Interpretation of electrocardiogram in an ultra-marathon athlete: a case report

Antonio Villa,[1] Pietro Vandoni,[2] Isabella Riva,[1] Claudio Moro,[2] Luisa Chiappa,[2] Carlo Valena,[1] Mario Macchiarulo[1]

[1]Emergency Department, P.O. Desio, ASST Monza, Italy; [2]Department of Cardiology, P.O. Desio, ASST Monza, Italy

ABSTRACT

The electrocardiogram (ECG) of athletes, especially in those that are endurance-trained, frequently shows some alterations; however, abnormalities of athlete's ECG may be an expression of an underlying heart disease, which carries a risk of sudden death during sport. It is important that ECG abnormalities are correctly distinguished. We report a case of an ultramarathon athlete who arrived in Emergency Department, after a 100-kilometer race, showing ECG alterations that required further investigations to rule out a cardiac disease. ECG trace showed anterior repolarization abnormalities with ST-segment elevation in V1 to V3 leads. He was admitted to the Cardiology Department and underwent a coronary study that was normal. A cardiac magnetic resonance was also performed. The final diagnosis was athlete's heart.

Introduction

The electrocardiogram (ECG) of athletes, especially in those that are endurance-trained, frequently shows some alterations and usually reflects structural and electrical remodeling of the heart as an adaptation to regular physical training (athlete's heart).[1] However, abnormalities of athlete's ECG may be an expression of an underlying heart disease which carries a risk of sudden death during sport.[2-4] It is important that ECG abnormalities are correctly distinguished.[5,6]

We report a case of an ultramarathon athlete who arrived in Emergency Department (ED), after a 100-kilometer race, with unspecific abdominal pain and showing ECG alterations that required further investigations to rule out a cardiac disease.

Correspondence: Antonio Villa, Emergency Department, P.O. Desio, ASST Monza, Italy.
E-mail: antonio.villa@asst-monza.it

Key words: Electrocardiogram; ultra-marathon athlete.

Conflict of interest: the authors declare no potential conflict of interest.

Received for publication: 2 August 2018.
Revision received: 13 December 2018.
Accepted for publication: 17 December 2018.

Italian Journal of Medicine 2019; 13:64-67
doi:10.4081/itjm.2019.1074

Case Report

A 47-year-old Caucasian man presented to our ED with aspecific abdominal pain; the symptom occurred after finishing an ultra-marathon of 100 kilometers. He did not have cardiovascular risk factors.

On physical examination, he had a blood pressure of 115/70 mmHg and a heart rate of 83 per minute. His chest was clear to auscultation and heart sounds were normal. His abdomen was soft and nontender. Bowel sounds were present and there was no guarding, rebound tenderness, or organomegaly; femoral pulse was isosphygmic.

ECG trace showed anterior repolarization abnormalities with ST-segment elevation in V1 to V3 leads with a convex toward the top morphology and normal T-wave and inverted T-wave in D1, aVL, and V5 to V6 leads (Figure 1).

His laboratory data showed potassium 5.0 mMol/L, creatinine 1.5 mg/dL, HS-troponin T 76 pg/mL (normal value 0-13 pg/mL).

He was admitted to the Cardiology Department and underwent a coronary study. Coronary angiography was normal. A cardiac magnetic resonance was also performed. In this study, the cavity size of left ventricle was normal, while the medium posterior septum thickness and the cardiac mass were increased [12.6 mm and left ventricular mass index 96 g/m^2 (normal value <72 g/m^2), respectively]. The left ventricular systolic function was normal; no papillary muscle hypertrophy or focal areas of myocardial edema or fibrosis were observed. The final diagnosis was therefore athlete's heart.

Subsequently, an ECG performed two months before was made available and showed similar abnormalities to the one performed on arrival (Figure 2).

During hospitalization the patient remained asymptomatic, troponin values reduced and he was discharged after four days.

Discussion

The patient presented with non-specific abdominal pain and the ECG trace showed some repolarization abnormalities. He was admitted to Cardiology Department to study these alterations and to exclude an

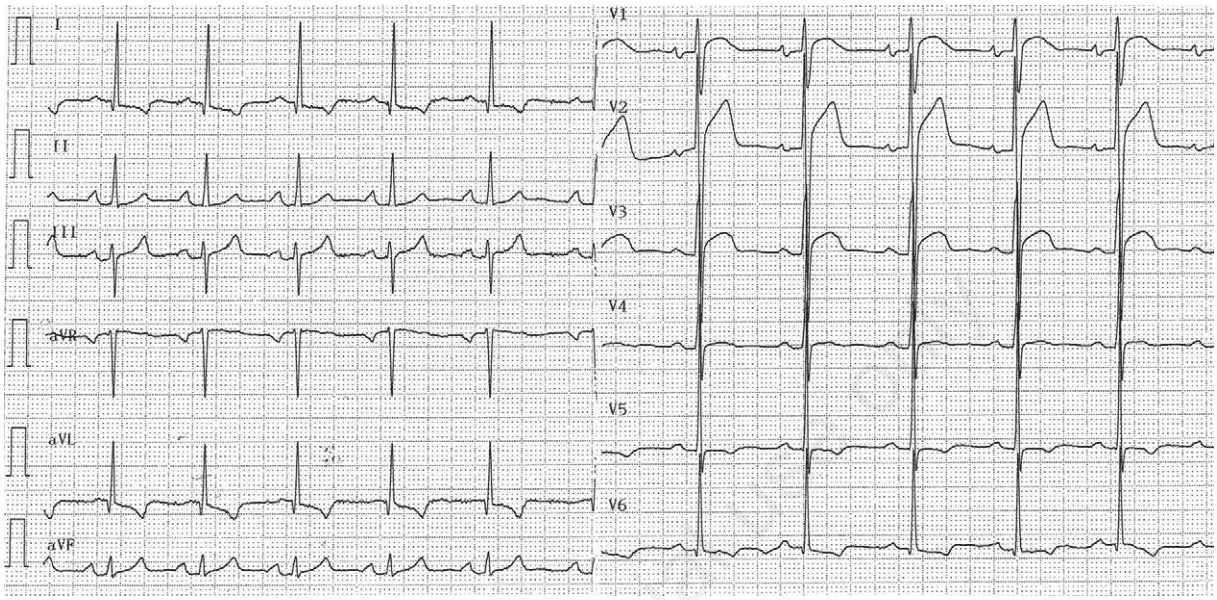

Figure 1. Electrocardiogram on arrival to the Emergency Department, showing high QRS voltages, ST elevation in V1-V3 leads with a convex toward the top morphology and positive T-wave, inverse T-wave in V5, V6, D1 and aVL leads.

Figure 2. Electrocardiogram performed two months previously. There are similar repolarization abnormalities.

acute coronary syndrome. Coronarography and magnetic resonance excluded a coronary disease. Moreover, magnetic resonance did not show a papillary muscle hypertrophy that sometimes can explain these abnormalities. Thus, it had been necessary to explain these repolarization alterations in a young health athlete.

Early repolarization (ER) has traditionally been regarded as an idiopathic and benign ECG phenomenon, with an estimated prevalence in healthy young individuals of 1-2%, and a clear male preponderance.[7] The ER ECG pattern is the rule rather than the exception among highly trained athletes, in whom it is observed in 50-80% of resting ECG.[7]

Over the last decade, ECG interpretation standards have undergone several modifications to improve the accuracy of detecting potentially life-threatening cardiac conditions in young athletes while also limiting false positive results.[8] In February 2015, an international group of experts convened in Seattle to update contemporary recommendations for ECG interpretation in asymptomatic athletes.[8]

The most common pattern of ER in anterior leads is characterized by J-point (QRS-ST junction) elevation, at least 0.1 mV from the baseline, associated with notching or slurring of the terminal QRS complex which may vary in location, morphology, and degree.[9,10] The most common morphological pattern seen in up to 45% of Caucasians athletes is an elevated ST-segment with an upward concavity, ending in a positive (*peaked and tall*) T-wave.[7] In 63-91% of athletes of African-Caribbean descent, however, the morphology is often different with an elevated ST-segment with an upward convexity, followed by a negative T-wave.[7] This pattern, with the *domed* morphology of the elevated ST-segment requires differentiation from the Brugada-ECG (Brugada-like ECG).[11] The European Society of Cardiology criteria proposed that a down-sloping ST-segment elevation is typical of Brugada pattern whereas an upsloping ST-segment elevation is characteristic of ER.[7]

Based on current evidence, all patterns of ER when present in isolation and without clinical markers of pathology, should be considered benign variants in athletes.[12]

Methods to differentiate between this benign repolarization abnormality and the pathological Brugada ECG pattern include measurement of the *Corrado index*: the measurement of the ST segment at the J point (STJ) and then 80 ms after the J point (ST80). In ER, the ST elevation is convex, therefore the ST80 is invariably higher than the STJ producing a STJ/ST80 ratio <1. In Brugada syndrome, the ST80 is lower than the STJ and so the STJ/ST80 ratio is >1[13] (Figure 3).

Zorzi *et al.*[13] found that an upsloping ST-segment configuration (STJ/ST80 <1) had a sensitivity of 97%, a specificity of 100%, and a diagnostic accuracy of 98.7% for the diagnosis of ER.

Our patient showed some ECG patterns associated with athlete's heart. Right precordial leads ST-segment elevation with a convex toward the top morphology can be related to an early repolarization. Moreover, this presentation is original, because there is an upward convexity (as African-Caribbean athletes) followed by a positive T-wave (as Caucasian athletes).

A recent study on ECG variations pre- and post-marathon[14] showed that the most common finding was ER pattern, typically manifesting with ST elevation, J point elevation or terminal slurring of the QRS; some athletes had more pronounced ER after the race. Finally, no correlations between ECG changes and serum cardiac biomarkers levels were found.

The magnitude of ST-segment elevation is characteristically modulated by autonomic influences and heart rate changes which explain the dynamic nature of the ECG abnormalities with waxing and waning of the ST-segment and T-wave over time.[9,10,15] ER in athletes reflects the development of a training-related hypervagotonia, and ECG abnormalities are a reversible phenomenon which reduces or disappears with deconditioning.[7]

The Brugada ECG pattern is particularly problematic in athletes because of the risk of hyperthermia during training in addition to their increased vagal tone, which places them at higher risk of development of ventricular arrhythmias seen in patients with Brugada.

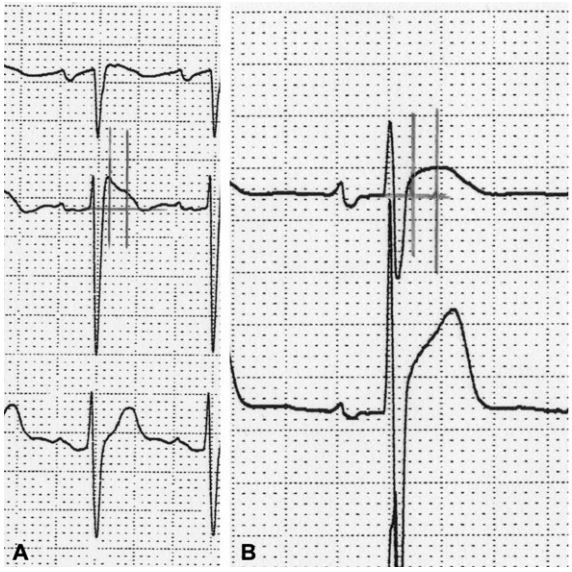

Figure 3. Measurement of *Corrado index*. A) Brugada pattern (personal case): the ST80 is lower than the STJ = STJ/ST80 ratio is >1. B) Early repolarization (reported case): the ST80 is higher than the STJ = STJ/ST80 ratio <1.

Isolated changes of ER in inferior and/or lateral leads with terminal QRS slurring have been reported in patients with idiopathic ventricular fibrillation.[16] Also recently, ER (particularly in the inferolateral leads) has been associated with an increased risk of idiopathic ventricular fibrillation and cardiovascular death in the general, non-athletic population.[11] The available data do not support the view that in general population of asymptomatic young individuals or athletes this ECG pattern is predictive of an increased risk of malignant ventricular arrhythmias[7] and recent studies on large populations of athletes and long follow-up do not support the view that among healthy athletes this ECG pattern is predictive of malignant ventricular arrhythmias and death.[12,17-19] This pattern appears not to confer a significant risk of recurrent malignant ventricular arrhythmias in the general athletic population.[20]

Conclusions

Although it can also be found in normal people, ER is almost always the rule in athletes and represents one of the elements, which characterize the typical athlete's ECG.

ER patterns deserve specific mention because they have been associated with an increased risk of ventricular fibrillation and sudden cardiac death. However, in otherwise healthy athletes without heart disease, the strong association between athletic performance and ER appears benign.[21]

An unfamiliarity with common ECG manifestations of regular or prolonged aerobic exercise may lead to misdiagnosis, unnecessary treatment, and the avoidable consumption of healthcare resources. Clinicians should be familiar with the normal ECG variants associated with significant aerobic activity.[14]

This case report could contribute to remind clinicians to consider the contextual clinical pictures behind the ECG findings.

References

1. Fagard R. Athlete's heart. Heart 2003;89:1455-61.
2. Corrado D, Thiene G, Nava A, et al. Sudden death in young competitive athletes: clinico-pathologic correlations in 22 cases. Am J Med 1990;89:588-96.
3. Maron BJ. Sudden death in young athletes. N Engl J Med 2003;349:1064-75.
4. Corrado D, Basso C, Thiene G. Sudden death in young athletes. Lancet 2005;366:S47-8.
5. Wu J, Stork TL, Perron AD, Brady WJ. The athlete's electrocardiogram. Am J Emerg Med 2006;24:77-86.
6. Corrado D, McKenna WJ. Appropriate interpretation of the athlete's electrocardiogram saves lives as well as money. Eur Heart J 2007;28:1920-2.
7. Corrado D, Pelliccia A, Heidbuchel H, et al. Recommendations for interpretation of 12-lead electrocardiogram in the athlete. Eur Heart J 2010;31:243-59.
8. Sharma S, Drezner JA, Baggish A, et al. International recommendations for electrocardiographic interpretation in athletes. Eur Heart J 2018;39:1466-80.
9. Gussak I, Antzelevitch C. Early repolarization syndrome: clinical characteristics and possible cellular and ionic mechanisms. J Electrocardiol 2000;33:299-309.
10. Boineau JP. The early repolarization variant - an electrocardiographic enigma with both QRS and JSTT anomalies. J Electrocardiol 2007;40:3e1-10.
11. Zorzi A, El Maghawry M, Corrado D. ST-segment elevation and sudden death in the athlete. Card Electrophysiol Clin 2013;5:73-84.
12. Quattrini FM, Pelliccia A, Assorgi R, et al. Benign clinical significance of j-wave pattern (early repolarization) in highly trained athletes. Heart Rhythm 2014;11:1974-82.
13. Zorzi A, Leoni L, Di Paolo FM, et al. Differential diagnosis between early repolarization of athlete's heart and coved-type Brugada electrocardiogram. Am J Cardiol 2015;115:529-32.
14. Martin-Beaulieu JP, Myrick KM, Martin T, et al. Common electrocardiogram variations pre- and post-marathon. Clin Case Rep 2016;4:944-7.
15. Brady WJ, Chan TC. Electrocardiographic manifestations: benign early repolarization. J Emerg Med 1999;17:473-8.
16. Haissaguerre M, Derval N, Sacher F, et al. Sudden cardiac arrest associated with early repolarization. N Engl J Med 2008;358:2016-23.
17. Muramoto D, Yong CM, Singh N, et al. Patterns and prognosis of all components of the j-wave pattern in multiethnic athletes and ambulatory patients. Am Heart J 2014;167:259-66.
18. Serra-Grima R, Doñate M, Alvarez-Garcia J, et al. Long term follow-up of early repolarization pattern in elite athletes. Am J Med 2015;128:192e1-9.
19. De Ambroggi L, Sorgente A, De Ambroggi G. Early repolarization pattern: innocent finding or marker of risk? J Electrocardiol 2013;46:297-301.
20. Cappato R, Furlanello F, Giovinazzo V, et al. J wave, QRS slurring, and ST elevation in athlete with cardiac arrest in absence of heart disease: marker of risk or innocent bystander? Circ Arrhythm Electrophysiol 2011;3:305-11.
21. Noseworthy PA, Weiner R, Kim J, et al. Early repolarization pattern in competitive athletes: clinical correlates and the effects of exercise training. Circ Arrhythm Electrophysiol 2011;4:432-40.