rhabdomyolysis when unexplained muscle swelling, weakness, or elevated muscle enzymes occur in a patient who uses inhalants.

Limitations

This is a single case, so causality cannot be established. The patient had polysubstance use disorder and had recently left opioid rehabilitation. While other potential toxic or metabolic causes of rhabdomyolysis were systematically excluded, subtle confounding factors such as baseline nutritional deficiencies or unquantified intermittent inhalant exposures could not be entirely ruled out. N_2O use was self-reported and cannot be confirmed by any reliable screening test or standard urine drug panel.

Conclusions

In this patient, N_2O misuse was associated with severe rhabdomyolysis and dialysis-requiring AKI, likely through prolonged immobility. This association remains poorly characterized compared with the well-established neurologic toxicity of N_2O. The renal injury was at least partly reversible with prompt recognition and aggressive care, including dialysis. Clinicians should consider N_2O misuse in young patients with unexplained muscle injury or renal decline and should integrate screening for inhalant abuse into routine assessments. Vitamin B_{12} should be considered to treat the underlying N_2O toxicity. Further case series and epidemiologic and mechanistic studies are needed to define how often N_2O-associated myotoxicity occurs and what causes it.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Sumil A. Shah, Dilan Shah, Jason Cobb

Acquisition, analysis, or interpretation of data: Sumil A. Shah, Dilan Shah, Jason Cobb

Drafting of the manuscript: Sumil A. Shah, Dilan Shah, Jason Cobb

Critical review of the manuscript for important intellectual content: Sumil A. Shah, Dilan Shah, Jason Cobb

Supervision: Jason Cobb

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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References

1. Lu Y, Neyra JA: How I treat rhabdomyolysis-induced AKI? . Clin J Am Soc Nephrol. 2024, 19:385-7. 10.2215/CJN.0000000000000372
2. Walid MS: Blood urea nitrogen/creatinine ratio in rhabdomyolysis . Indian J Nephrol. 2008, 18:173-4. 10.4103/0971-4065.45295

3. Gernez E, Lee GR, Niguet JP, Zerimech F, Bennis A, Grzych G: Nitrous oxide abuse: clinical outcomes, pharmacology, pharmacokinetics, toxicity and impact on metabolism. Toxics. 2023, 11:962. 10.3390/toxics11120962
4. Sanders RD, Weimann J, Maze M: Biologic effects of nitrous oxide: a mechanistic and toxicologic review . Anesthesiology. 2008, 109:707-22. 10.1097/ALN.0b013e3181870a17
5. Flanagan JC, Hakes JK, McClure EA, Snead AL, Back SE: Effects of intimate partner violence, PTSD, and alcohol use on cigarette smoking in a nationally representative sample. Am J Addict. 2016, 25:283-90. 10.1111/ajad.12381
6. Thompson AG, Leite MI, Lunn MP, Bennett DL: Nitrous oxide-induced myelopathy with subacute combined degeneration. J Neurol. 2015, 262:1079-82.
7. Xiang Y, Li L, Ma X, et al.: Recreational nitrous oxide abuse: prevalence, neurotoxicity, and treatment . Neurotox Res. 2021, 39:975-85. 10.1007/s12640-021-00352-y
8. Meier E, Malviya M, Kaur S, et al.: Neurologic and thrombotic complications in the setting of chronic nitrous oxide abuse. Case Rep Med. 2023, 2023:5058771. 10.1155/2023/5058771
9. Lin JP, Gao SY, Lin CC: The clinical presentations of nitrous oxide users in an emergency department . Toxics. 2022, 10:112. 10.3390/toxics10030112
10. Melli G, Chaudhry V, Cornblath DR: Rhabdomyolysis: an evaluation of 475 hospitalized patients . Medicine (Baltimore). 2005, 84:377-85. 10.1097/01.md.0000188565.48918.41
11. Cervellin G, Comelli I, Benatti M, Sanchis-Gomar F, Lippi G: Epidemiology and etiology of rhabdomyolysis in a large tertiary hospital emergency department. Intern Emerg Med. 2010, 5:19-22. 10.1007/s11739-009-0294-x
12. Bosch X, Poch E, Grau JM: Rhabdomyolysis and acute kidney injury . N Engl J Med. 2009, 361:62-72. 10.1056/NEJMra0801327
13. Khan FY: Rhabdomyolysis: a review of the literature . Neth J Med. 2009, 67:272-83.