JACC: CASE REPORTS VOL. 4, NO. 21, 2022

CASE REPORT

BEGINNER

EDUCATIONAL CLINICAL CASE SERIES

Electrocardiograms in Critical Care Cardiology

Is it Acute Coronary Syndrome?

Kuang-Yuh Chyu, MD, PhD, Prediman K. Shah, MD

ABSTRACT

Patients with critical illness may present with electrocardiogram (ECG) findings difficult for physicians to distinguish them from acute coronary syndrome. This article provides three cases of such clinical scenarios. Examples of ECGs and their clinical characteristics and significance are discussed. (**Level of Difficulty: Beginner.**) (J Am Coll Cardiol Case Rep 2022;4:1394–1398) © 2022 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Patients with critical illness may present with electrocardiogram (ECG) findings difficult for physicians to distinguish them from acute coronary syndrome.

CASE 1

A 59-year-old woman with a history of hypertension, diabetes mellitus, hyperlipidemia, obesity, and breast and colon cancer presented with a 2-week history of dyspnea on exertion and acute worsening of shortness of breath with chest pressure 1 hour before presentation. Patient was initially triaged as having ST-segment elevation myocardial infarction (STEMI) for emergent coronary angiogram based on suggestive ST-segment elevation (STE) on V_1 and aVR on ECG (Figure 1). When the coronary angiogram showed no coronary obstruction, a pulmonary angiogram was immediately performed because pulmonary embolism (PE) was raised as an alternative diagnosis. Massive PE was found, and catheter-based embolectomy was done, with normalization of ECG changes afterward. A retrospective review of the ECG showed sinus tachycardia, S1Q3T3 pattern, and right bundle branch block.

LEARNING OBJECTIVES

- To identify 3 STEMI-mimic ECG patterns
- To learn the clinical significance and challenges in treating patients with these ECG patterns

CASE 2

A large T-wave inversion in multiple ECG leads (Figure 2) was recorded from a 77-year-old man after a motor vehicle accident. This ECG pattern has been referred as a cerebral T-wave pattern and can be seen in patients with ischemic or hemorrhagic stroke, subarachnoid hemorrhage, or head trauma.

CASE 3

A 78-year-old woman reported a 1-day history of palpitations, dry cough, and left shoulder and chest pain. She was in cardiogenic shock, with an elevated circulating level of troponin. Given her clinical

From the Smidt Heart Institute, Department of Cardiology, Cedars Sinai Medical Center, Los Angeles, California, USA.
The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received June 17, 2022; accepted June 30, 2022.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2022.06.028

presentation and STE in V_3, V_4 with poor R-wave progression in V_1 to V_4 on ECG (Figure 3A), an emergent coronary angiogram was performed and revealed patent coronary arteries. An echocardiogram showed markedly reduced ejection fraction and a left ventricular wall motion abnormality consistent with Takotsubo cardiomyopathy (TCM). Sequential ECGs during her recovery phase were also recorded (Figures 3B to 3D).

DISCUSSION

CASE 1: WHEN THE ECG SUGGESTS ACUTE PE. Acute PE is a potentially life-threatening event that is often underdiagnosed or misdiagnosed, mostly because of its nonspecific symptoms overlapping with those of other diseases. No specific ECG pattern is diagnostic of PE. Traditional ECG findings associated with PE are sinus tachycardia, right axis deviation, tall R in V_1 and V_2, right precordial T-wave inversion along with T-wave inversion in lead III, new incomplete or complete right bundle branch block, S1Q3T3 pattern, or atrial arrhythmia. Many of the ECG signs, except sinus tachycardia, occur in <25% of patients with diagnoses of PE, making these ECG changes insensitive to a diagnosis of PE. Most of these ECG abnormalities are related to right ventricular strain from PE, and their presence is strongly associated with elevation of cardiac biomarkers and echocardiographic signs of right ventricular overload, indicating a large clot burden with correlation to negative outcomes such as clinical deterioration, in-hospital mortality, or 30-day mortality.

A rarer ECG finding in PE is STE in precordial leads, especially V_1, V_2, and sometimes V_3, V_4 (Figure 1). This pattern of ECG can present a diagnostic and management challenge to treating physicians because many cases have been triaged initially as STEMI. A case-series review reported that among 12 PE cases with STE in V_1 to V_4, 11 cases were initially diagnosed as STEMI. Ten patients underwent coronary angiogram, and only 1 of their 10 cases was diagnosed with PE before a coronary angiogram.[1]

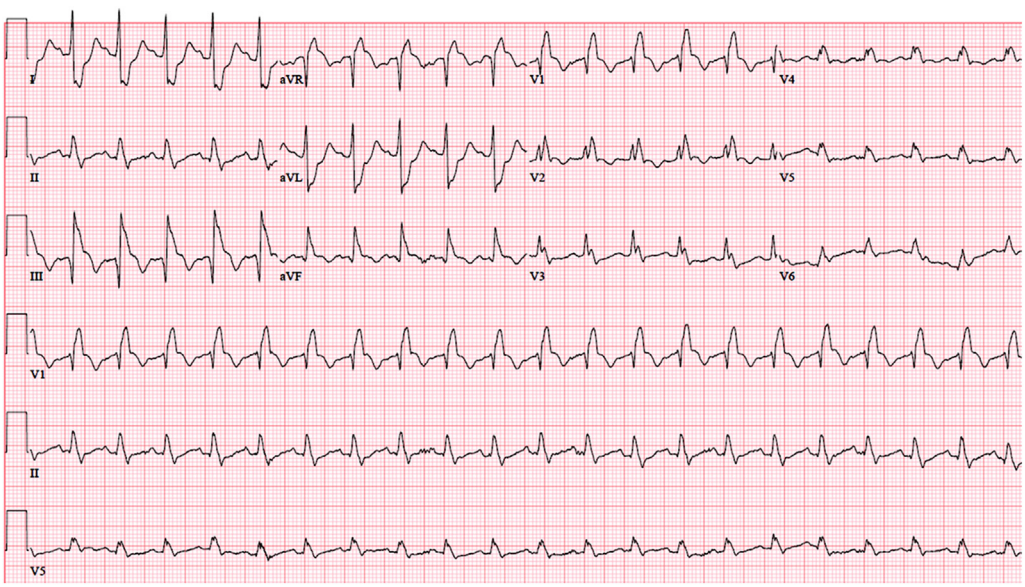
CASE 2: WHEN THE ECG SUGGESTS CNS EVENTS: CEREBRAL OR WATERFALL T WAVES. Patients with acute neurological disorders can present with ECG abnormalities including ST-segment depression, nonspecific ST-T wave changes, cerebral T-wave, prolonged QT interval, U waves, brady- or tachyarrhythmia. Among these, cerebral T waves, defined as T-wave inversion of ≥5 mm depth in ≥4 contiguous precordial leads, is visually striking (Figure 2), but its prevalence in patients with CNS events is low, ranging from 1.4% to 2.5%.[2-4]

Given that patients with neurologic disorders can present with ST-segment depression, T-wave inversion, or QT prolongation, and many of them have

ABBREVIATIONS AND ACRONYMS

CAD = coronary artery disease
ECG = electrocardiogram
PE = pulmonary embolism
STE = ST-segment elevation
STEMI = ST-segment elevation myocardial infarction
TCM = Takotsubo cardiomyopathy

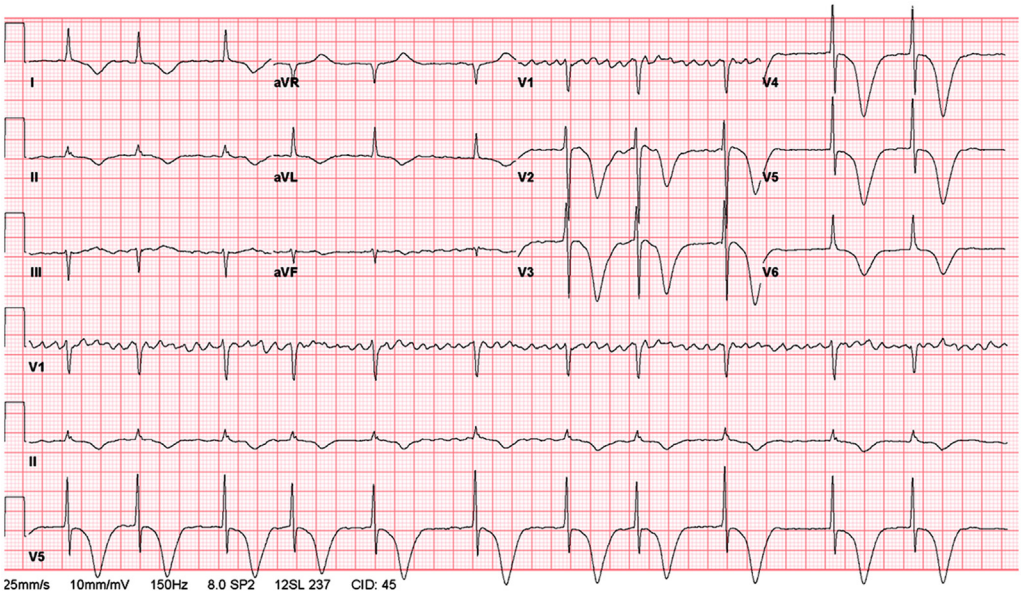
FIGURE 1 ST-Segment Elevation in Pulmonary Embolism



An electrocardiogram pattern of pulmonary embolism may be mistaken as ST-segment elevation myocardial infarction.

JACC: CASE REPORTS, VOL. 4, NO. 21, 2022
NOVEMBER 2, 2022:1394–1398

FIGURE 2 Cerebral T Waves



An electrocardiogram pattern with giant T-wave inversion over precordial leads can be observed in patients with central nervous system event, especially hemorrhagic event.

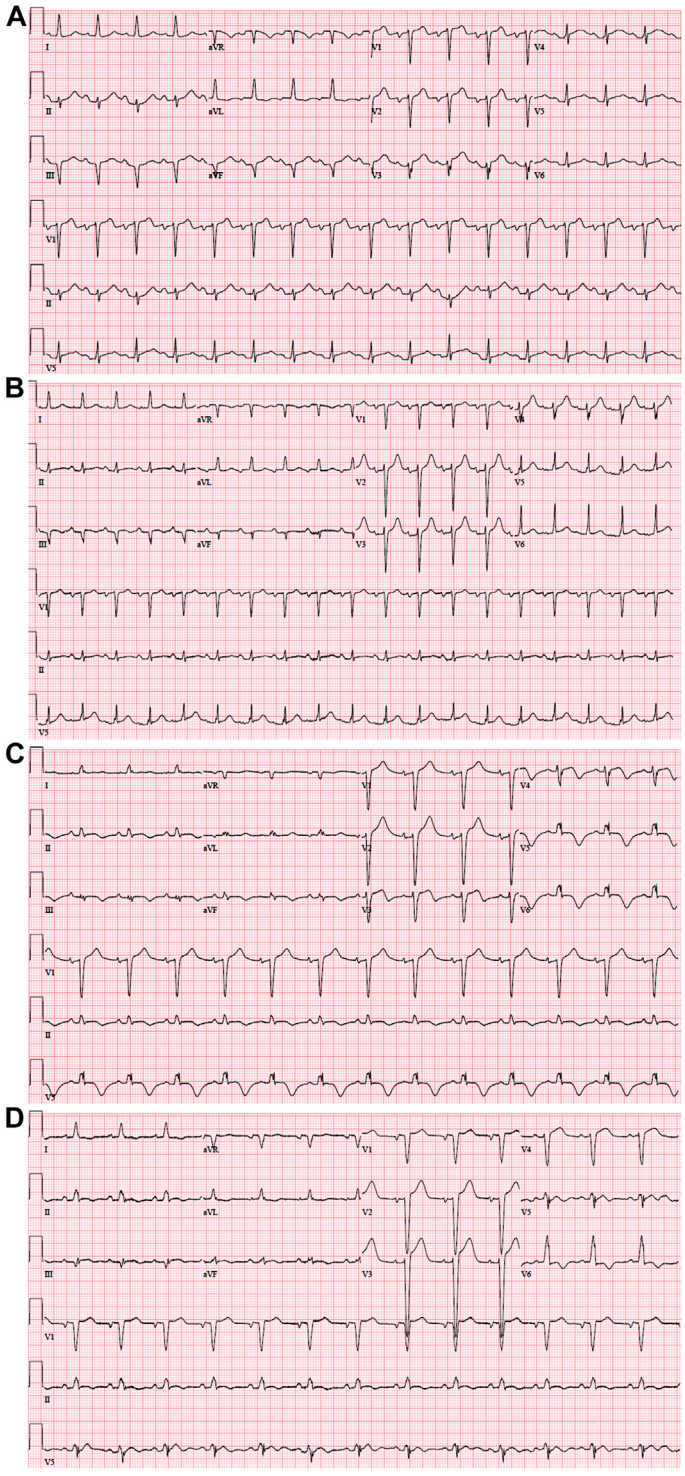
atherosclerotic risk factors common to both cerebral vascular disease and CAD, it can be challenging for treating physicians to treat such patients. Some patients with cerebral T waves even experience abnormal left ventricular wall motion on echocardiogram and/or a modest elevation of troponin level, suggestive of concomitant ACS. This challenging clinical scenario requires close collaboration between neurologists and cardiologists because these patients are vulnerable to bleeding complications should they undergo coronary procedures requiring antithrombotic and antiplatelet medications. Some of these cases eventually can be attributed to TCM because of the transient nature of ECG and wall motion changes. However, the diagnosis of TCM can only be made retrospectively after patients have been followed up for a few days or after coronary angiography has been performed to exclude obstructive CAD.

An ECG pattern like a cerebral T-wave can be seen in Wellens syndrome, post-percutaneous coronary intervention reperfusion in STEMI, hypertrophic cardiomyopathy, or T-wave changes after cessation of RV pacing, attributed to cardiac memory. Clinical context and cardiac imaging can help the differentiation and establishment of clinical diagnosis.

CASE 3: THE ECG IN THE OCTOPUS CATCHER SYNDROME (TCM). TCM is characterized by symptoms of myocardial ischemia with apical LV ballooning (sometimes the reverse pattern of basal LV dyskinesis) without significant coronary obstructive lesion as a culprit on coronary angiogram. This entity may cause enormous anxiety and debate among emergency department physicians, cardiologists, and interventional cardiologists when they evaluate the conditions of patients with chest pain, positive troponin, and suggestive myocardial ischemic ST-T changes on ECG. Although diagnostic criteria for TCM have been established,[5] the ECG changes can simulate a classic STEMI on presentation.

Inasmuch as many of the ECG changes in TCM mimic classic acute coronary syndrome, many attempts have been made to distinguish the ECG features between the 2 entities. TCM is generally associated with absence of abnormal Q waves, absence of reciprocal ST-T changes, presence of STE in lead -aVR, and absence of STE in lead V_1 when compared with ECG changes in anterior STEMI, but such distinguishing features have only modest predictive accuracy.[6] In addition to STE in precordial leads (excluding V_1), STE in TCM has been observed more in II, III, aVF, and aVR in comparison with anterior STEMI. The magnitude of precordial STE in TCM is less than that in anterior STEMI.[7] These ECG criteria were established retrospectively with the use

FIGURE 3 Electrocardiograms of Takotsubo Cardiomyopathy



(A) Electrocardiogram recorded at patient's presentation in emergency department. **(B)** 24 hours after presentation, ST-segment changes were largely normalized. **(C)** 49 hours after presentation, deep T-wave inversion occurred in precordial leads with T-wave inversion in inferior leads. **(D)** 8 days after presentation, T-wave inversion persists.

JACC: CASE REPORTS, VOL. 4, NO. 21, 2022
NOVEMBER 2, 2022:1394–1398

of ECGs from patients with confirmed diagnoses of TCM. The prospective use of these criteria when evaluating patients' conditions carries reduced accuracy in differentiating TCM from anterior STEMI.[8] Therefore, coronary angiography still needs to be performed to exclude (or establish the diagnosis of and treat) anterior STEMI from obstructive CAD.

The ECG features in TCM can evolve with time (**Figures 3A to 3D**). Phase 1 shows initial STE immediately or within a few hours after symptom onset; phase 2 shows initial T-wave inversion after resolution of STE from days 1 to 3; phase 3 shows either deep T-wave inversion or transient improvement in T-wave inversion between days 2 and 6 from symptom onset. Phase 4 shows either persistent deeper T-wave inversions persisting for several weeks to a few months or normalization of T waves by the second week from symptom onset.[9,10] In clinical practice, depending on the timing of a patient's presentation for evaluation, first-line physicians usually observe ECG changes in phase 1 or 2. Given the phase 2 ECG mimicking Wellens sign and the reduced accuracy of using the aforementioned ECG criteria to differentiate TCM from anterior myocardial infarction, coronary angiography is hence recommended in this clinical setting.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr. Prediman K. Shah, Department of Cardiology, Smidt Heart Institute, Cedars Sinai Medical Center, 127 South San Vicente Boulevard, Suite A-3307, Los Angeles, California 90048, USA. E-mail: ShahP@cshs.org.

REFERENCES

1. Omar HR. ST-segment elevation in V1-V4 in acute pulmonary embolism: A case presentation and review of literature. *Eur Heart J Acute Cardiovasc Care*. 2016;5:579–586.

2. Rudehill A, Olsson GL, Sundqvist K, Gordon E. ECG abnormalities in patients with subarachnoid haemorrhage and intracranial tumours. *J Neurol Neurosurg Psychiatry*. 1987;50:1375–1381.

3. Stone J, Mor-Avi V, Ardelt A, Lang RM. Frequency of inverted electrocardiographic T waves (cerebral T waves) in patients with acute strokes and their relation to left ventricular wall motion abnormalities. *Am J Cardiol*. 2018;121:120–124.

4. Povoa R, Cavichio L, de Almeida AL, et al. Electrocardiographic abnormalities in neurological diseases. *Arq Bras Cardiol*. 2003;80:351–358.

5. Ghadri JR, Wittstein IS, Prasad A, et al. International expert consensus document on Takotsubo syndrome (part I): Clinical characteristics, diagnostic criteria, and pathophysiology. *Eur Heart J*. 2018;39:2032–2046.

6. Frangieh AH, Obeid S, Ghadri JR, et al. ECG criteria to differentiate between Takotsubo (stress) cardiomyopathy and myocardial infarction. *J Am Heart Assoc*. 2016;13(5):e003418.

7. Kosuge M, Kimura K. Electrocardiographic findings of takotsubo cardiomyopathy as compared with those of anterior acute myocardial infarction. *J Electrocardiol*. 2014;47:684–689.

8. Vervaat FE, Christensen TE, Smeijers L, et al. Is it possible to differentiate between Takotsubo cardiomyopathy and acute anterior ST-elevation myocardial infarction? *J Electrocardiol*. 2015;48:512–519.

9. Dias A, Núñez Gil I, Santoro F, et al. Takotsubo syndrome: State-of-the-art review by an expert panel - part 2. *Cardiovasc Revasc Med*. 2019;20:153–166.

10. Chhabra L, Butt N, Ahmad SA, et al. Electrocardiographic changes in Takotsubo cardiomyopathy. *J Electrocardiol*. 2021;65:28–33.

KEY WORDS electrocardiogram, pulmonary embolism, stroke, Takotsubo cardiomyopathy