CASE REPORT / PRIKAZ SLUČAJA

COCAINE-ASSOCIATED SODIUM CHANNEL CARDIOTOXICITY PRESENTING WITH WIDE QRS TACHYARRHYTHMIA: A CASE REPORT

KOKAINOM INDUCIRANA KARDIOTOKSIČNOST ZBOG BLOKADE NATRIJSKIH KANALA SA ŠIROKOM QRS TAHIARITMIJOM: PRIKAZ SLUČAJA

***Denis Senzen[1], Jasmin Hamzić[2], Magdalena Kujundžić[1]**

https://doi.org/10.64266/amu.2.4.2

Abstract

Background: Cocaine toxicity is frequently mediated by sympathomimetic effects; however, direct inhibition of cardiac fast sodium channels (Nav1.5) may result in rate-dependent intraventricular conduction delay, QRS prolongation, and life-threatening ventricular arrhythmias.

Case presentation: A 25-year-old man with unknown medical history presented after confirmed cocaine use with altered mental status and seizures. During initial resuscitation, he developed progressive wide-complex tachycardia, resulting in cardiac arrest. Return of spontaneous circulation was achieved following advanced life support and administration of hypertonic sodium bicarbonate. The patient required intensive care but recovered with correction of metabolic derangements and supportive management.

Discussion: This case illustrates the electrophysiological consequences of cocaine-induced sodium channel blockade, typical electrocardiographic findings, and the role of sodium bicarbonate as targeted therapy.

Conclusion: Early recognition of sodium channel toxicity and prompt administration of sodium bicarbonate, alongside comprehensive supportive care, are critical to improving outcomes in severe cocaine-related cardiotoxicity.

Keywords: arrhythmia; cocaine; QRS widening; sodium bicarbonate; sodium channel

Sažetak

Uvod: Toksičnost kokaina često je posredovana simpatomimetičkim učincima; međutim, izravna inhibicija brzih natrijevih kanala u srcu (Nav1.5) može dovesti do o frekvenciji ovisnog intraventrikulskog poremećaja provođenja, produljenja QRS-a i po život opasnih ventrikulskih aritmija.

Prikaz slučaja: Muškarac od 25 godina s nepoznatom anamnezom zaprimljen je nakon potvrđenog korištenja kokaina s poremećenim mentalnim statusom i konvulzijama. Tijekom početne resuscitacije razvio je progresivnu tahikardiju sa širokim QRS kompleksom, što je rezultiralo srčanim zastojem. Povrat spontane cirkulacije postignut je nakon naprednih mjera održavanja života i primjene hipertoničnog natrijeva bikarbonata. Bolesnik je zahtijevao intenzivno liječenje, ali se oporavio uz korekciju metaboličkih poremećaja i potporne mjere.

Rasprava: Ovaj slučaj prikazuje elektrofiziološke posljedice blokade natrijevih kanala inducirane kokainom, tipične elektrokardiografske nalaze, te ulogu natrijeva bikarbonata kao ciljane terapije.

Zaključak: Rano prepoznavanje toksičnosti natrijevih kanala i pravodobna primjena natrijeva bikarbonata, uz sveobuhvatnu potpornu terapiju, ključni su za poboljšanje ishoda u teškoj kardiotoksičnosti povezanoj s kokainom.

Ključne riječi: aritmija; kokain; natrijev bikarbonat; natrijev kanal; proširenje QRS-a

1 Emergency Medical Service of the Krapina-Zagorje County, Krapina, Croatia

2 University Hospital Center Zagreb, Zagreb, Croatia

*** Corresponding author:**

Denis Senzen, MD
Emergency Medical Service of the Krapina-Zagorje County
Mirka Crkvenca 1, 49000, Krapina
Croatia
Phone number: +385915195877
E-mail: denis.senzen@gmail.com

ORCID ID:

Denis Senzen:
0009-0000-2701-729X

Jasmin Hamzić:
0000-0003-2726-4308

Magdalena Kujundžić:
0000-0001-6359-2654

Introduction

Cocaine remains a major contributor to drug-related emergency department visits and is associated with substantial cardiovascular morbidity and mortality. Cardiac complications range from transient conduction abnormalities to myocardial ischemia, cardiomyopathy, malignant arrhythmias, and sudden cardiac death (2,3). While enhanced sympathetic activity and coronary vasoconstriction are well-recognised contributors, cocaine also exerts direct toxic effects on cardiac ion channels (1-3).

Cocaine cardiotoxicity is caused by use-dependent blockade of cardiac sodium channels (Nav1.5), leading to QRS widening, rate-dependent conduction slowing, and arrhythmias. Sodium bicarbonate can reverse this and is potentially lifesaving..

Experimental and clinical evidence shows that cocaine inhibits fast sodium channels (Nav1.5) and modulates calcium and potassium currents (1-3). Sodium channel inhibition reduces the slope of phase 0 depolarisation, resulting in slowed ventricular conduction and QRS prolongation. This interaction is state- and use-dependent, intensifying at higher heart rates and with repetitive depolarisation, thereby explaining the association between tachycardia and progressive QRS widening (1-3).

Recognition of toxic sodium channel blockade is clinically important because management differs from that for ischemic or structural causes of wide-complex arrhythmias. In this context, sodium bicarbonate represents a targeted and potentially lifesaving intervention (2,4).

Case presentation

A 25-year-old man with no known chronic illnesses and no regular medications was brought to the emergency department for an altered mental status. On arrival, he was febrile, tachycardic, tachypneic, hypotensive, and actively seizing with associated myoclonus. Urine toxicology screening was positive for cocaine and amphetamines.

During early resuscitation, the patient developed worsening tachycardia with progressive QRS widening, which rapidly degenerated into cardiac arrest. Advanced life support was initiated, including endotracheal intubation and mechanical ventilation. Benzodiazepines were administered for seizure control. A bolus of hypertonic sodium bicarbonate was given, after which narrowing of the QRS complex was observed, followed by return of spontaneous circulation after approximately eight minutes.

Laboratory evaluation revealed severe lactic acidosis, markedly elevated creatine kinase consistent with rhabdomyolysis, and transient renal and hepatic dysfunction. Computed tomography of the head showed no acute intracranial pathology. The patient was admitted to the intensive care unit, where metabolic abnormalities were corrected, and organ function improved. He was discharged from the ICU in stable condition after six days and referred for psychiatric follow-up.

Initial electrocardiograms showed markedly prolonged QRS complexes with lateral ST-segment depressions and ST elevation in lead aVR. Following sodium bicarbonate administration, serial ECGs showed progressive QRS narrowing and stabilisation of cardiac rhythm, consistent with reversal of sodium channel blockade.

Discussion

Cocaine produces conduction abnormalities through direct inhibition of Nav1.5 channels, binding preferentially to activated and inactivated channel states (1). This interaction reduces inward sodium current and delays ventricular depolarisation. Because binding is use-dependent, tachycardia exacerbates conduction slowing and promotes QRS prolongation (1-3).

In addition to sodium channel inhibition, cocaine disrupts repolarising potassium currents, alters intracellular calcium handling, induces mitochondrial dysfunction, and triggers catecholamine excess and myocardial ischemia (2,5,6). These overlapping mechanisms create a proarrhythmic substrate capable of producing ventricular tachycardia, ventricular fibrillation, and transient Brugada-like electrocardiographic patterns (2,5).

Cocaine's multi-channel cardiac toxicity and catecholamine surge predispose to malignant arrhythmias, highlighting the importance of early recognition and supportive interventions.

Clinical manifestations of cocaine-induced sodium channel toxicity range from asymptomatic conduction delay to unstable wide-complex arrhythmias and sudden cardiac arrest. Electrocardiographic findings suggestive of sodium channel blockade include QRS duration exceeding 100–120 ms, a prominent terminal R wave in lead aVR, and rightward terminal QRS axis deviation (2,4). Progressive QRS widening with increasing heart rate is particularly concerning and correlates with arrhythmic risk (2,4).

Metabolic acidosis, electrolyte abnormalities, co-ingestion of other cardiotoxic substances, and underlying structural heart disease or channelopathies may exacerbate toxicity (2,6).

Management priorities include airway protection, seizure control, and attenuation of sympathetic overactivity, most commonly with benzodiazepines (2,4). When sodium channel blockade is suspected, intravenous sodium bicarbonate is the treatment of choice (2,4,6).

The therapeutic benefit of sodium bicarbonate is attributed to serum alkalinization, which reduces drug–channel binding affinity, and increased extracellular sodium concentration, which competitively mitigates channel blockade (2,4). These effects frequently result in rapid QRS narrowing and hemodynamic improvement. Repeated boluses or infusion may be required, guided by ECG response and acid–base status.

Antiarrhythmic agents with sodium channel–blocking properties should be avoided, and β-blockers lacking α-adrenergic antagonism should be used cautiously due to the risk of unopposed vasoconstriction (7). In refractory cases, lipid emulsion therapy or extracorporeal life support may be considered (2,6).

Conclusion

Cocaine-related cardiotoxicity is multifactorial, with direct, use-dependent sodium channel inhibition representing a central and potentially reversible mechanism. In patients presenting with wide QRS tachyarrhythmias and suspected stimulant exposure, toxic sodium channel blockade should be promptly considered. Early ECG recognition and timely administration of sodium bicarbonate, in conjunction with comprehensive supportive care, can be lifesaving.

References

1. O'Leary ME, Chahine M. Cocaine binds to a common site on open and inactivated human heart (Nav1.5) sodium channels. J Physiol. 2002;541:701–716. doi:10.1113/jphysiol.2001.016139.
2. Richards JR, Garber D, Laurin EG, Albertson TE, Derlet RW, Amsterdam EA et al. Treatment of cocaine cardiovascular toxicity: a systematic review. Clin Toxicol (Phila). 2016;54:345–364. doi:10.3109/15563650.2016.1142090.
3. Phillips K, Luk A, Soor GS, Abraham JR, Leong S, Butany J. Cocaine cardiotoxicity: a review of the pathophysiology, pathology, and treatment options. Am J Cardiovasc Drugs. 2009;9:177–196. doi: 10.2165/00129784-200909030-00005.
4. Nelson LS, Hoffman RS, Howland MA, Lewin NA, Goldfrank LR. Goldfrank's Toxicologic Emergencies. 11th ed. New York: McGraw-Hill Education; 2019.
5. Bauman JL, DiDomenico RJ. Cocaine-induced channelopathies and sudden cardiac death. J Cardiovasc Pharmacol Ther. 2002;7:195–202. doi:10.1177/107424840200700309.
6. Peruch M, Giacomello E, Radaelli D, Concato M, Addobbati R, Fluca AL et al. Subcellular Effectors of Cocaine Cardiotoxicity: All Roads Lead to Mitochondria-A Systematic Review of the Literature. Int J Mol Sci. 2023;24:14517. doi:10.3390/ijms241914517.
7. Richards JR, Hollander JE, Ramoska EA, Fareed FN, Sand IC, Izquierdo Gómez MM et al. β-Blockers, Cocaine, and the Unopposed α-Stimulation Phenomenon. J Cardiovasc Pharmacol Ther. 2017;22:239-249. doi:10.1177/1074248416681644.