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CASE REPORT

BEGINNER

CLINICAL CASE SERIES: EDUCATIONAL, PART 1 OF 3

ECGs in Critical Care Cardiology

Do Not Miss That Myocardial Infarction

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ABSTRACT

This paper provides clinical cases of acute myocardial infarction that do not show ST-segment elevation on 12-lead electrocardiogram, but should be clinically treated as ST-segment elevation myocardial infarction with early diagnostic coronary angiogram followed by appropriate strategy of revascularization. (**Level of Difficulty: Beginner.**) (J Am Coll Cardiol Case Rep 2022;4:1297–1305) © 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/).

CASE 1

A 79-year-old woman presented to the emergency room (ER) with electrocardiogram (ECG) showing ST-segment depression (STD) in leads V_1 to V_4 (Figure 1A). Flipping the ECG 180 degrees from front to back demonstrated Q-wave and STE in V_1 to V_3 (Figure 1B); a posterior lead ECG confirmed ST-segment elevation (STE) on V_7 to V_9 (Figure 1C), indicating true posterior ST-segment elevation myocardial infarction (STEMI). Emergent coronary angiography revealed total occlusion of the proximal left circumflex artery.

CASE 2

A 67-year-old man presented to the ER with syncope and systolic blood pressure between 80 and 90 mm Hg. ECG demonstrated STD in multiple leads with STE in aVR (Figure 2A). Emergent coronary angiography revealed 99% ostial stenosis of the left main coronary artery (LMCA) with Thrombolysis In Myocardial Infarction flow grade 2 into the left anterior descending (LAD) and left circumflex arteries.

LEARNING OBJECTIVES

- To recognize the ECG features of 4 STEMI equivalent ECG patterns.
- To learn the clinical significance and management of patients with STEMI equivalent ECG patterns.

CASE 3

A 69-year-old man presented to the ER with intermittent chest pressure, diaphoresis, and nausea for 2 days. Initial troponin was 1.7 ng/ml with left bundle branch block (LBBB) pattern on 12-lead ECG (Figure 3A). The patient was initially triaged as non-ST-segment elevation myocardial infarction (NSTEMI) for cardiac care unit admission but because of clinical congestive heart failure, the patient underwent emergent coronary angiogram, which revealed severe multivessel coronary artery disease.

The patient's ECG (Figure 3A) did not meet original Sgarbossa criteria to diagnose acute myocardial infarction (AMI) with LBBB, but aVR showed ST/S ratio of −0.33, meeting the modified Sgarbossa criteria for AMI. In addition, many leads in this ECG (aVR, aVL, V_5, V_6) met the second criterion in the

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ABBREVIATIONS AND ACRONYMS

AMI = acute myocardial infarction

ECG = electrocardiogram

ER = emergency room

LAD = left anterior descending artery

LBBB = left bundle branch block

LMCA = left main coronary artery

NSTEMI = non-ST-segment elevation myocardial infarction

STD = ST-segment depression

STE = ST-segment elevation

STEMI = ST-segment elevation myocardial infarction

Barcelona algorithm. This ECG illustrates the increased sensitivity of using multiple ECG criteria to diagnosis AMI in the presence of LBBB.

CASE 4

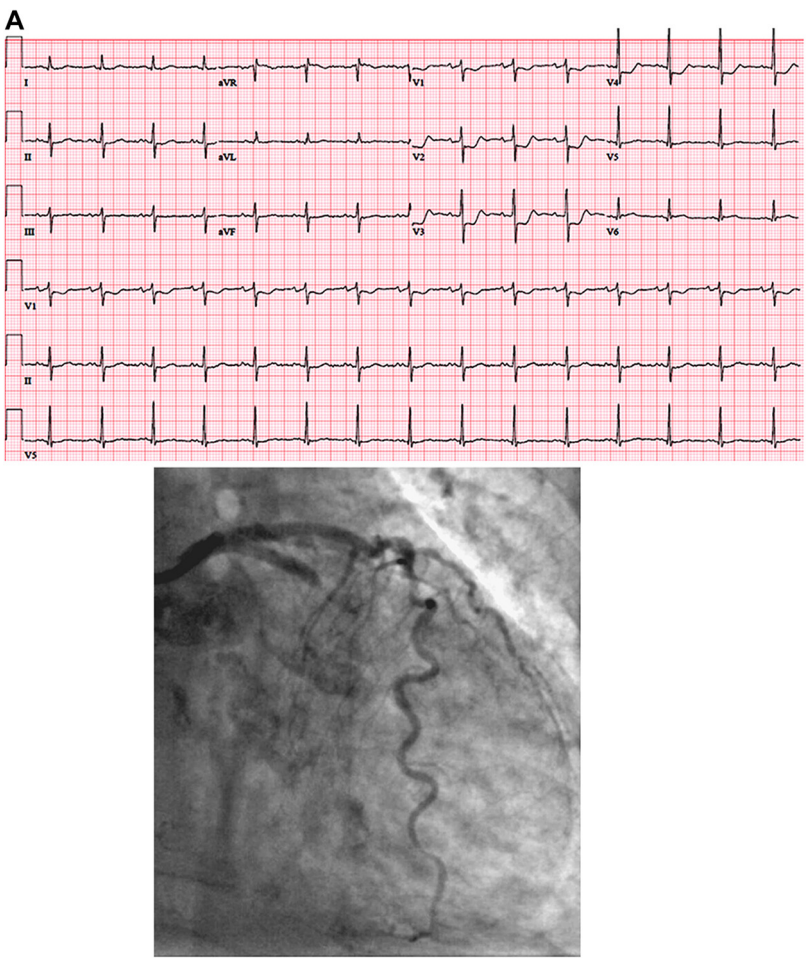
A 65-year-old man presented to the ER with chest pain with ECG as shown in Figure 4. Emergent coronary angiogram demonstrated a total occlusion of the LAD right after the first septal branch. This ECG pattern has been described as the de Winter pattern.

DISCUSSION

CASE 1: ISOLATED POSTERIOR STEMI. ECG criteria for isolated posterior STEMI include STD in V_1 to V_3, prominent R-wave limited to V_1 to V_3, R/S ratio >1 in V2, and prominent and upright T-wave in V_1 to V_3 without concomitant ECG evidence of inferior or lateral STE. Because of lack of STE in standard 12-lead ECG, isolated posterior STEMI is often misdiagnosed as NSTEMI, leading to delay in revascularization with higher in-hospital complications and mortality when compared with patients with nonposterior STEMI.[1]

A helpful clinical pearl to diagnose isolated posterior STEMI is to flip the ECG 180 degrees from front to back (Figure 1B) or perform ECGs with posterior leads (Figure 1C). The R-wave and STD in V_1 to V_3 on standard ECG become Q-wave and STE on the flipped ECG, respectively. Placement of posterior leads V_7 to V_9 to detect posterior STE increases the sensitivity of diagnosing isolated posterior STEMI.[2,3] This pearl

FIGURE 1 ECG of Isolated Posterior MI



(A) An electrocardiogram (ECG) example of isolated posterior myocardial infarction. **(B)** Flipping the ECG in **(A)** 180 degrees from front to back shows Q-wave and ST-segment elevation (STE) in V_1 to V_3 **(red square)**. **(C)** Posterior leads ECG demonstrated STE in V_7 to V_9.
MI = myocardial infarction.

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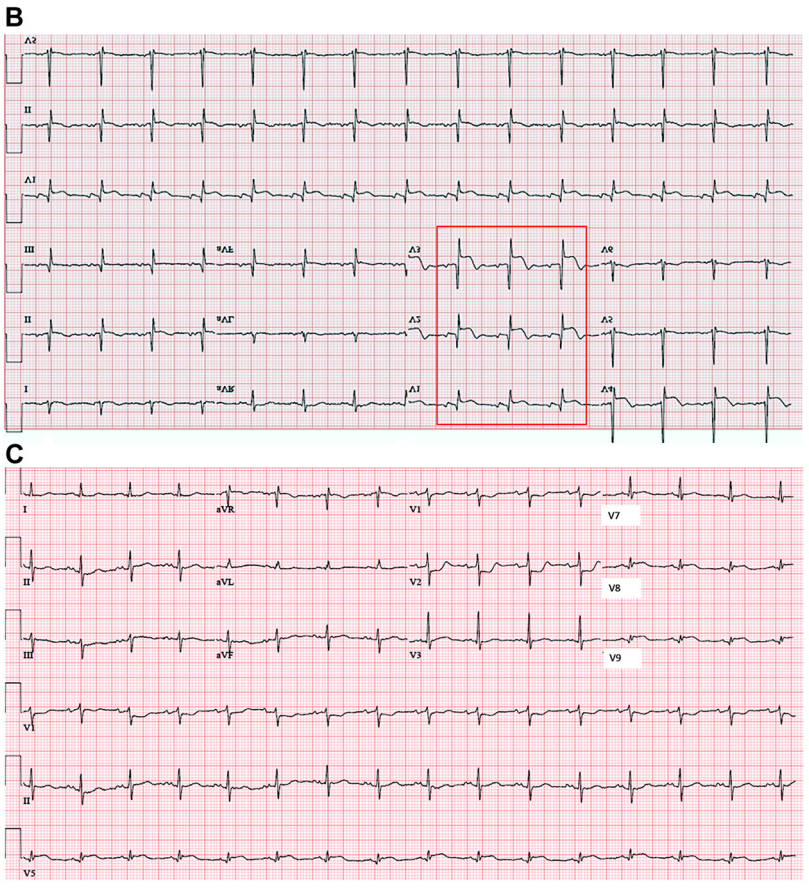
FIGURE 1 Continued



works only if treating physicians have a high index of suspicion to do so.

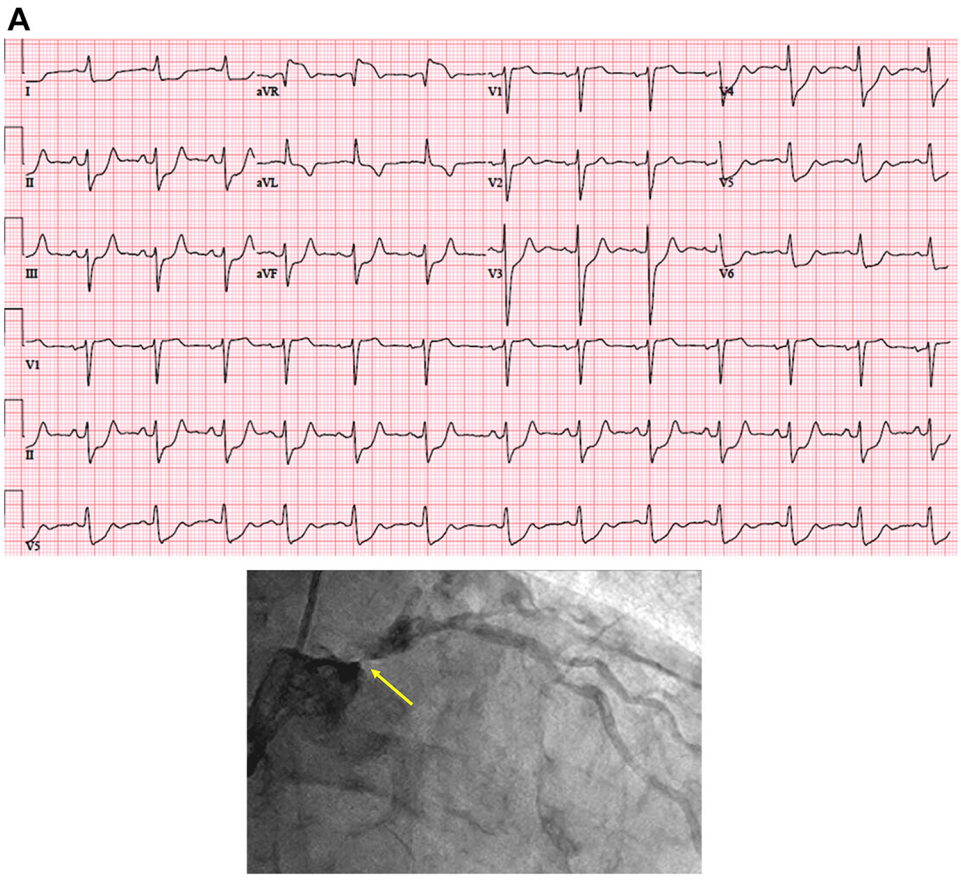
CASE 2: LMCA OCCLUSION. Acute LMCA occlusion can present as NSTEMI or STEMI on standard 12-lead ECG. The diffuse STD in more than 6 leads and STE in aVR, indicating global ischemia, is a pattern frequently reported as NSTEMI in case series (**Figure 2A**). Such patients have either subtotal LMCA occlusion or total LMCA occlusion with collateral circulation on coronary angiogram. When occlusion is total without collateral circulation, the ECG pattern shows clinical syndrome of STEMI, such as classic LAD type (STE in V_2-V_5, I, and aVL), partial LAD type (STE in I and aVL), STE only in peripheral leads, or STE in inferior leads (III and aVF).[4] No specific ECG pattern predicts total or subtotal LMCA occlusion on coronary angiogram, although ECG pattern of proximal LAD occlusion (STE in V_2-V_6, I, and aVL with STD in inferior leads) with right bundle branch block and left anterior hemiblock (**Figure 2B**) can be seen in patients with total LMCA occlusion without collateral circulation.[5]

STE in aVR strongly predicts the presence of LMCA or 3-vessel coronary artery disease. STE in aVR is significantly higher in LMCA occlusion than in LAD occlusion, whereas STE in V1 is significantly lower in LMCA occlusion than in LAD occlusion with sensitivity, specificity, and accuracy of approximately 80%.[6]

Patients with left ventricular hypertrophy, severe aortic stenosis, or acute neurological disorder can

JACC: CASE REPORTS, VOL. 4, NO. 19, 2022
OCTOBER 5, 2022:1297–1305

FIGURE 2 ECG of LMCA Occlusion



(A) An electrocardiogram (ECG) example of critical stenosis of the left main coronary artery (arrow). **(B)** An ECG was recorded from a 47-year-old woman who presented to the emergency room with syncope/near syncope. Emergent coronary angiogram showed left main coronary artery had a 95% stenosis.

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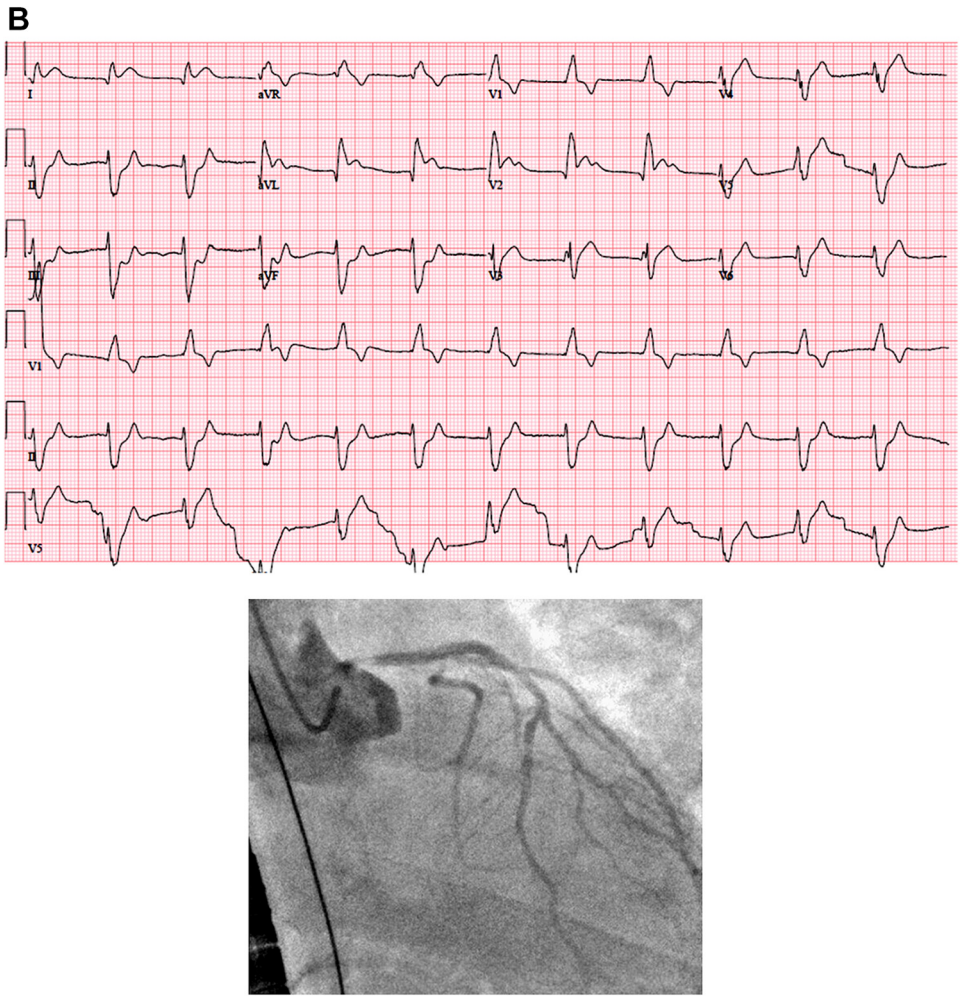
present with diffuse STD with STE in aVR. Clinical context alone may not be enough to differentiate these conditions from acute LMCA occlusion, as patients can be critically ill with preexisting coronary artery disease risk factors/history and mildly elevated circulating level of troponin during initial evaluation. Sometimes an emergent diagnostic coronary angiogram is necessary in the early phase of evaluation, as knowing coronary anatomy may change the next step of clinical management.

CASE 3: CHEST PAIN WITH LBBB OR RIGHT VENTRICULARLY PACED RHYTHM: IS IT AMI OR NOT? Diagnosis of AMI in the presence of LBBB or

FIGURE 2 Continued

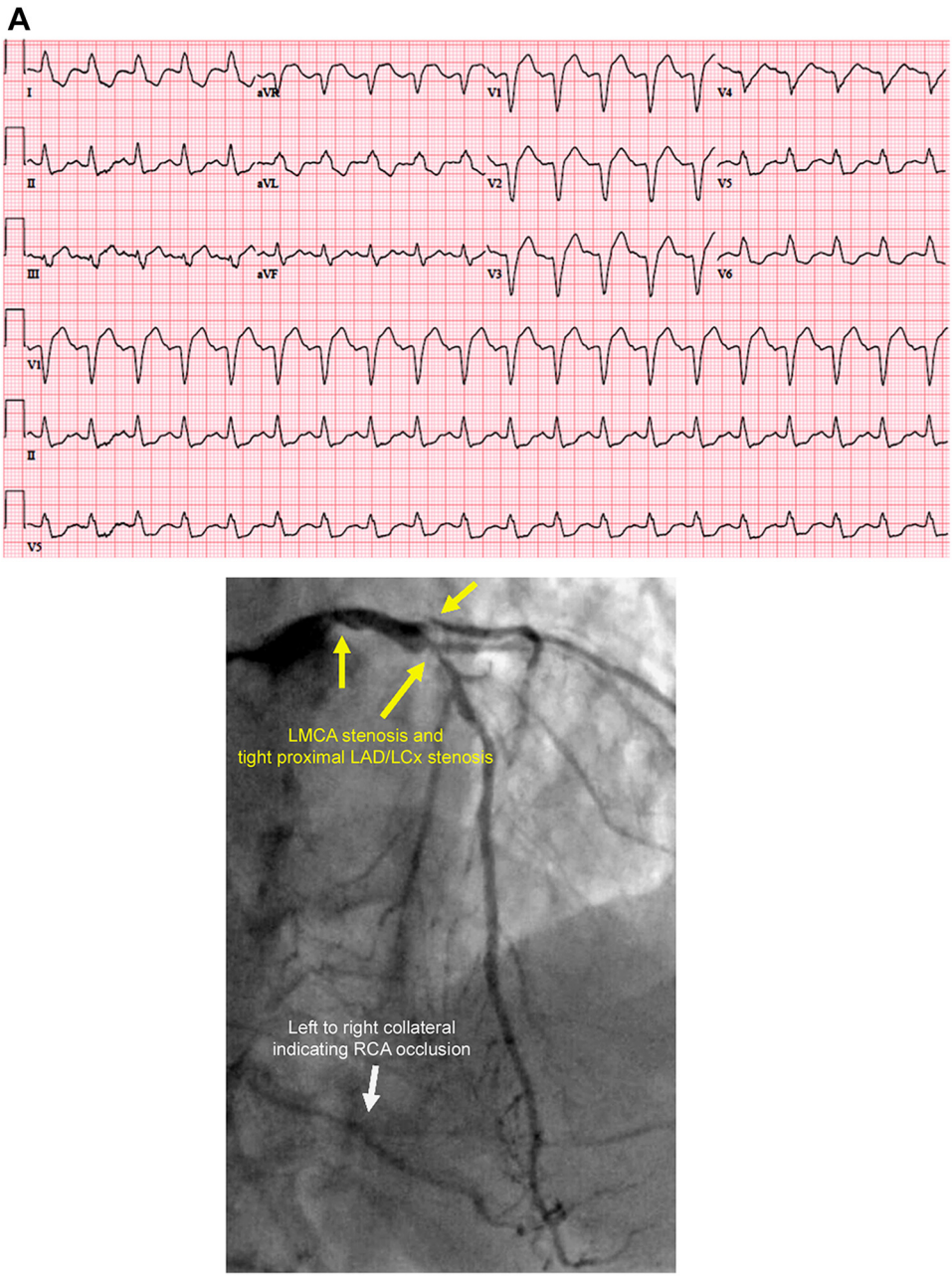


right ventricularly paced rhythm is challenging because of secondary repolarization ST-T changes from LBBB or paced beat. A comparison with old ECGs helps to detect new ischemic ECG changes, but in clinical practice old ECGs often are not available in a timely manner.

Multiple ECG criteria to diagnose AMI in the presence of LBBB have been published (Table 1), with the Barcelona algorithm having the highest sensitivity and specificity in achieving diagnosis. Cai et al[7] proposed a decision-making algorithm in treating patients with suspected AMI and LBBB. If patients are clinically unstable or have CHF, emergent coronary angiogram and reperfusion therapies should be considered. Otherwise original Sgarbossa criteria and modified Sgarbossa criteria will be applied to evaluate

JACC: CASE REPORTS, VOL. 4, NO. 19, 2022
OCTOBER 5, 2022:1297–1305

FIGURE 3 ECGs of MI in the Setting of LBBB/RV Paced Rhythm



(A) Lead aVR showed ST/S ratio of −0.33, meeting the modified Sgarbossa criterial for acute myocardial infarction (AMI). Lead aVR, aVL, V_5, and V_6 also meet the second criterion in the Barcelona algorithm. **(B)** A modified algorithm based on that proposed by Cai et al[7] to highlight the simultaneous use of 3 electrocardiogram (ECG) criteria in diagnosing AMI with left bundle branch block (LBBB) or right ventricularly paced rhythm. **(C)** Concordant ST-segment depression in V_4 to V_6 in this ECG with ventricularly paced rhythm fulfills modified Sgarbossa criteria to diagnose AMI. CAD = coronary artery disease; LAD = left anterior descending artery; LCx = left circumflex coronary artery; LMCA =left main coronary artery; MI = myocardial infarction; PCI = percutaneous coronary intervention; RCA = right coronary artery.

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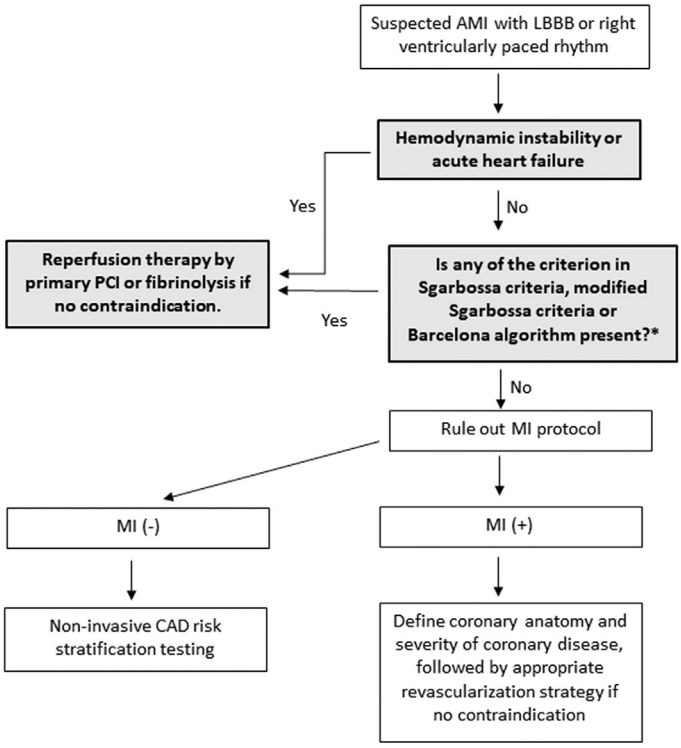
FIGURE 3 Continued

B



Shaded squares depict important triage points for physicians to evaluate patients with suspected AMI with LBBB or paced rhythm.

*These criteria can be used in any order for evaluation and physicians need not to apply these criteria in a sequential manner.

C

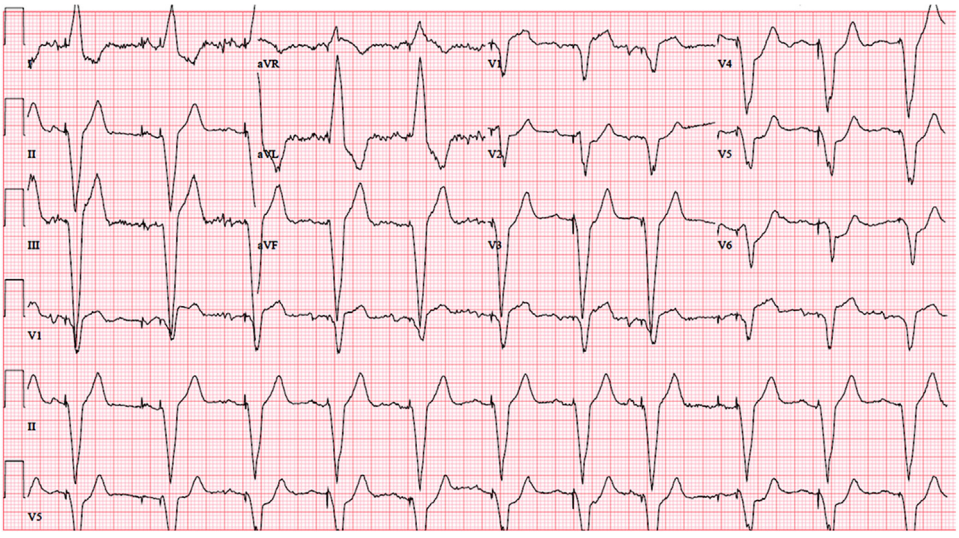
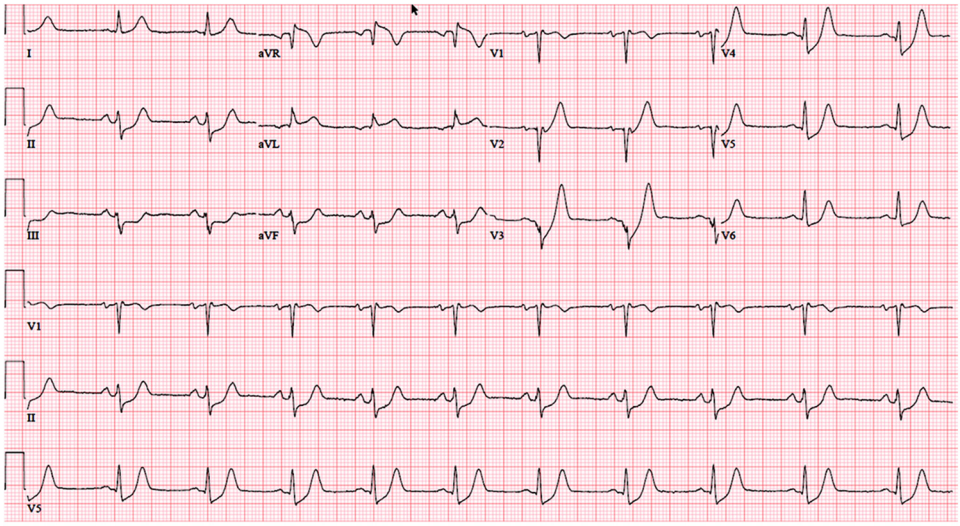


FIGURE 4 ECGs of De Winter Sign



An electrocardiographic example of the de Winter sign with ST-T segment changes seen in V_3 to V_5 and ST-segment elevation in aVR.

ECG evidence of AMI. Given the Barcelona algorithm has high sensitivity and specificity, we recommend using it as a part of the ECG evaluation as well (Figure 3B). If any one is positive, patients should undergo emergent reperfusion therapy if there is no clinical contraindication.

Sgarbossa and modified Sgarbossa criteria have been used to identify patients with AMI in the presence of right ventricularly paced rhythm (Figure 3C). Given patients in this subpopulation tend to be older, more frequently presenting with hemodynamic instability and higher 30-day mortality, it is crucial to identify these patients for timely reperfusion therapy to improve their outcomes.

CASE 4: de WINTER SIGN. This ECG pattern consists of a 1- to 3-mm upsloping STD at the J point in precordial leads with a tall positive symmetrical T-wave. QRS complexes are narrow or only slightly widened and, in some patients, accompanied with loss of R-wave progression. STE of 1 to 2 mm in aVR can sometimes be observed.[8]

The overall prevalence of de Winter ECG pattern in patients with anterior myocardial infarction was reported to be approximately 1.6% to 2.0%.[8,9] In addition to LAD occlusion, a similar pattern has been reported in occlusion of the right coronary artery, left circumflex artery, or microvascular dysfunction in LAD territory.[10]

TABLE 1 ECG Diagnostic Criteria for AMI in the Presence of LBBB

	ECG Criteria	First Author
Original Sgarbossa criteria	(a) STE ≥1 mm and concordant with the QRS complex; (b) STD ≥1 mm in V_1, V_2, or V_3; (c) STE ≥5 mm and discordant with QRS complex	Sgarbossa et al.[11]
Modified Sgarbossa criteria	(a) STE ≥1 mm and concordant with the QRS complex; (b) STD ≥1 mm in V_1, V_2, or V_3; (c) ST/T ratio <-0.25 with at least 1 mm ST-segment deviation in leads with discordant QRS complex	Smith SW et al.[12]
Barcelona algorithm	(a) ST deviation ≥1 mm concordant with QRS polarity in any lead; (b) ST deviation ≥1 mm discordant with QRS polarity in any lead with max R- or S-wave ≤6 mm	Di Marco A et al.[13]

AMI = acute myocardial infarction; ECG = electrocardiogram; LBBB = left bundle branch block; STD = ST-segment depression; STE = ST-segment elevation.

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KEY WORDS critical cardiac care, ECG, myocardial infarction