Prolonged Atrial Fibrillation Precipitated by New-Onset Seizures and Marijuana Abuse

abstract

We report a case of prolonged atrial fibrillation (AF) precipitated by new-onset generalized tonic–clonic convulsions and marijuana abuse in a developmentally normal 18-year-old adolescent with a structurally normal heart. Our case highlights an interesting association and a unique pathophysiology between generalized tonic–clonic convulsions, marijuana abuse, and AF. We suggest that seizures and marijuana abuse should be considered in the differential diagnosis of the etiology of AF in children. Pediatrics 2014;133:e443–e446

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KEY WORDS
PICU, adolescents, seizures, arrhythmia, drug abuse

ABBREVIATIONS
AF—atrial fibrillation
ED—emergency department
GTCC—generalized tonic–clonic convulsion

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Marijuana is one of the most commonly abused illicit drugs among young people in the United States, and it accounts for 61% of admissions for drug abuse treatment under age 15 years and for 56% between 15 and 19 years of age. Research shows that ∼9%, or ∼1 in 11, of those who use marijuana at least once will become addicted. This rate is 16%, or ∼1 in 6, in those who start using the drug in their teenage years. The addiction rate is 25% to 50% among daily users.\(^1\) Marijuana use has been associated with serious cardiovascular complications, including acute angina, myocardial infarction, ventricular arrhythmias, and a few cases of atrial fibrillation (AF) in young adults.\(^2,3\) Similarly, peri-ictal cardiac rhythm abnormalities are common and mostly include sinus tachycardia or occasionally bradycardia. Rarely, lethal rhythm abnormalities such as ventricular tachycardia, prolonged QT abnormalities, and asystole can occur, leading to serious consequences including sudden unexplained death in epilepsy.\(^4-6\) Although a few cases of hemodynamically stable AF have been reported as a result of generalized tonic–clonic convulsions (GTCCs) in adults with structurally normal hearts, there are no such data in the pediatric or adolescent age group. We report a hemodynamically stable adolescent with a structurally normal heart who developed AF in the setting of GTCCs and marijuana abuse.

**CASE REPORT**

An 18-year-old previously healthy young man presented to the emergency department (ED) with 2 new-onset, afebrile GTCCs. The 2 seizures occurred 21 hours apart, both early in the morning while the patient was sleeping. Both seizures were witnessed, each lasting for ∼10 minutes, and each time, the patient fell off the couch on which he was sleeping. The patient stated that his “heart began feeling weak” after the first seizure. He noted transient left leg numbness and 1 episode of emesis after the second seizure. He denied aura, palpitations, and bladder and bowel incontinence. He denied any history of seizures or syncope and stated that he had been in his usual state of health with the exception of a mild cough for the past 2 weeks. According to the emergency response team, the patient was postictal, afebrile, and hemodynamically stable at home and on arrival at the ED. He was noted to have an irregular heart rate of 85 to 96 beats per minute, with a blood pressure of 115/80 mm Hg and an oxygen saturation of 99% on room air. Otherwise, his physical examination was benign, and a thorough review of systems was negative. He had no significant past medical history. Family history was noncontributory. He also admitted to nightly marijuana use the week before the seizures and occasional alcohol and cigarette use.

A 12-lead electrocardiogram was performed that confirmed AF (Fig 1), and a loading dose of anticonvulsant therapy with levetiracetam was given in the ED. He was transferred to the PICU with the diagnoses of new-onset GTCC, marijuana abuse, and AF.

Laboratory studies including complete blood count, complete metabolic panel, serum magnesium, phosphate, troponin

![FIGURE 1](image-url)

Electrocardiogram before cardioversion.
I, thyroid studies, coagulation profile, lipid panel, antistreptolysin O titers, serum alcohol levels, viral studies, cultures, and basic autoimmune workup were within normal limits. Urine drug screen was positive for marijuana. Myoglobin and creatinine kinase were mildly elevated secondary to seizures. Urine mass spectroscopy was negative. Arterial blood gas was within normal limits, with pH = 7.42, PaO2 = 100, PaCO2 = 38, bicarbonate = 22, and Base Deficit BD —0.5.

A transesophageal echocardiogram identified no anatomic abnormalities or thrombi. The size of the right ventricle was reported to be 1.5 cm, and the estimated right ventricle systolic pressure was 32 mm Hg. MRI of the brain revealed a 1.7 × 1.0 cm nonenhancing abnormal intensity in the subcortical left frontal gray matter suggestive of heterotopic gray matter possibly mild cortical dysplasia. (Figs 2 and 3). EEG demonstrated no evidence of seizure activity.

The patient remained in documented AF for at least 6 hours before admission to the PICU. Electrical cardioversion was performed, which resulted in normal sinus rhythm. Maintenance anticonvulsant therapy with levetiracetam was initiated. There was no recurrence of either seizures or AF during the patient’s stay in the PICU. However, the patient left against medical advice after 24 hours of PICU stay and did not attend scheduled follow-up appointments.

**DISCUSSION**

AF in a child with a structurally normal heart is extremely rare. A large Australian pediatric ED study over 6.5 years showed that the incidence of pediatric arrhythmias was 11.5 in 10 000 ED visits, and more than half of them were supraventricular tachycardias, which occurred with an incidence of 6.5 in 10 000 ED visits. AF occurred in 0.2 in 10 000 ED visits, and all these children had structural heart disease. Common and uncommon causes of AF are listed in Table 1.

On the other hand, seizures are the most common pediatric neurologic disorder, with ~150 000 children presenting with a first-time, unprovoked seizure each year. Depending on the duration and the frequency, the seizures can be associated with various complications that include hypoxemia, hypercapnia, hypotension or hypertension, acidosis, rhabdomyolysis, acute renal failure, apnea, bradytachyarrhythmias, and death.

AF secondary to GTCC is well recognized in adults, but the data in the pediatric population are sparse. The exact mechanism of AF secondary to seizures is not clearly understood. The possible mechanisms may include a sudden catecholamine surge and simultaneous sympathetic and parasympathetic (sympathovagal) discharge. Prolonged GTCC and to a lesser extent complex partial seizures result in a sudden surge in circulating plasma norepinephrine and epinephrine levels by 12 and 40 times, respectively. Factors such as hypoxia further increase these levels.

The heart is richly innervated by both the extrinsic (sympathovagal) and the intrinsic cardiac nervous system (intracardiac specialized ganglia), particularly around the pulmonary veins, and these areas are thought to be the foci of AF in structurally normal hearts. Imbalances in the sympathovagal discharges greatly influence the atrial electrophysiological properties acting via these specialized ganglia. Thus, AF appears to be vagally mediated in young patients without structural heart disease and sympathetically mediated in subjects with structural heart disease. At the cellular level,
tachycardia associated with simultaneous sympathovagal discharge results in accumulation of intracellular calcium and significant shortening of action potential duration. High intracellular calcium then causes activation of the sodium–calcium exchanger, which results in triggered activity and rapid heart rate, culminating in rhythm abnormalities including AF.\(^1\)\(^5\)

We think that frequent marijuana abuse and GTCC probably increased the risk of AF in our patient. The consequences of marijuana abuse on the cardiovascular system are caused primarily by \(\Delta^9\)-tetrahydrocannabinol mediated via cannabinoid CB1 and CB2 receptors. These effects vary depending on the route of administration, the preparation of cannabis, and the \(\Delta^9\)-tetrahydrocannabinol content. High-dose \(\Delta^9\)-tetrahydrocannabinol results in a marked increase in heart rate, postural hypotension, and serum carboxyhemoglobin levels. This results in decreased oxygen-carrying capacity and increased myocardial oxygen demand, leading to acute coronary ischemia. This ischemic insult in the presence of sympathovagal imbalance acts as a substrate for various types of arrhythmias, including AF.\(^1\)\(^5\)

Our patient had normal troponin I levels and echocardiogram. Therefore, we postulate that the significant sympathovagal imbalance resulting from both the GTCC and the marijuana abuse might have led to an additive effect, which in the presence of ictal or postictal tachycardia might have triggered the AF.

Factors such as vomiting, hypoxia, hypercapnia, acidosis, and electrolyte abnormalities commonly seen during GTCC are proarrhythmogenic and have been implicated in causing AF. These factors are less likely to be responsible for the initiation of AF in our patient because the arterial blood gas and serum electrolytes were completely normal. Severe hemodynamic compromise leading to hypoxemic ischemic injury to the brain and ischemic stroke caused by thromboembolic phenomenon secondary to atrial dilatation may also lead to seizures, but in our case these 2 possibilities were ruled out by imaging. However, the etiology of the abnormal heterotopic focus on the MRI (brain) could not be ascertained because of the lack of follow-up by the patient, and it probably represents cortical dysplasia. We also postulate that our patient might have developed AF after the first seizure (when his “heart began feeling weak”), which would mean that the duration of AF was more than 24 hours, but the documented AF was only for 6 hours.

**CONCLUSIONS**

Our case is unique in that 2 common conditions, GTCC and marijuana abuse, resulted in AF, a rare condition in an adolescent with a structurally normal heart. We suggest that seizures and marijuana abuse, occurring both individually or in combination, should be considered in the differential diagnosis of the etiology of AF in a patient with a structurally normal heart. Considering the heterogeneity of AF, we suggest that the goals of treatment should be individualized according to the risk factors. We recommend close monitoring of cardiac function in patients with marijuana abuse and GTCC, which may reduce subsequent morbidity and mortality. We anticipate that future studies involving genetic, metabolic, and neurohumoral mechanisms, at both the macroscopic and microscopic levels, will increase our knowledge.
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