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# Sudden cardiac arrest during marathon training in a young adult with short QT syndrome

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## 1. Introduction

A variety of mostly hereditary, structural, or electrical cardiac disorders are associated with sudden cardiac death in young athletes and amateur sport participants [1]. Short QT syndrome (SQTS), a condition first described in 2000 [2], is a rare cardiac channelopathy characterized by abnormally short cardiac repolarization. Data from only a small group of patients identified worldwide are available. The annual risk of cardiac arrest among patients in the largest SQTS cohort to date was approximately 1%, and most of the cardiac arrests reported in the cohort occurred during rest or sleep [3]. Risk stratification and management of SQTS remain uncertain, however, as data on the natural history of SQTS are lacking. Here we report a patient with SQTS who suffered a sudden cardiac arrest when marathon training.

## 2. Case

A 22-year-old, previously healthy man collapsed while running in the early evening after work in 2016. A colleague who witnessed the episode initiated cardiopulmonary resuscitation and called for ambulance service. The patient was in ventricular fibrillation upon the arrival of the emergency medical service (EMS) but achieved return of spontaneous circulation after desynchronised cardioversion by an automated external defibrillator (Fig. 1a). Upon the patient's transfer to our hospital, a 12-lead electrocardiogram (ECG) revealed sinus rhythm with complete right bundle branch block and right axis dimension (Fig. 1b). A bedside echocardiogram after the event revealed global mild hypokinesis with normal left ventricle dimension and thickness. He was taken to the catheterization laboratory and underwent emergent coronary angiography. No coronary anomalies or obstructive lesions were detected. Hormonal and metabolic disorders were also ruled out. He required intensive care and therapeutic hypothermia to prevent neurological dysfunction due to hypoxia, but neuropsychological deficiency remained to a degree in the convalescent phase.

Upon the patient's discharge from the intensive care unit, 12-lead ECG findings were altered to within normal limits (Fig. 1c). Cardiac function documented by echocardiogram also recovered to normal ejection fraction without dyskinesis. The patient had no history of previous angina, exertional dyspnea, or syncope, and his family had no history of sudden cardiac death or known congenital cardiac conditions. An ECG record from an annual medical screening in 2014, however, showed a QT interval of 360 milliseconds (ms) that corrected to 340 ms (Fig. 2a). Twenty-four-hour ECG Holter monitoring in the hospital also revealed a short QT interval with impaired adaptation to heart rate changes during sleep. Specifically, the patient had an QT interval of 340 ms that corrected to 320 ms at a heart rate of less than 60 bpm (Fig. 2b). SQTS was diagnosed based on the criteria by the expert consensus statement [4]. Besides a short QT interval, a PQ depression of more than 0.5 mm was recently determined to be a novel marker for SQTS because it rarely appears in healthy subjects [5]. The present patient manifested a PQ depression of 0.79 mm (Fig. 2c). The patient's family consented to a further study of gene mutations potentially responsible for SQTS but denied our request to proceed with a electrophysiologic study and stress testing using arrhythmogenic and antiarrhythmic agents. DNA analysis detected a W927G mutation in the KCNH2 gene. Six genetic subtypes of SQTS have been identified so far [6]. Among the gain-of-function mutations in the K+ channel genes, KCNH2 is responsible for SQTS type-1. An active W927G mutation is potentially associated with a shortened QT interval [7]. The mutation was originally identified in Brugada syndrome patients with short QT interval, though it could not be found in genuine SQTS type-1. Our case, meanwhile, exhibited no features of Brugada syndrome.

As with other inherited channelopathies, the implantable cardioverter defibrillator (ICD) is recommended in symptomatic SQTS patients who are either survivors of sudden cardiac arrest and/or have documented spontaneous sustained ventricular tachyarrhythmias with or without

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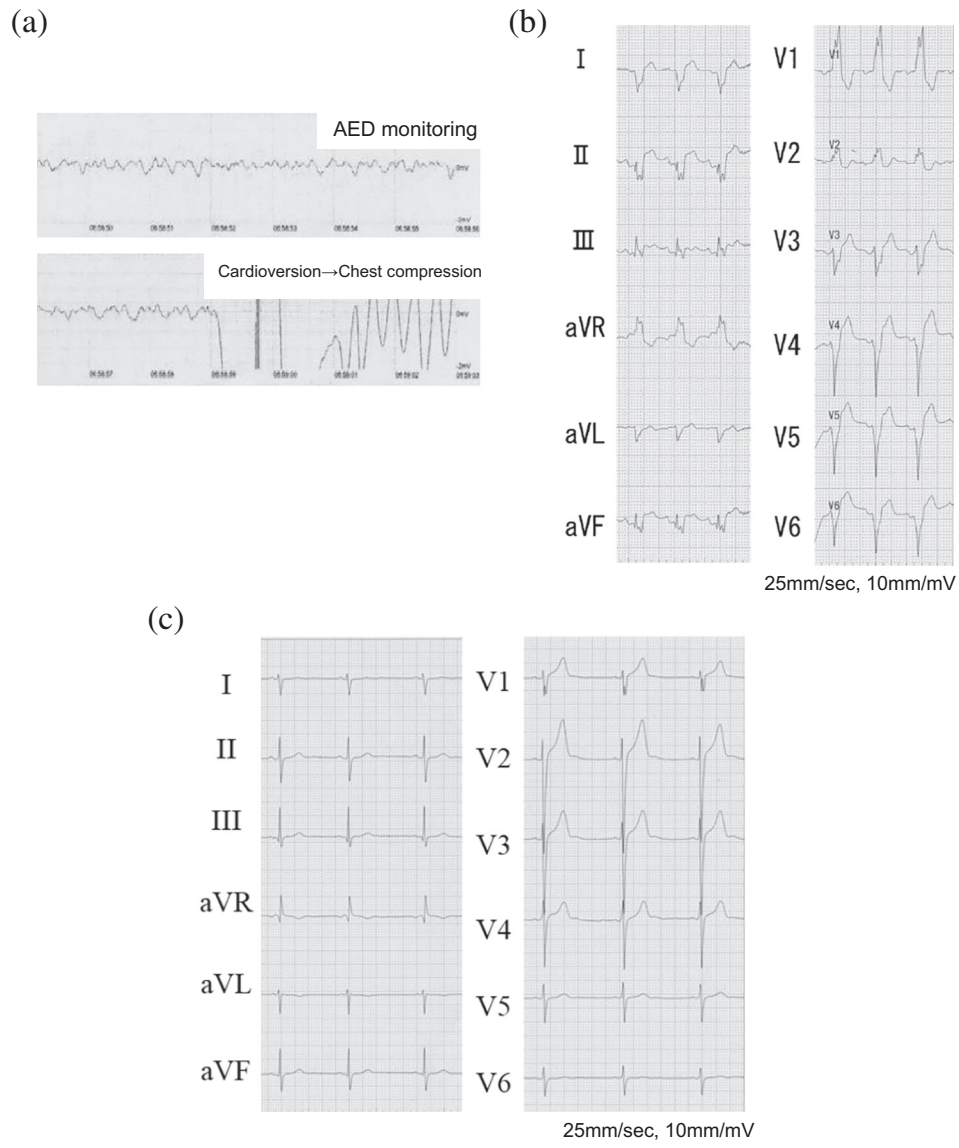


**Fig. 1.** (a) Ventricular fibrillation on the AED monitor recording electrocardiogram upon the arrival of the EMS revealed. (b) 12-lead ECG upon the patient's transfer to hospital. Sinus rhythm with complete right bundle branch block and right axis dimension. Heart rate = 112 bpm, PQ = 122 ms, QRS = 154 ms, QT = 388 ms. (c) Normal QT interval in 12-lead ECG upon the patient's discharge from the intensive care unit. PQ = 120 ms, QRS = 120 ms, QT = 400 ms, QTc = 380 ms.

syncope [4]. The patient therefore underwent an ICD implantation for secondary prevention and was then transferred to a rehabilitation hospital for further recovery from his neuropsychological deficiency.

## 3. Discussion

Arrhythmic events in patients with channelopathies may be associated with external triggers such as strenuous exercise, auditory stimuli, sudden bursts of activity, or sudden changes in temperature, or may otherwise occur during rest or sleep [8]. There is consensus that patients with inherited arrhythmogenic diseases should not perform competitive sports, though the recommendations for recreational physical activity are much less clear. Patients with SQTS, on the other hand, rarely suffer cardiac arrests during emotional stress or physical effort [3]. Data from over 18,000 asymptomatic young British athletes found less than an 0.1% prevalence of a QTc of less than 320 ms [9]. And among the few individuals who did have a QT of less than 320 ms, none experienced any adverse events, syncope, or sudden death over a mean follow-up period of 5.3 years [9]. To the best of our knowledge, this is the first reported case of an aborted sudden cardiac death during sporting activity in a previously asymptomatic SQTS patient with negative family history.

The mechanisms of arrhythmogenesis in SQTS is less well understood than that of long QTS [6]. In our case a W927G mutation was identified in the KCNH2 gene. We speculate that the rare mutation might confer an exercise-induced cardiac arrest as well as an occasional and/or circadian appearance of a short QT interval. Also, cardiac parasympathetic activity evaluated by heart rate variability during exercise is sometimes observed to increase slightly as exercise intensity increases toward maximum [10], which theoretically could increase the risk of ventricular arrhythmia in SQTS patients.

Based on the rarity of the findings and absence of data to suggest long-term morbidity in asymptomatic athletes with SQTS, the latest international consensus statement [1] recommends that a short QT interval only be investigated if potentially unfavorable clinical markers accompany the condition. The experience of our case, however, compels us to pay closer attention in such cases. Given the current gaps in our knowledge of the natural history and pathophysiology, we believe

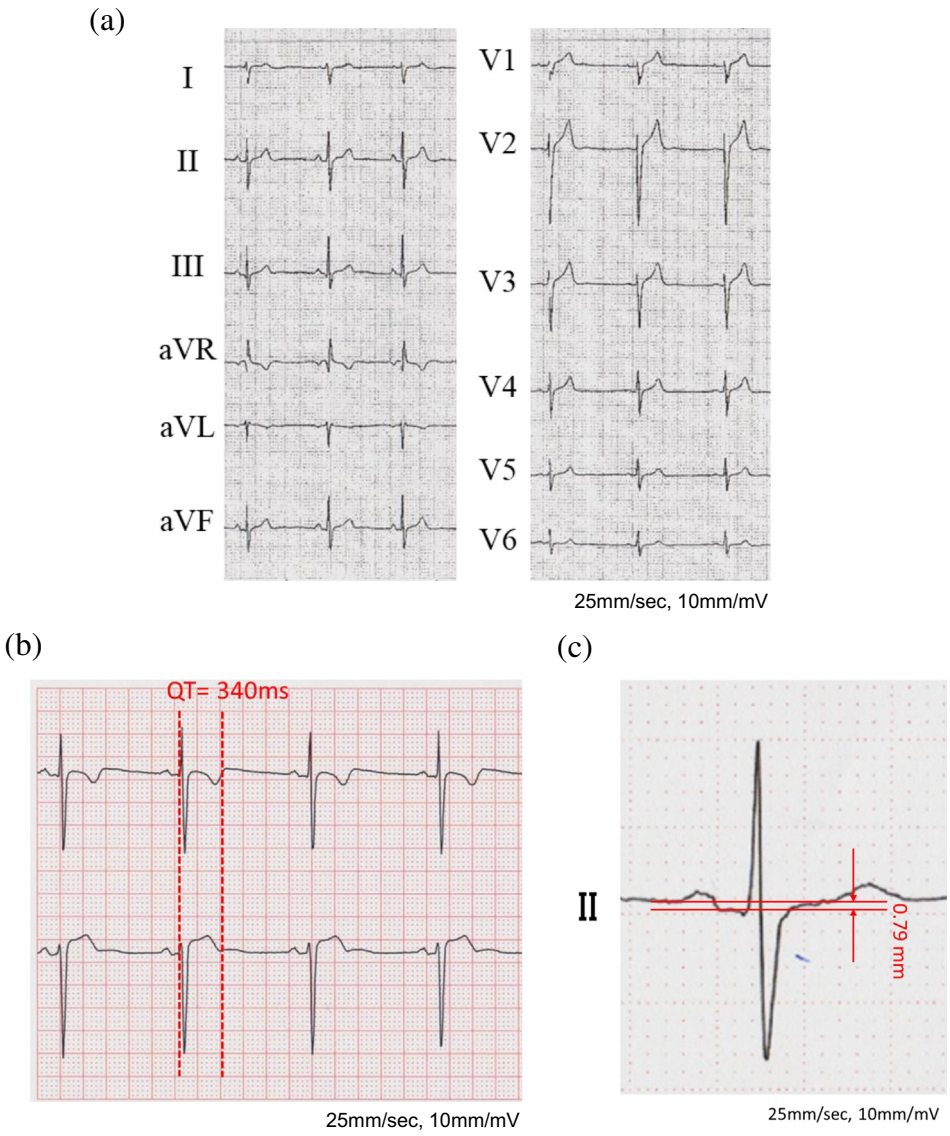


**Fig. 2.** Short QT interval. (a) Short QT interval in ECG record in 2014 (2 years before the sudden cardiac arrest). PQ = 120 ms, QRS = 80 ms, QT = 360 ms, QTc = 340 ms. (b) Representative ECG waveform recorded by 24-hour ECG Holter monitoring during sleep in the hospital. QT = 340 ms, QTc = 320 ms. (c) ECG wave form of the present case manifested a PQ depression of 0.79 mm (between red arrows).

that careful monitoring and secondary evaluation in sports participation should be requisite even for asymptomatic SQTS patients without a family history.

## Conflict of interest

The authors have no conflicts of interest.

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