

# Interpolated junctional extrasystoles mimicking complex polymorphic ventricular arrhythmias in a healthy young athlete: a case report

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## Background

In young competitive athletes, ventricular arrhythmias could be a reason for concern as they may represent the sign of a serious underlying cardiac condition. On the other hand, atrial or conduction system premature beats are usually benign. However, when the properties of the His-Purkinje system lead to conduction aberrancies, there is a risk of misinterpreting benign arrhythmias as potentially at risk ventricular ectopic beats.

## Case summary

We described the case of a healthy young athlete with asymptomatic interpolated junctional ectopic beats interpreted as polymorphic ventricular tachycardia during pre-participation screening.

## Discussion

Strange and rare electrocardiogram pictures may be observed during sport pre-participation screening. The small atrioventricular (AV) junction is made up of many specialized fibres with different conduction properties. Junctional arrhythmias can have a normal anterograde conduction or can be conducted with aberrancy. Rarely, they can be interpolated and cause PR prolongation or bundle branch block by increasing the refractory period of the AV node and/or the conduction system. When aberrancy occurs, they can be mistaken for 'atypical' ventricular arrhythmias. Prognosis of these events remains uncertain.

## Keywords

Junctional ectopic beats • Conduction system • Pre-participation screening • Ventricular arrhythmias • Case report

## ESC curriculum

8.1 Sports Cardiology • 8.5 Primary prevention

## Learning points

- Competitive Italian athletes must undergo annual pre-participation screening to detect cardiovascular conditions at risk of sudden cardiac death.
- When the properties of the His-Purkinje system lead to conduction aberrancies, there is a risk of misinterpreting benign arrhythmias as potentially at risk ventricular ectopic beats.

## Introduction

Ectopic beats are arrhythmic events resulting from premature depolarization that may take place anywhere in the myocardium. In the setting

of pre-participation screening of young competitive athletes, the recording of premature beats on the electrocardiogram (ECG) may raise the concern of an underlying disease potentially at risk of sudden cardiac death (SCD). While ventricular arrhythmias (especially if complex)

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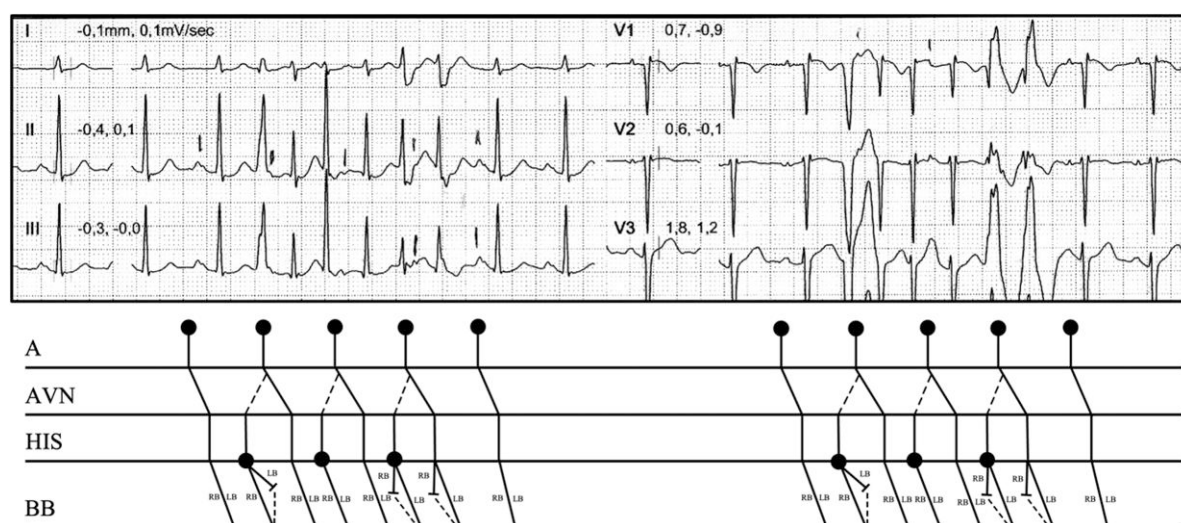
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may represent the sign of a serious underlying cardiac condition and requires careful clinical assessment, atrial or conduction system premature beats are usually benign.<sup>1-4</sup> However, understanding the origin and the mechanism behind these arrhythmias may be somewhat challenging, as they can mimic each other according to the electrophysiological properties of the myocardial tissues and to the quality of the ECG signals. In particular, the risk of labelling the patient as having a potentially at-risk condition increases when the properties of the His-Purkinje system lead to conduction aberrancies that may resemble ventricular arrhythmias.<sup>5,6</sup>

Herein, we present the case of a healthy young athlete with interpolated junctional beats (JBs) in the ECG that were interpreted as polymorphic ventricular tachycardia.

## Summary figure



Schematic representation of one of the arrhythmic episodes. Junctional ectopic beats and sinus p waves are dissociated. Ectopic beats are conducted with three different QRS morphologies during the same paroxysm according to the refractory period of the bundle branches. The first one is conducted with left-bundle-branch-block, the second with narrow QRS, and the third with right-bundle-branch-block morphologies. The PR interval of the sinus beats following each extrasystole is prolonged because of the partial retrograde penetration of the AV node by the ectopic impulses. RR intervals of the premature beats are constant suggesting a protected focus (parasytyle). There is no compensatory pause after each extrasystole.

## Case presentation

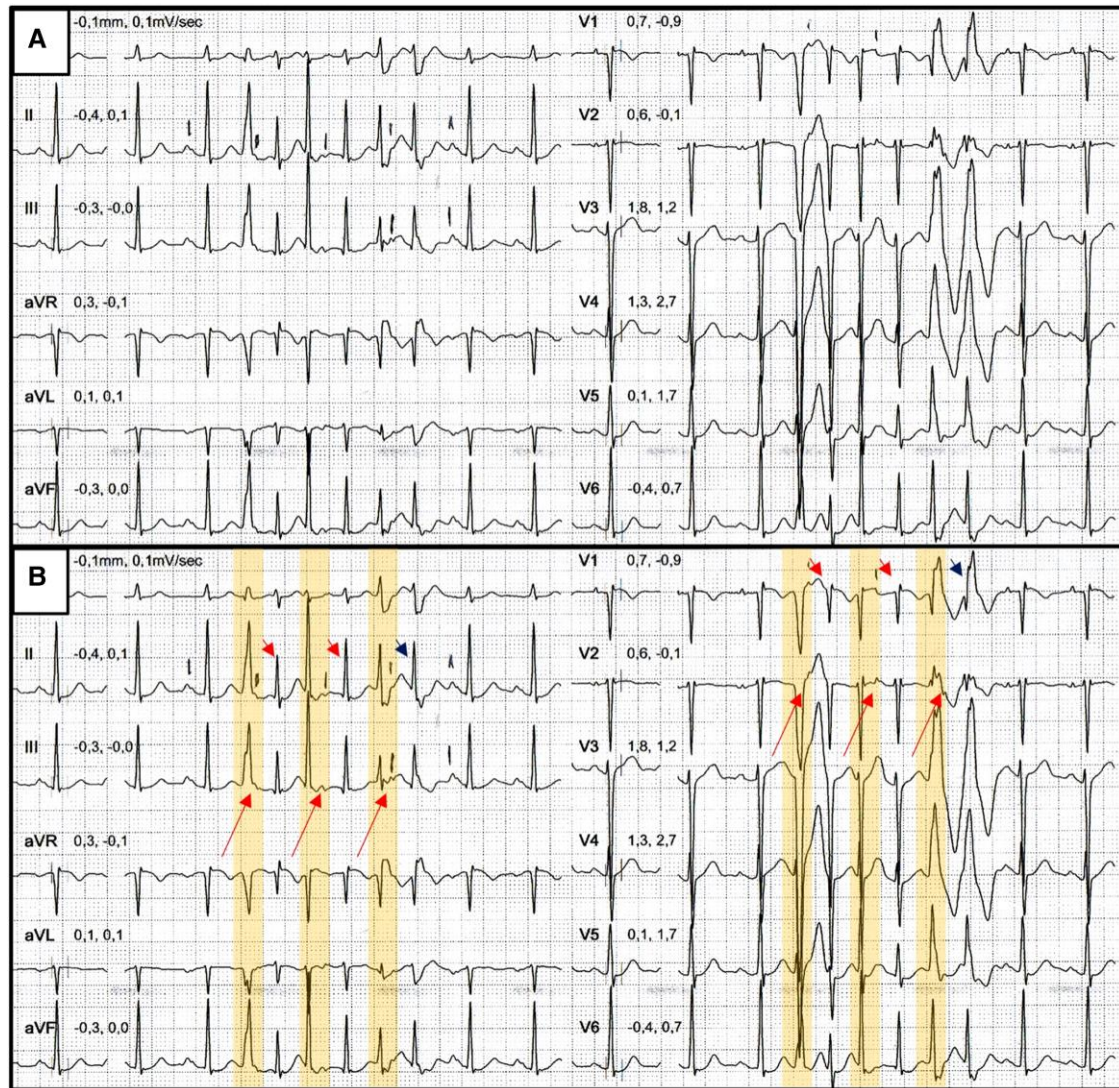
The patient was a 15-year-old asymptomatic teenager who played soccer at a regional level. His past medical history was unremarkable while familial history was negative for cardiomyopathies or SCD. He had undergone an ECG in the previous year that was normal. At the last annual pre-participation screening, which in Italy is mandatory by law, the resting ECG revealed brief paroxysms of asymptomatic tachycardia featured by the alternation of narrow and wide QRS complexes with both right-bundle-branch (RBBB) and left-bundle-branch-block (LBBB) morphologies (Figure 1). Following this finding, sports eligibility was temporarily denied, and he was referred to cardiological evaluation.

To investigate the nature and extent of the arrhythmic episodes, he was admitted to the Cardiology Unit. Physical examination and laboratory tests were unremarkable. At telemetry monitoring, similar resting asymptomatic non-sustained arrhythmic episodes were

recorded (Figure 2). Two-dimensional echocardiogram was normal. He then underwent cardiac magnetic resonance (CMR) (Figure 3) that did not reveal any structural or functional cardiac abnormalities and showed a normal origin of the coronary arteries. In contrast to the resting arrhythmic burden, maximal exercise testing was free of arrhythmias and symptoms. Genetic screening was also performed, but no pathogenic or likely pathogenic variants emerged. Beta-blocker therapy with bisoprolol 1.25 mg once a day was then started, but it was ineffective. Until diagnostic and prognostic clarification of the arrhythmias, a wearable cardioverter defibrillator was prudentially positioned, and the patient was discharged.

He was then referred to a tertiary centre where he underwent outpatient exercise testing and CMR that were again free of arrhythmias and structural cardiac abnormalities. A 12-lead 24 h Holter ECG let to clarify the nature of the arrhythmic episodes. The patient, indeed, showed sporadic paroxysms of tachycardia consisting of the alternation

of sinus beats and interpolated JB, both conducted with wide and narrow QRS. As the RR intervals of repeated interpolated JB were constant while the RR intervals of the sinus beats varied slightly because of PQ interval prolongation, we hypothesized that it was a protected ectopic focus (parasytyle) (Figure 4 and Summary figure). After a careful discussion and taking into consideration the preference of the patient and parents, no invasive electrophysiological study was performed to confirm the diagnosis because the arrhythmia was very infrequent ( $\approx 100$  JB/day) and was unlikely to be induced by isoproterenol infusion (considering the results of the two exercise tests). Moreover, the additional value of the study for risk stratification and therapeutic purpose was questionable. Considering the absence of sustained arrhythmias, their regression during effort and the absence of structural heart disease, sports eligibility was granted, and the patient was discharged without any wearable device with a six-month follow-up programme.



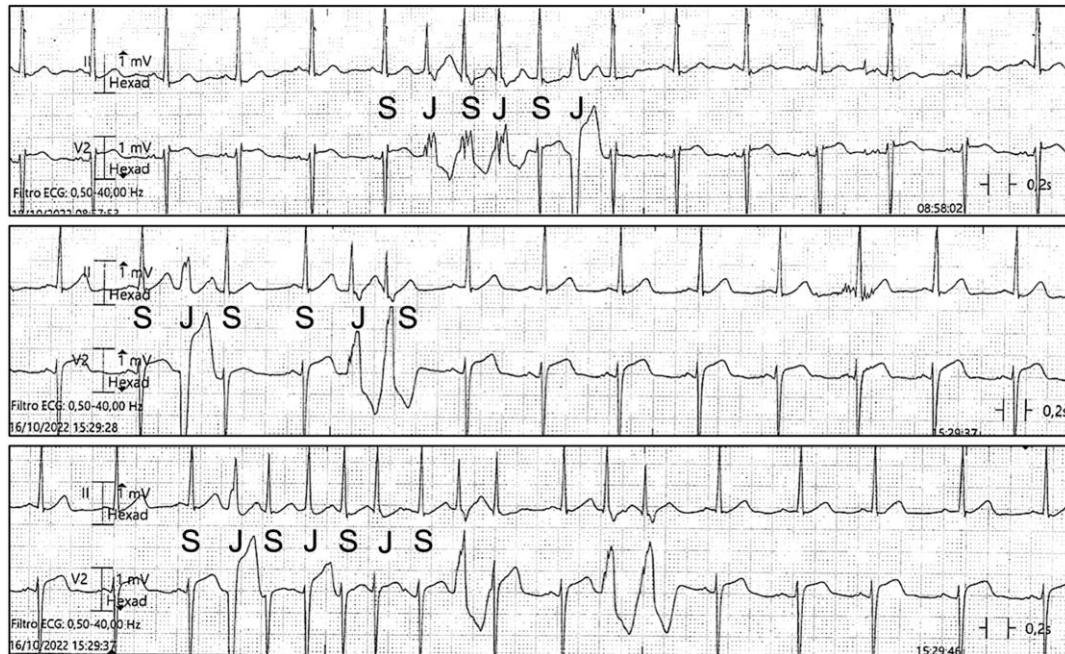
**Figure 1** Pre-participation 12-lead resting ECG showing brief episodes of pseudotachycardia (A). A more-in-depth evaluation of the same ECG (B) shows three interpolated junctional extrasystoles (yellow background) conducted respectively with left bundle branch block, narrow QRS, and right bundle branch block. The sinus beats (red arrows) after the interpolated ectopic beat are conducted with a longer PR interval and either with narrow QRS (red arrowheads) or with right bundle branch block (blue arrowhead).

## Discussion

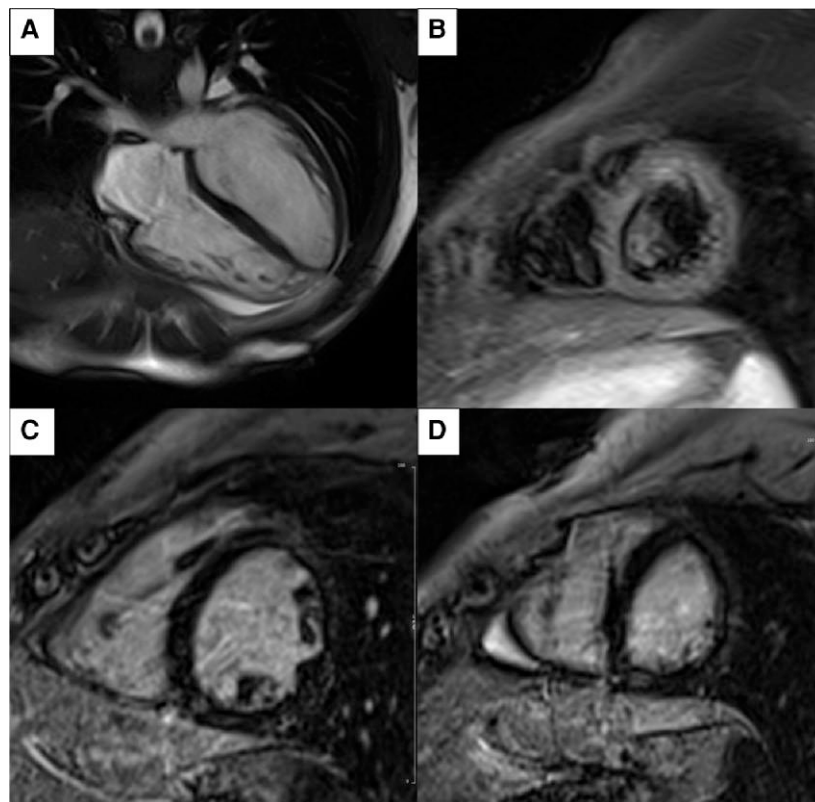
Since the early 80s, competitive Italian athletes must undergo annual pre-participation screening to detect cardiovascular conditions at risk of SCD.<sup>7,8</sup> Despite the benefits of this systematic screening,<sup>9</sup> strange and rare ECG pictures may be observed. In particular, premature beats, whether isolated or repetitive, can be very easy to diagnose, but sometimes difficult to interpret. They are the most common arrhythmic events, and while atrial and ventricular extrasystoles account for most of them, arrhythmias originating from the specialized conduction system other than the left bundle fascicles are rare and mostly unrecognized. Studies on the Purkinje fibres placed emphasis on these areas as a trigger source for ventricular fibrillation in many cardiac diseases and target for catheter ablation.<sup>10</sup> Cases of concealed JB causing atrioventricular (AV) block or interpolated JB

mimicking supraventricular tachycardia (so-called ‘pseudotachycardia’) have been described.<sup>5,6,11,12</sup>

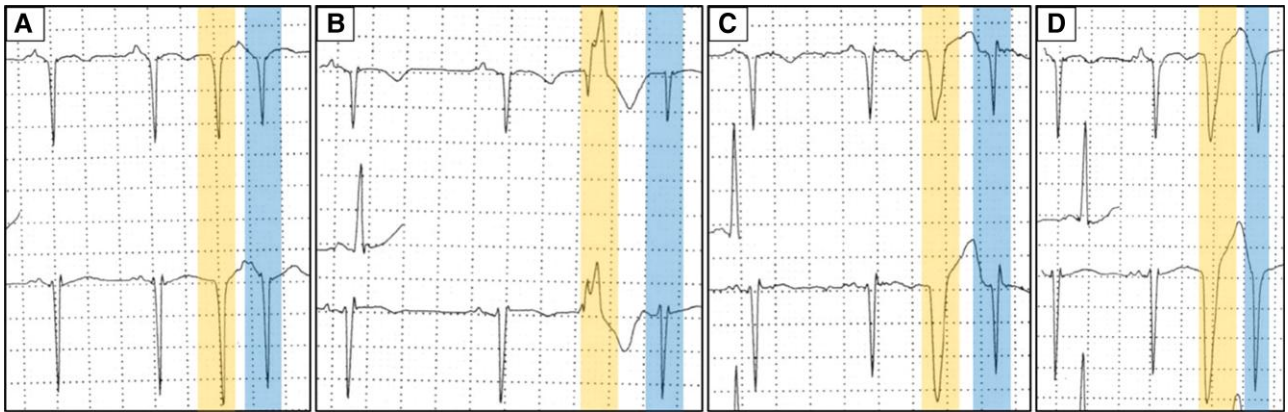
The small AV junction is made up of many specialized fibres with different conduction properties and whose electrical impulses may interfere with the anterograde and retrograde conduction from the atria and the ventricles, respectively.<sup>13</sup> This part of the conduction system, as other myocardial sites, could be the home of automatic and re-entry activities that may take origin either from the atrial-nodal, nodal, and nodal-His portions.<sup>13,14</sup> Junctional arrhythmias can have a normal anterograde conduction or can be conducted with aberrancy. Rarely they can be interpolated and, in this case, by increasing the refractory period of the AV node and/or the conduction system, they can cause the following sinus beat to be conducted with prolonged PR interval or bundle branch block. When aberrancy occurs, they can be mistaken for ‘atypical’ ventricular arrhythmias. Retrograde p waves may not be



**Figure 2** Telemetry monitoring at rest during the hospital stay. Frequent polymorphic episodes of the pseudotachycardia were recorded.



**Figure 3** Cardiac magnetic resonance of the patient. Cine long axis view (A), turbo inversion recovery magnitude (TIRM) short axis view (B), and post-contrast short axis view (C and D) showing normal biventricular and atrial volumes. No late gadolinium enhancement or oedema is appreciable.



**Figure 4** Representative example of junctional ectopic beats recorded on 12-lead ambulatory ECG monitoring showing: (A) an interpolated junctional ectopic beat (yellow background) conducted with narrow QRS followed by a sinus beat conducted with prolonged PQ interval and narrow QRS (blue background); (B) an interpolated junctional ectopic beat conducted with right bundle branch block (yellow background) followed by a sinus beat conducted with normal PQ interval and narrow QRS (blue background); (C) an interpolated junctional ectopic beat conducted with left bundle branch block (yellow background) followed by a sinus beat conducted with prolonged PQ interval and narrow QRS (blue background); (D) an interpolated junctional ectopic beat conducted with left bundle branch block (yellow background) followed by a sinus beat conducted with aberrancy (blue background).

easily seen, especially during high heart rate, pseudotachycardia, or poor-quality ECG.

Our patient shared many of these ‘junctional properties’, as ectopic beats were conducted both normally and with aberrancy, and in this latter case, both the right bundle and left bundle branches were alternatively affected. Additionally, the JBs were often interpolated and the sinus beats following each extrasystoles showed first degree AV block and, occasionally, right or left bundle branch block. Management and decision-making when dealing with young athletes with strange arrhythmias, as in this case, can be challenging and a greater caution may be appropriate at the beginning. Our patient, indeed, underwent an initial in-hospital management and, after the exclusion of structural heart disease and sustained life-threatening arrhythmias, a wearable cardioverter defibrillator was prudentially positioned while awaiting a second opinion at a specialized tertiary centre. The patient was asymptomatic, showed a negative family history, no arrhythmia-inducibility at exercise testing, and negative cardiac imaging.<sup>1</sup> Moreover, the genetic testing, which was performed because frequent JBs have been associated to mutations in the *SNC5A* gene and SCD, was also negative.<sup>15</sup> For this reason, we were reassured on the benign nature of the arrhythmia and cleared the athlete for competition, with a 6-month follow-up programme. Here we presented a rare case of a healthy young athlete with structurally normal heart and resting interpolated JB, sometimes conducted with aberrancy and also causing aberrant conduction of the following sinus beat, mimicking polymorphic ventricular tachycardia. The prognosis remains uncertain but, given their clinical features, is probably favourable.

## Lead author biography



Nicolò Martini is a Cardiology Resident at the University of Padova. He has a particular interest in arrhythmias and cardiomyopathies.

**Consent:** The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

**Conflict of interest:** None declared.

**Funding:** None.

## Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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