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**Author(s):** Joki, Tuukka; Nikus, Kjell; Laukkanen, Jari

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# The electrocardiographic 'triangular QRS-ST-T waveform' pattern: a marker of severe haemodynamic compromise in Takotsubo syndrome—a case report

Tuukka Joki <sup>1\*</sup>, Kjell Nikus<sup>2</sup>, and Jari Laukkanen <sup>3</sup>

<sup>1</sup>Department of Cardiology, Central Hospital of Central Finland, Keskussairaalantie 19, 40600 Jyväskylä, Finland; <sup>2</sup>Faculty of Medicine and Health Technology, Tampere University, Tampere, Finland; and <sup>3</sup>Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland

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## Background

Takotsubo cardiomyopathy is characterized by transient regional systolic dysfunction of the left ventricle, mimicking myocardial infarction. Although systolic left ventricular (LV) function normalizes in most cases, the outcome is not always favourable. Recently, a rare electrocardiogram (ECG) finding, lambda wave ST elevation or 'triangular QRS-ST-T waveform', was suggested as a possible marker of poor outcome in Takotsubo patients

## Case summary

After a brief episode of chest pain and shortness of breath, a 67-year-old woman developed cardiogenic shock. Her resting ECG showed widespread ST elevations, which soon evolved into a pattern of triangular QRS-ST-T waveforms in the inferior leads and V3–V6. Emergent coronary angiography was normal. The ejection fraction was 20% with apical ballooning and an LV thrombus. At 1-month follow-up, the patient was asymptomatic and the ECG showed only T-wave inversions.

## Discussion

The triangular QRS-ST-T waveform ECG pattern has recently been introduced as a high-risk marker in the Takotsubo syndrome.

## Keywords

Takotsubo • QRS-ST-T waveform • High-risk ECG • ST elevation • Cardiogenic shock • Case report

## Learning points

- Triangular QRS-ST-T waveform ST elevation is associated with life-threatening ventricular arrhythmias and cardiogenic shock.
- Takotsubo syndrome is a relevant differential diagnosis in acute patients with lambda-shaped/triangular QRS-ST-T type ST elevation and haemodynamic compromise.

## Introduction

Takotsubo syndrome is characterized by transient regional systolic dysfunction of the left ventricle, mimicking myocardial infarction (MI), without angiographic evidence of obstructive coronary artery disease or acute plaque rupture.<sup>1</sup> In most patients, the regional wall motion abnormality extends beyond territories perfused by single epicardial coronary artery. Takotsubo syndrome often presents with ST elevation in the electrocardiogram (ECG).<sup>2,3</sup> We encountered a patient with Takotsubo syndrome, who presented with a rare ECG manifestation.

\* Corresponding author. Tel: +358 445504234, Email: [tuukka.joki@ksshp.fi](mailto:tuukka.joki@ksshp.fi)

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## Timeline

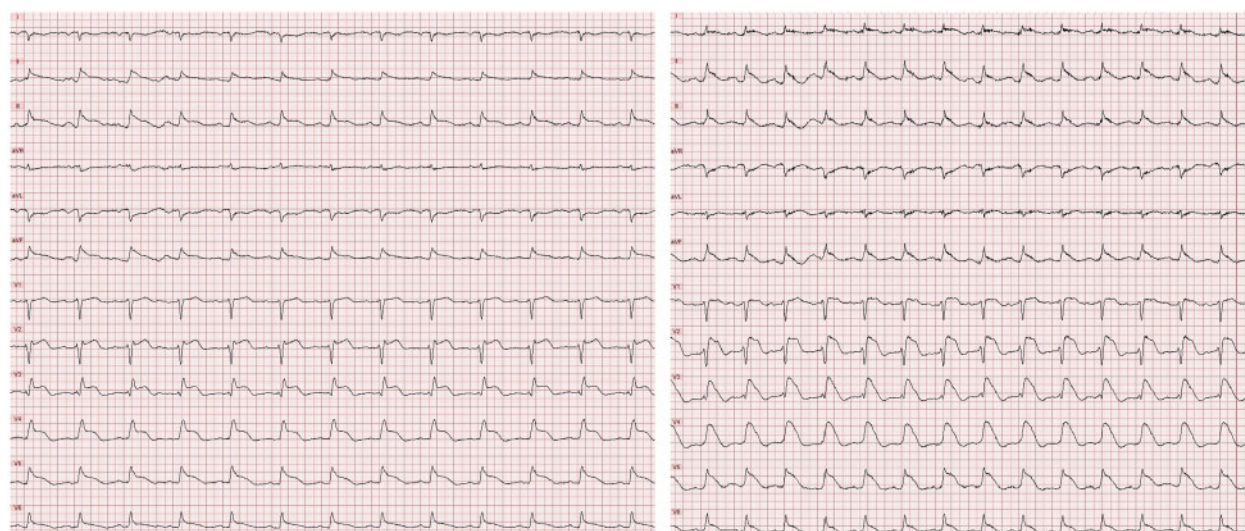
Health centre	Chest pain Shortness of breath Blood pressure 60/30 mmHg	Troponin T elevated Electrocardiogram (ECG): Anterior ST elevation Inferior ST elevation Grade 3 ischaemia Antithrombotic medication
Emergency room	Intense chest pain Blood pressure 60/30 mmHg Oxygen saturation 75%	ECG: Triangular-shaped QRST in: II, III, aVF, V3–V6 Telemetry Non-sustained ventricular tachycardia (VT)
Emergent invasive evaluation		Angiography No stenosis TIMI II flow Optical coherence tomography Normal findings
Intensive Care	Cardiogenic shock Non-invasive ventilatory support Levosimendan Non-sustained VT Amiodarone Lidocain	Echo Apical ballooning Apical left ventricular (LV) thrombus Ejection fraction (EF) 20%
Cardiology ward 1 week after admission	Haemodynamic stability	ECG: Almost complete ST resolution Minor T-wave inversion Inferior and anterior Q waves
1-month follow-up	Asymptomatic	Echo: EF 50% ECG: Complete ST resolution Q-wave resolution T-wave inversion
2-month follow-up		Cardiac magnetic resonance imaging Thrombus dissolved Late enhancement in LV apex compatible with Takotsubo
9-month follow-up	Asymptomatic	ECG T-wave inversion V2–V6
2-year follow-up	Asymptomatic Only beta-blocker medication	ECG normal Echo normal

## Case presentation

A 67-year-old woman without previous medical history felt emotionally affected during the funeral of a close relative. Four days later, she felt sudden chest pain and shortness of breath. In the local health centre, her haemodynamic state deteriorated within a few minutes with a blood pressure drop to 60/30 mmHg. She had worsening chest pain. Troponin-T was elevated and the ECG (*Figure 1*) showed widespread ST-elevations in the anterior and inferior leads with Grade 3 ischaemia. There were no cardiac murmurs but auscultation of the lungs revealed fine crepitant rales suspecting cardiac oedema.

Ticagrelor, Enoxaparin, and Aspirin were administered and she was immediately transported to hospital for primary percutaneous coronary intervention. At hospital arrival, she had intense chest pain and her blood pressure was 60/30 mmHg. The ECG (*Figure 2*) showed extensive ST elevations in all precordial leads and also in the inferior leads. The ST elevations had a triangular or lambda shape in II, III, aVF, and V3–V6. Oxygen saturation was 75%. Echocardiography showed an ejection fraction (EF) of 20%.

The patient had repeated episodes of non-sustained ventricular tachycardia (VT) at 165 b.p.m. During the VT episodes, she lost her consciousness, electrical cardioversion was not required.



**Figure 1** Electrocardiogram in the health centre and at hospital admission.

In emergent coronary angiography, a 7-Fr guiding catheter was introduced into the left coronary artery immediately because of a suspicion of left main occlusion. Surprisingly, there were no signs of coronary artery disease. Coronary flow was slightly reduced (TIMI II) most probably due to severe hypotension. The patient was haemodynamically unstable, and optical coherence tomography was performed to rule out plaque rupture or thrombosis of the left main or left anterior descending coronary artery; the findings were completely normal. Ticagrelor and Aspirin therapy was not continued.

The patient was admitted to the intensive care unit with a suspicion of Takotsubo syndrome. Cardiogenic shock was treated with non-invasive ventilatory support, levosimendan infusion, and parenteral furosemide. Repeated VTs were treated with 300 mg amiodarone bolus + 1200 mg/24 h infusion and one 30 mg lidocaine bolus.

Troponin-T elevated to maximum of 500 ng/L (<15 ng/L) and P-Probnp to 6900 ng/L (<285 ng/L).

The ECG (Figure 3) remained severely distorted with triangular QRS-ST-T waveforms and the patient continued to have haemodynamic compromise and repeated non-sustained VTs. Echocardiography showed typical apical ballooning and an ejection fraction of 20% with thrombus in the left ventricular (LV) apex (Figure 4). Low-molecular weight heparin was started 100 mg × 2 s.c.

Mechanical LV support therapy was considered, but our hospital does not provide such equipment, and patient transfer to the nearest university hospital was not considered safe because of haemodynamic instability. If transport would have been necessary in case of further clinical deterioration, the LUCAS chest compression system would have been considered. The patient's condition improved steadily within a few days, and after a week, she was discharged home with an EF of 35%. Because of the thrombus, warfarin was started during the



**Figure 2** Angiography of the left coronary artery.

initial hospital stay. Low-molecular weight heparin therapy was discontinued on the 6th day of hospital stay when INR reached 2.0.

Within a week, the ECG showed almost complete ST resolution with minor T-wave inversions in V3–V4. The QRS complex was narrow and inferior and anterior Q waves had developed.



At 1-month follow-up, the patient was asymptomatic with an almost normal EF of 50% and no signs of apical thrombus. The ECG (Figure 5) showed complete ST resolution and resolution of Q waves with T-wave inversions in I, aVL, and V2–V6.

After 2 months, cardiac magnetic resonance imaging was performed. The thrombus had dissolved and only mild hypokinesia and late enhancement in the LV apex compatible with Takotsubo syndrome was found. Warfarin was stopped.

Nine months after the event, the patient was completely asymptomatic, but the ECG still showed T-wave inversions in V2–V6. Two

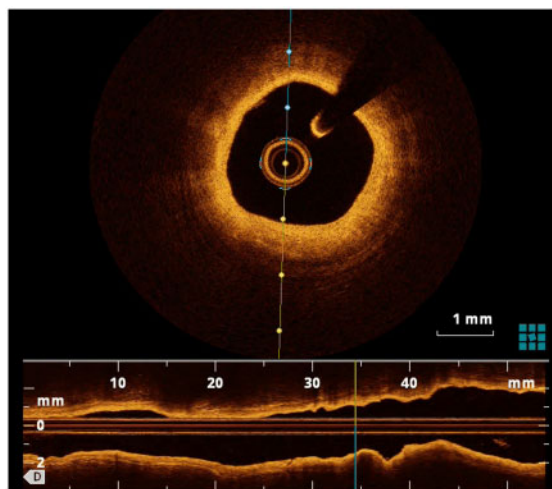
years after, the event the ECG and echocardiography were completely normal and patient had a betablocker as the sole medication.

## Discussion

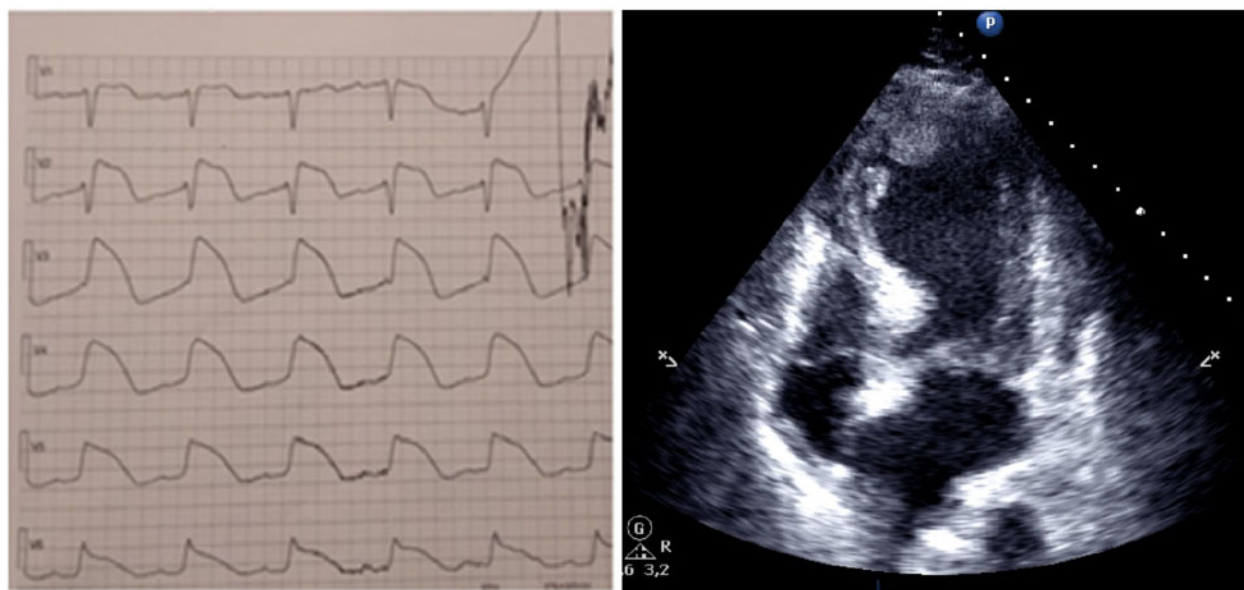
The Takotsubo syndrome is a quite common finding in patients with a suspicion of acute coronary syndrome. Previous studies showed that in-hospital mortality in the Takotsubo syndrome is similar to that of ST-elevation MI, 20% of the patients were haemodynamically unstable at admission and in 15% medical or mechanical circulatory support was required.<sup>4,5</sup> The ECG typically shows ST elevation, ST depression, and/or T-wave inversions. Emergent coronary angiography is recommended to exclude acute coronary occlusion if ST elevations are present.

Severe (Grade 3) ischaemia in ST-elevation MI results in distortion of the terminal part of the QRS complex, either with disappearance of S waves or with a J-point/R-wave ratio of  $\geq 50\%$ <sup>6</sup> and is associated with poor outcome. Downsloping or lambda-shaped ST elevation was so far reported in six patients with Takotsubo syndrome.<sup>7,8</sup> In a small series of five patients with this ECG pattern, mean EF was 32% and all patients had in-hospital complications, including cardiogenic shock, and two patients died in-hospital due to refractory cardiogenic shock.<sup>8</sup> Interestingly, maximal ST elevation was reached 6 h from admission. Also in our patient, the ST elevations at hospital arrival were more severe than at the initial presentation in the health centre.

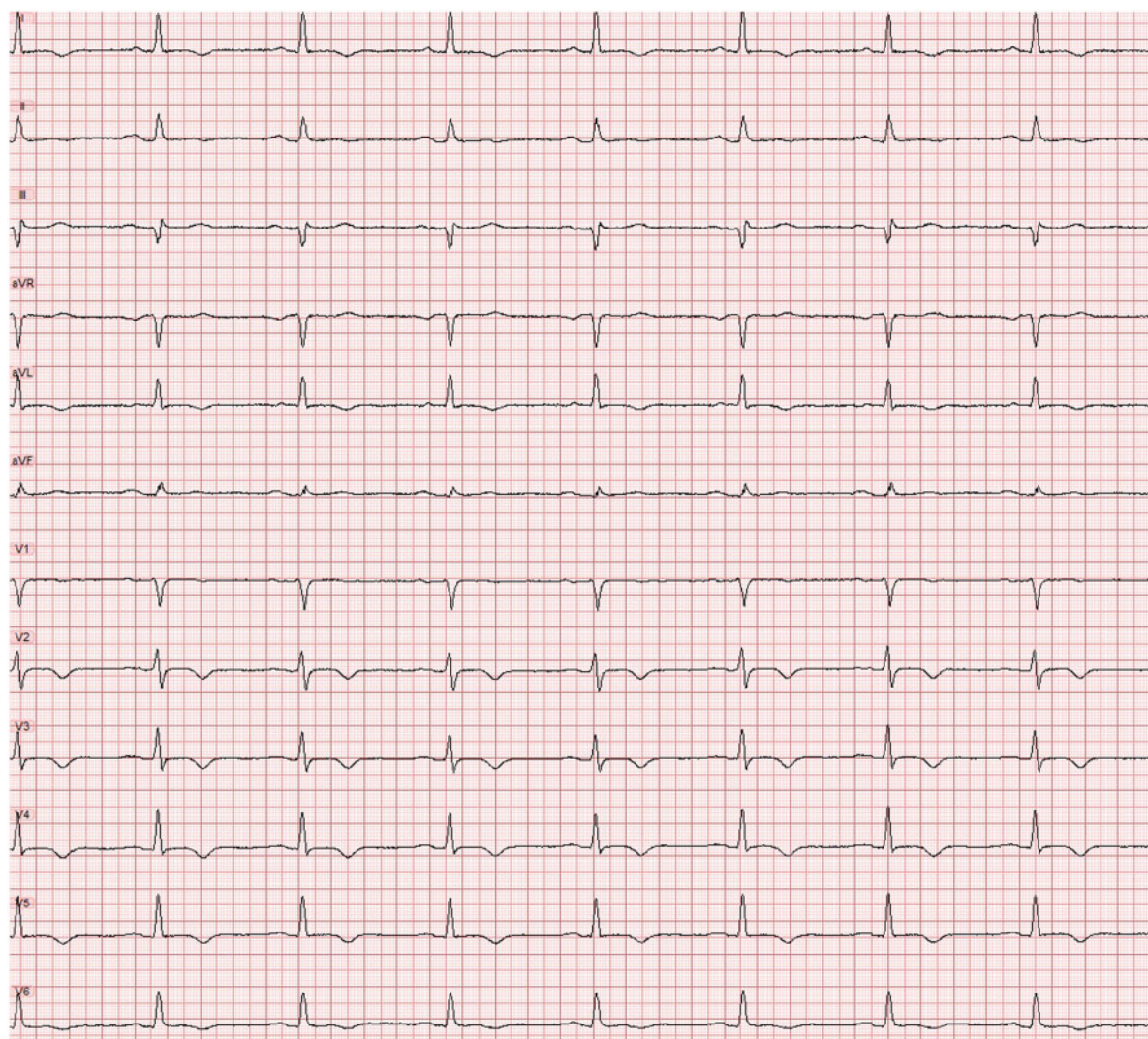
This ECG pattern is not limited to ST-elevation MI and Takotsubo syndrome. A similar pattern in the inferolateral ECG leads was reported as an atypical Brugada syndrome in a young male patient without ischaemia.<sup>9</sup> The ECG pattern was associated with polymorphic VT, ventricular fibrillation, and sudden cardiac death. In ST-elevation MI, the term Grade 3b ischaemia was proposed to describe



**Figure 3** Optical coherence tomography findings of the left main and left anterior descending coronary artery.



**Figure 4** Electrocardiogram and echocardiography in the intensive care unit. There is thrombus in the left ventricular apex.



**Figure 5** Electrocardiogram at 1-month follow-up.

this phenomenon, which has been considered as a sign of severe myocardial ischaemia. Aizawa *et al.*<sup>10</sup> reported a similar ECG pattern (steep down-sloping ST elevation with negative T waves) is a predictor of ventricular fibrillation during acute MI.

## Conclusion

A rare ECG finding, lambda-shaped or triangular QRS-ST-T waveform ST elevation, is associated with cardiogenic shock and ventricular arrhythmias in Takotsubo syndrome.

## Lead author biography



Tuukka Joki, MD is an invasive cardiologist in the Central Finland Central Hospital, Department of Cardiology, Jyväskylä, Finland. His area of interest is acute cardiac care, coronary interventions, pacemaker, cardiac resynchronization therapy, and implantable cardioverter-defibrillator implantations.



## Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

**Slide sets:** A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

**Consent:** The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

**Conflict of interest:** none declared.

## References

- Ghadri J-R, Wittstein IS, Prasad A, Sharkey S, Dote K, Akashi YJ, Cammann VL, Crea F, Galiuto L, Desmet W, Yoshida T, Manfredini R, Eitel I, Kosuge M, Nef HM, Deshmukh A, Lerman A, Bossone E, Citro R, Ueyama T, Corrado D, Kurisu S, Ruschitzka F, Winchester D, Lyon AR, Omerovic E, Bax JJ, Meimoun P, Tarantini G, Rihal C, Y-Hassan S, Migliore F, Horowitz JD, Shimokawa H, Lüscher TF, Templin C. International expert consensus document on Takotsubo syndrome (part I): clinical characteristics, diagnostic criteria, and pathophysiology. *Eur Heart J* 2018;**39**:2032–2046.
- Ghadri J-R, Wittstein IS, Prasad A, Sharkey S, Dote K, Akashi YJ, Cammann VL, Crea F, Galiuto L, Desmet W, Yoshida T, Manfredini R, Eitel I, Kosuge M, Nef HM, Deshmukh A, Lerman A, Bossone E, Citro R, Ueyama T, Corrado D, Kurisu S, Ruschitzka F, Winchester D, Lyon AR, Omerovic E, Bax JJ, Meimoun P, Tarantini G, Rihal C, Y-Hassan S, Migliore F, Horowitz JD, Shimokawa H, Lüscher TF, Templin C. International expert consensus document on Takotsubo syndrome (part II): diagnostic workup, outcome, and management. *Eur Heart J* 2018;**39**:2047–2062.
- Templin C, Ghadri JR, Diekmann J, Napp LC, Bataiosu DR, Jaguszewski M, Cammann VL, Sarcon A, Geyer V, Neumann CA, Seifert B, Hellermann J, Schwyzer M, Eisenhardt K, Jenewein J, Franke J, Katus HA, Burgdorf C, Schunkert H, Moeller C, Thiele H, Bauersachs J, Tschöpe C, Schultheiss H-P, Laney CA, Rajan L, Michels G, Pfister R, Ukena C, Böhm M, Erbel R, Cuneo A, Kuck K-H, Jacobshagen C, Hasenfuss G, Karakas M, Koenig W, Rottbauer W, Said SM, Braun-Dullaeus RC, Cuculi F, Banning A, Fischer TA, Vasankari T, Airaksinen KEJ, Fijalkowski M, Rynkiewicz A, Pawlak M, Opolski G, Dworakowski R, McCarthy P, Kaiser C, Osswald S, Galiuto L, Crea F, Dichtl W, Franz WM, Empen K, Felix SB, Delmas C, Lairez O, Erne P, Bax JJ, Ford I, Ruschitzka F, Prasad A, Lüscher TF. Clinical features and outcomes of Takotsubo (stress) cardiomyopathy. *N Engl J Med* 2015;**373**:929–938.
- Singh K, Carson K, Shah R, Sawhney G, Singh B, Parsaik A, Gilutz H, Usmani Z, Horowitz J. Meta-analysis of clinical correlates of acute mortality in takotsubo cardiomyopathy. *Am J Cardiol* 2014;**113**:1420–1428.
- Sharkey SW, Pink VR, Lesser JR, Garberich RF, Maron MS, Maron BJ. Clinical profile of patients with high-risk Tako-Tsubo cardiomyopathy. *Am J Cardiol* 2015;**116**:765–771.
- Birnbaum Y, Herz I, Sclarovsky S, Zlotikamien B, Chetrit A, Olmer L, Barbash GI. Prognostic significance of the admission electrocardiogram in acute myocardial infarction. *J Am Coll Cardiol* 1996;**27**:1128–1132.
- Yochai B, Nikus K, Birnbaum Y. About QRS prolongation, distortion and the acuteness score. *J Electrocardiol* 2016;**49**:265–271.
- Tarantino N, Santoro F, Guastafierro F, Di Martino LFM, Scarcia M, Ieva R, Ruggiero A, Cuculo A, Mariano E, Di Biase M, Brunetti ND. “Lambda-wave” ST-elevation is associated with severe prognosis in stress (takotsubo) cardiomyopathy. *Ann Noninvasive Electrocardiol* 2018;**23**:e12581.
- Pérez-Riera A, Ferreira C, Schapachnik E, Sanches PC, Moffa PJ. Brugada syndrome with atypical ECG: downsloping ST-segment elevation in inferior leads. *J Electrocardiol* 2004;**37**:101–104.
- Aizawa Y, Jastrzebski M, Ozawa T, Kawecka-Jaszcz K, Kukla P, Mitsuma W, Chinushi M, Ida T, Aizawa Y, Ojima K, Tagawa M, Fujita S, Okabe M, Tsuchida K, Miyakita Y, Shimizu H, Ito S, Imaizumi T, Toba K. Characteristics of electrocardiographic repolarization in acute myocardial infarction complicated by ventricular fibrillation. *J Electrocardiol* 2012;**45**:252–259.