Review Article

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Modified Occlusion Myocardial Infarction Electrocardiographic Criteria

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Abstract

The electrocardiogram (ECG) is a useful diagnostic tool that allows clinicians to rapidly evaluate patients for acute coronary syndrome. The EKG is crucial in the evaluation of chest pain and diagnosis of ischemia. It is critical for clinicians to be able to accurately recognize these ischemic patterns to allow timely and appropriate cardiovascular care. The classic ST-segment elevation myocardial infarction (STEMI) with rapid reperfusion within less than 60 minutes of acute coronary occlusion improve morbidity and decrees mortality. According to the Fourth Universal Definition of Myocardial Infarction, the STEMI criteria consist of (1) 1 mm ST-segment elevation in any 2 consecutive leads at the J point, excluding V2 and V3; and (2) age- and sex-specific ST-segment elevation thresholds in V2 and V3 (1.5 mm elevation in women regardless of age, 2.5 mm in men <40 years, and 2mminmen aged 40 years), in the absence of left ventricular hypertrophy and bundle branch block (1), but despite that approximately half of high-risk patients with occlusion myocardial infarction fail to meet STEMI criteria, resulting in delays in urgent revascularization (2,3). Definition of occlusion myocardial infarction representing near or total occlusion of a culprit epicardial coronary artery with insufficient collateral circulation causing active infarction, thus necessitating emergency reperfusion (4) In this review we detail the high-risk ECG occlusion myocardial infarction patterns indicative of acute myocardial ischemia resulting from active totally or near totally occlusion of coronary artery

Keywords: Electrocardiographic, Myocardial infarction, New pattern

Introduction

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Hyperacute T waves (HATW)

The T waves (TW) in the affected leads are both more symmetric and enlarged in terms of overall area under

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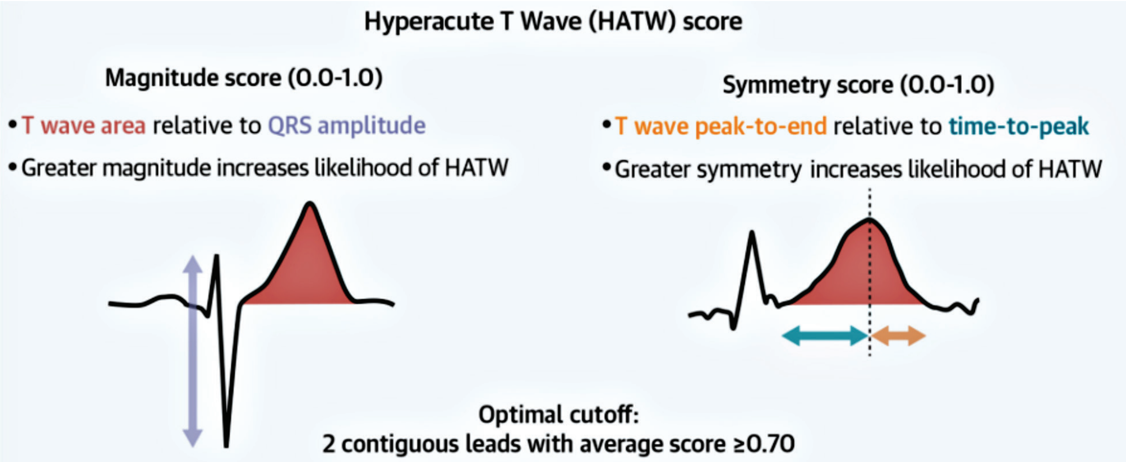

Figure 1. The T-wave magnitude (T-wave area/QRS amplitude) and T wave symmetry score

the curve relative to both their baseline size and to their QRS complex amplitude. T-wave with both magnitude (T-wave area / QRS amplitude) and T wave symmetry score more than 0.70 (Figure 1). ECG leads are only eligible for the HATW score if they satisfy the following requirements: (5)

1. Not lead aVR or V1
2. Narrow QRS: QRS duration less than 110 ms
3. Well-defined QRS complex: Total QRS amplitude more than 1.0 mm (0.1 mV)
4. Well-defined and positive T-wave:
   a. Positive T-wave amplitude more than 1.0 mm (0.1 mV)
   b. TW start-to-peak and TW peak-to-end each ≥ 40 ms
5. T-wave neither inverted nor biphasic

Figure 1 the T-wave magnitude (T-wave area/QRS amplitude) and T wave symmetry score

Left Bundle Branch Block

Diagnostic criteria of myocardial infarction in patient with LBBB.

The Sgarbossa criteria (6)

1. The confirm diagnosis of MI must be need at least 3 or more points from the following criteria. Figure 1. ST-elevation of ≥1 mm and concordant with the QRS complex (5 points)
2. ST-segment depression ≥1 mm in lead V1-3 (3 points)

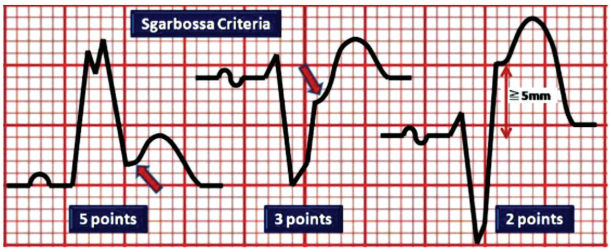

Figure 3. Sgarbossa criteria for myocardial infarction.

Simple calculation for HATW

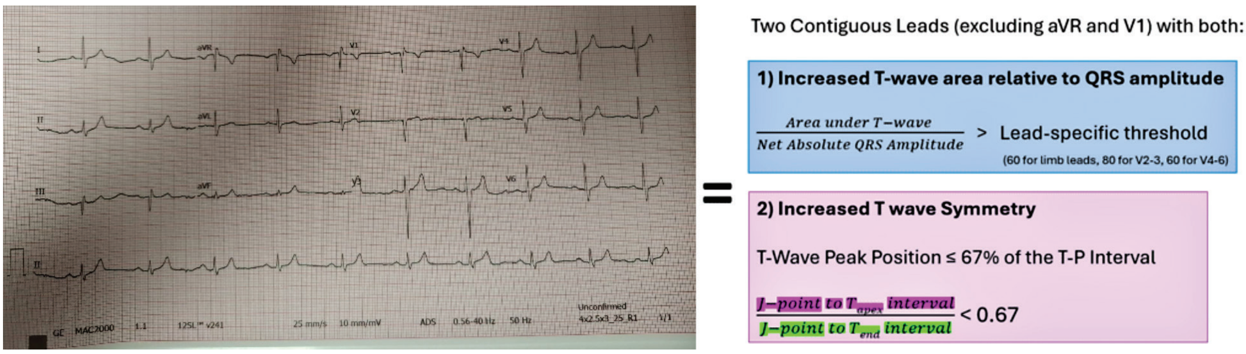

Figure 2. Calculation of T-wave magnitude (T-wave area/QRS amplitude) = 1 and T wave symmetry 0.60 (from III ve AvF), coronary angiography suggested tight stenosis in mid RCA.

3. ST elevation ≥5 mm and discordant with the QRS complex (2 points)

The specificity of 98%, but poorer sensitivity of 20%. The third criteria have only 2 point so that no add any significant value as it alone does not confirm diagnosis of acute myocardial infarction. (Figiure 3)

Modified Sgarbossa (Smith-Sgarbossa) Criteria (7)

Because of the third criteria of Sagarbossa have only 2 point and does not confirm diagnosis of acute myocardial infarction. The modified Sgarbossa criteria was used to modified and support the third criteria by calculation the ratio of ST segment elevation to the depth S wave. The discordant ST/S ratio ≥ 0.25 mm in any lead suggested acute MI. Figure 4.

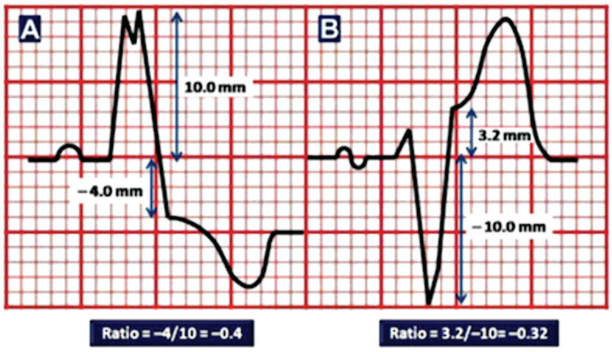

Figure 4. Modified Sgarbossa Criteria for myocardial infarction

The Barcelona Criteria (8)

Barcelona Criteria contains of 3 criteria, As with the prior Sgarbossa criteria , criteria 1 is the same. Criteria 2 is expanded to all leads (but in Sgarbossa just in V1-3).

Criteria 3 is specific for the Barcelona criteria and suggested that discordance deviation of ≥ 1mm in any lead with a dominant R or S wave ≤ 6 mm.

A. ST deviation ≥1 mm concordant with QRS complex in any lead;
   1. Concordant with QRS complex and ST depression ≥1 mm
   2. Concordant with QRS complex and ST elevation ≥1 mm

B. Discordant ST deviation ≥ 1mm with QRS complex in any lead where the R or S is ≤ 6 mm. (Figure 5)

Summary of electrocardiographic criteria; (9)

This is simple 6 steps for diagnosis Patients with Left Bundle Branch Block and suspected occlusion acute myocardial infarction

1. Confirm diagnosis of LBBB. If yes go to 2nd step
2. Calculate ST segment deviation ≥ 1 mm in any lead If
   1. Confirm diagnosis of LBBB. If yes go to 2nd step yes go to 3nd step
3. Concordant or Discordant with QRS complex?

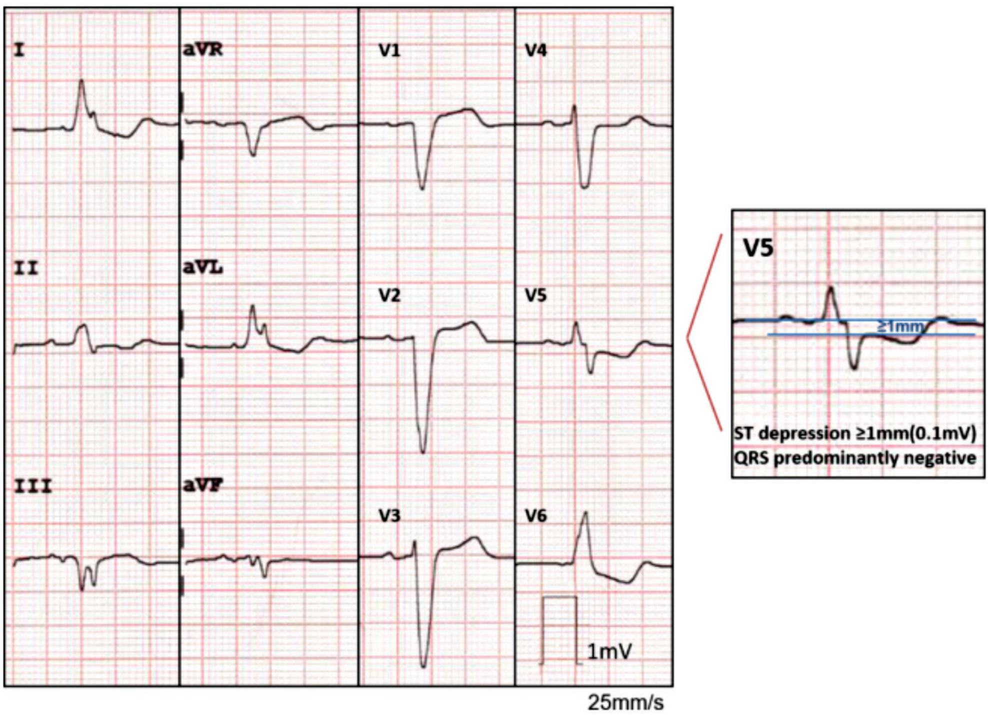

Figure 5. ECG from a patient with acute myocardial infarction and culprit lesion in the right coronary artery, showing ST-segment depression ≥1 mm (0.1 mV) concordant with negative QRS polarity in lead V5.

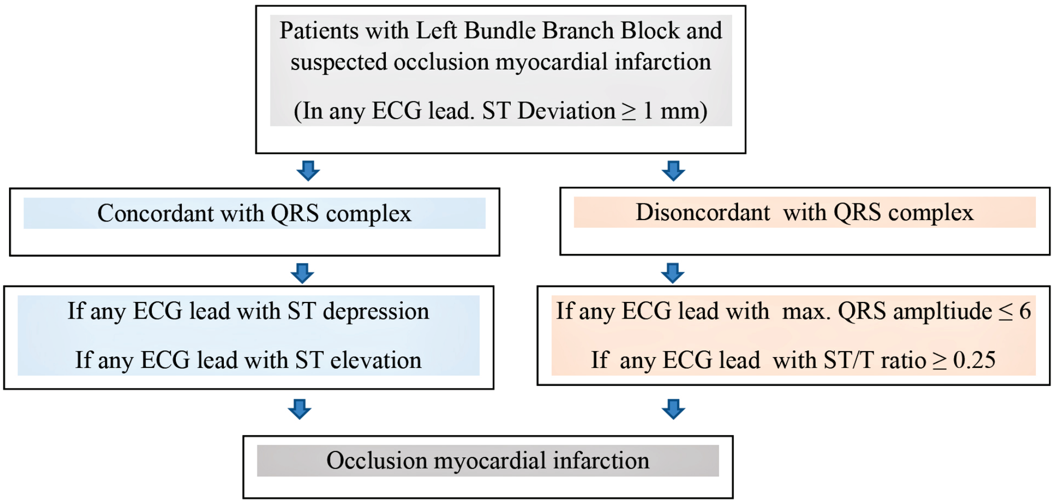

Figure 6. Summary of electrocardiographic criteria; ECG; Electrocardiogram.

4. If concordant and ≥ 1 mm ST segment deviation in any lead; Acute MI 4. If concordant and ≥ 1 mm ST segment deviation in any lead; Acute MI
5. If discordant in any lead with R or S is ≤ 6 mm; Acute MI 5. If discordant in any lead with R or S is ≤ 6 mm; Acute MI
6. If discordant in any lead with R or S is ≥ 6 mm; calculate the ratio of ST segment elevation to the depth S wave. If ≥ 25%; Acute MI

Summary of electrocardiographic criteria among patients with Left Bundle Branch Block and suspected occlusion myocardial infarction. Figure 6

Wellens syndrome

Wellens syndrome was described by Wellens, and colleagues, who identified a subset of patients with unstable angina who had specific precordial T-wave changes and subsequently developed anterior myocardial infarction (10). Wellens syndrome refers abnormalities in the precordial T waves (V2-4) , which are associated with moderate to severe stenosis of the proximal left anterior descending (LAD) coronary artery.

Syndrome criteria include the following:

Criteria for wellens' syndrome (11-12)

- Biphasic or deeply inverted symmetric T waves in leads V2 -3 during pain-free state (May be in leads V1, V4, V5 and V6)
- No pathologic precordial Q waves
- Preserved precordial R wave progression
- Isoelectric or minimally elevated (<1 mm) ST-segment
- Recent history of chest pain
- Normal or slightly elevated serum cardiac markers

Wellens syndrome is characterized by biphasic (pattern A) or deeply inverted (pattern B) T wave in leads V2-V3 and the absence of Q waves (Figure 7).

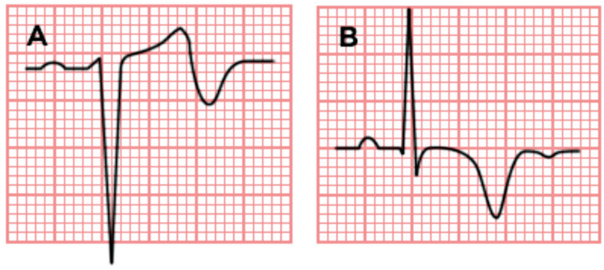

Figure 7. Wellens syndrome is characterized by biphasic (A) or deeply inverted (B).

De-Winter syndrome

The diagnostic criteria for de Winter syndrome include (figure 8)

- A 1 to 3 mm upsloping ST–segment depression at the J point in leads V1 to V6 that continues in totall, positive symmetrical T waves
- QRS complex usually not wide or only slightly widened
- In some patients, a loss of precordial R wave progression
- A 1 to 2 mmST–segment elevation in aVR.

The underlying mechanism of this ECG pattern in acute myocardial infarctions is unknown but probable mechanisms that lack of activation of sarcolemmal adenosine triphosphate (ATP) sensitive potassium channels that cause the absence of ST-segment elevation.(13)

Left ventricle aneurysm

Persistent ST segement elevation after previous myocardial infarction (MI). This is clinically and pathologically manifested as left ventricular aneurysm (LVA) and is found in up to 60% of completed anterior STEMI when there is no spontaneous or therapeutic reperfusion . (14)

The association between persistent STE on the ECG after prior MI and LVA has been well documented over the years, confirmed with autopsy studies (15).

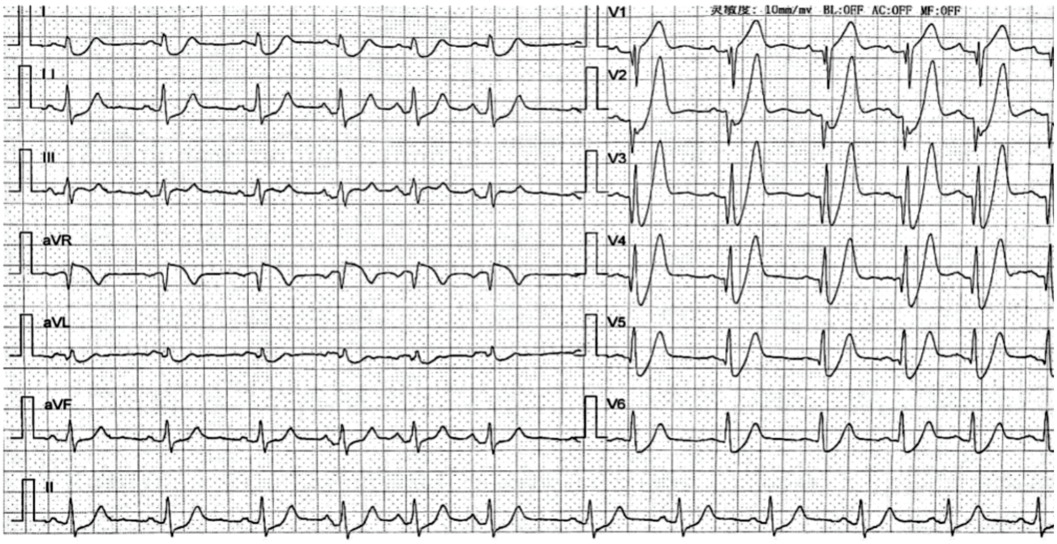

Figure 8. The electrocardiogram shows upsloping ST-segment depression at the J-point with tall and symmetrical T waves from V2 to V6 leads, as well as ST-segment elevation in the aVR lead.

Rule 1: Acute STEMI is predicted if:

$$\frac{\textit{sum of T wave amplitudes } V1 + V2 + V3 + V4}{\textit{sum of QRS amplitudes } V1 + V2 + V3 + V4} > 0.22$$

Rule 2: Acute STEMI is predicted if:

$$\frac{\textit{T wave amplitude}}{\textit{QRS amplitude}} \quad \textit{In any lead } V1, V2, V3 \textbf{ or } V4 \geq 0.36$$

Figure 9. Two ECG rules for predicting acute myocardial infarction vs Left ventricul aneurysm.

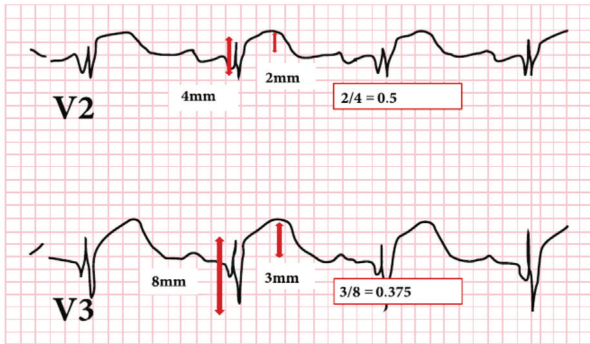

Figure 10. T wave amplitude/QRS ampltitude for predicting acute myocardial infarction in patient with left ventricul aneurysm.

Accoedint to Lauren R. Klein, suggested 2 rules among patients who present with ischemic symptoms and acute occlusion MI in previous LVAon ECG (16).

Left ventricle hypertrophy (LVH)

Algorithm to identify anterior STEMI in the presence of LVH: (17)

- If the ST segment to R-S–wave magnitude was 25%, presence of STE in 3 contiguous leads
- or presence of T-wave inversions in the anterior leads classified patients as having a 'true' OMI. (Figure 11)

In patients with STE in leads V1 to V3, an ST segment to R-S–wave magnitude < 25% excluded the diagnosis of a STEMI. If the ST segment to R-S–wave magnitude was

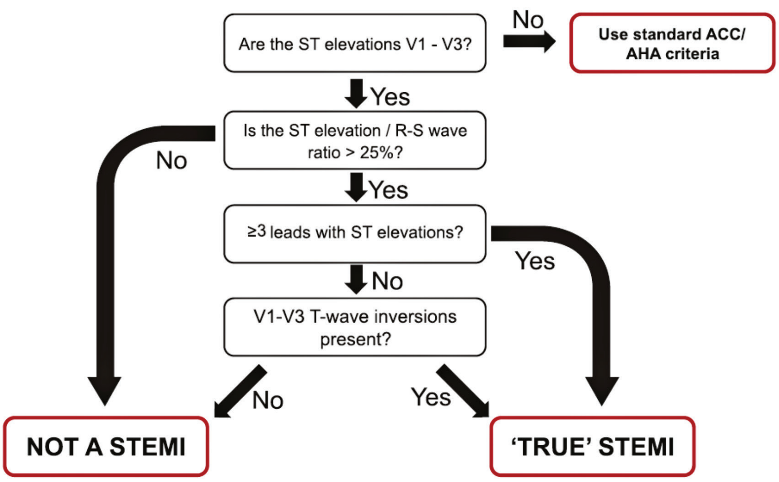

Figure 11. Occlusive anterior MI in the presence of LVH.

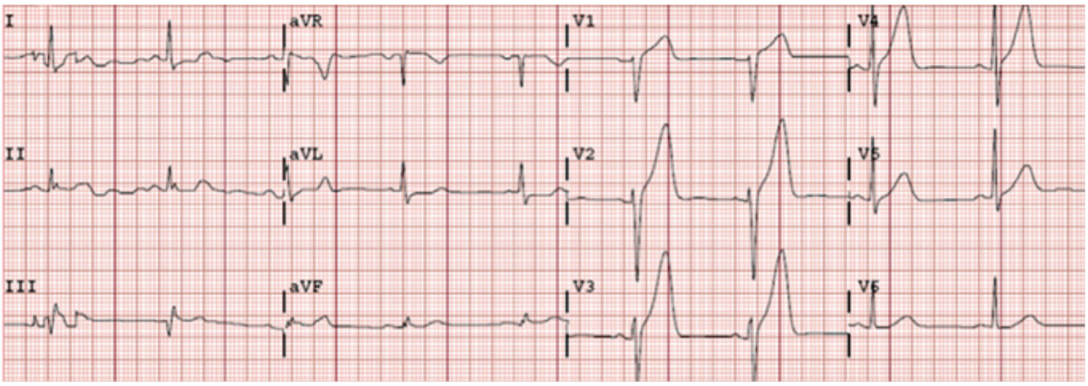

Figure 12. Occlusive anterior MI in the presence of LVH.

≥ 25%, presence of STE in 3 contiguous leads or presence of T-wave inversions in the anterior leads classified patients as having a "true" STEMI. Increasing the cutoff of "significant" STEs to 2.5 mm in leads V1 to V3 increased the specificity of the electrocardiogram to 74%, but sensitivity was decrease to 68% (18)

Aslanger pattern

ECG pattern indicating inferior MI in patients with concomitant critical lesion (s) in coronary arteries other than the infarct-related artery.(19)

ECG pattern consisting of three criteria:

- Any STE in DIII but not in other inferior leads,
- STD in any of leads V4 to V6 but not inV2,
- STin lead V1 higher than ST in V2 (Figure 13)

The South African Flag Sign

It is typically reflective of "high lateral" myocardial infarction (MI) due to the occlusion of the first diagonal (D_1) branch of the left anterior descending (LAD) coronary artery. there is ST-segment elevation (STE) in leads I, aVL, V_2, and ST-segment depression in lead III (20) (Figure 14).

New-Onset Bifascicular Block

A necropsy study disclosed that blood supply to the right bundle branch and left anterior fascicle is predominantly provided by septal perforators of the proximal left anterior descending coronary artery in 90% of the cases examined (21).The diagnostic particulars of the ECG include; (Figure 15)

- New-onset RBBB
- New-onset LAFB
- Concordant STE in any of the anterior and/or lateral leads; concordant ST-depression in the inferior

Precordial swirl sign

In this pattern the ECG manifests abnormal ST elevation (STE) in V1-V2, with reciprocal ST depression (STD)

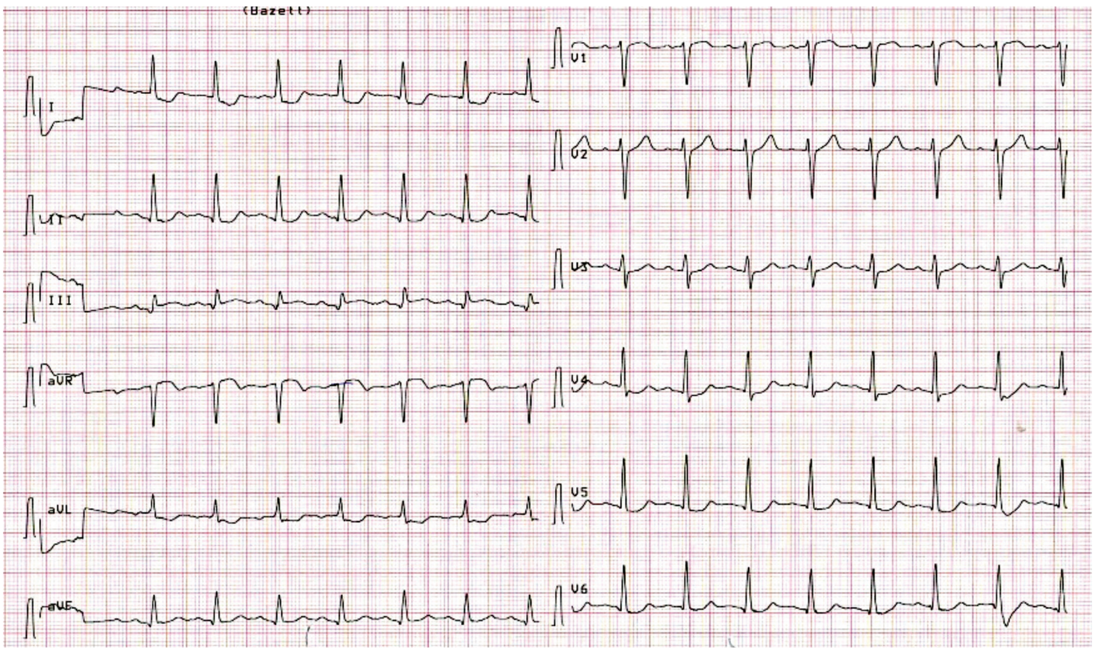

Figure 13. Alsanger pattern STE in DIII but not in other inferior leads, STD in leads V4 to V6 and STE in lead V1 higher than ST in V2.

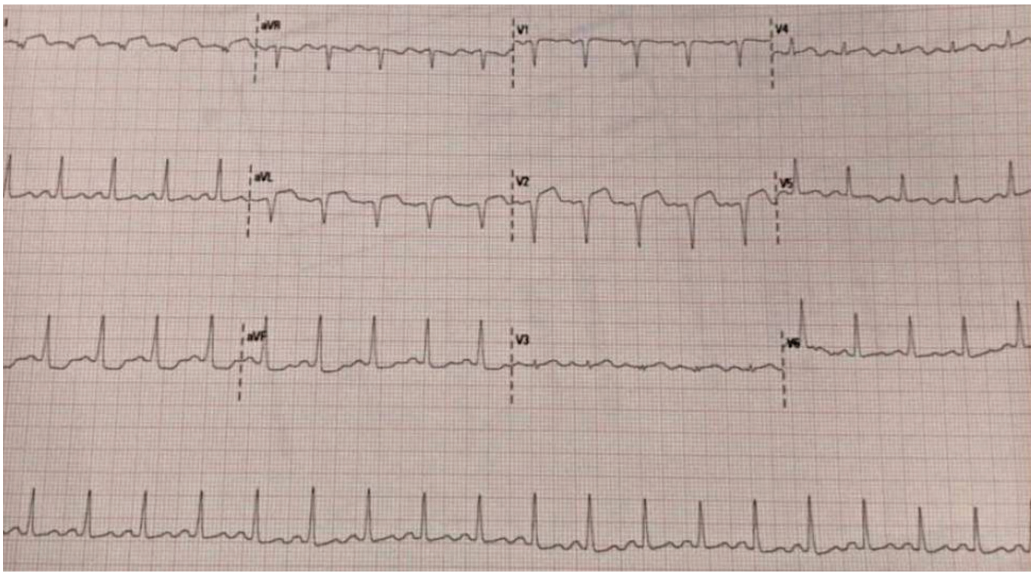

Figure 14. ST-segment elevation (STE) in leads I, aVL, V2, and ST-segment depression in lead III .

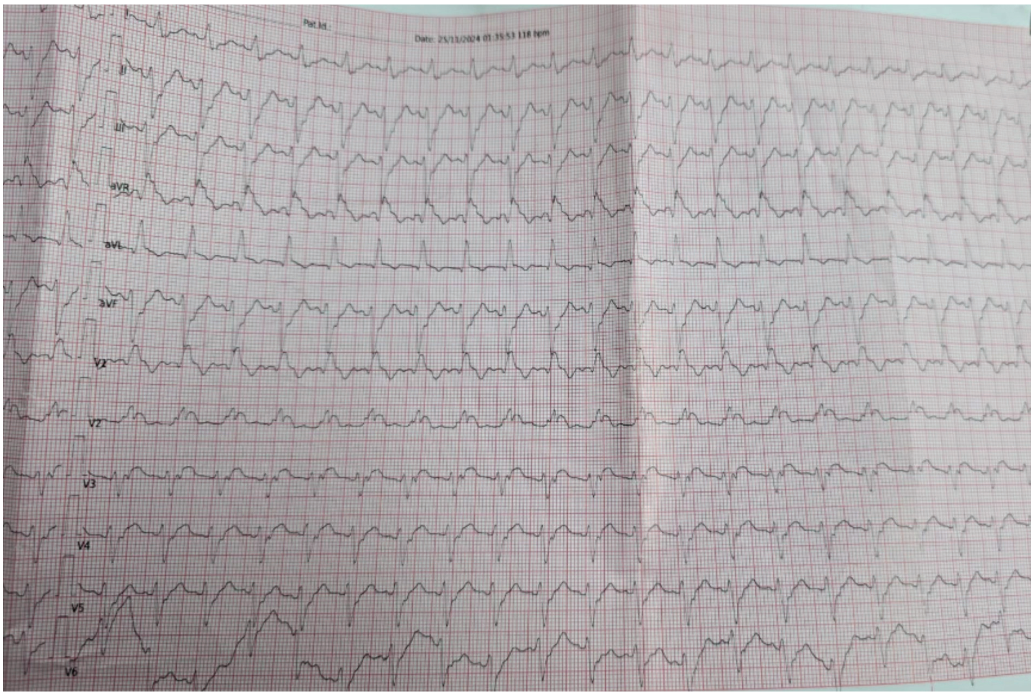

Figure 15. Right bundle branch and left anterior fascicle .

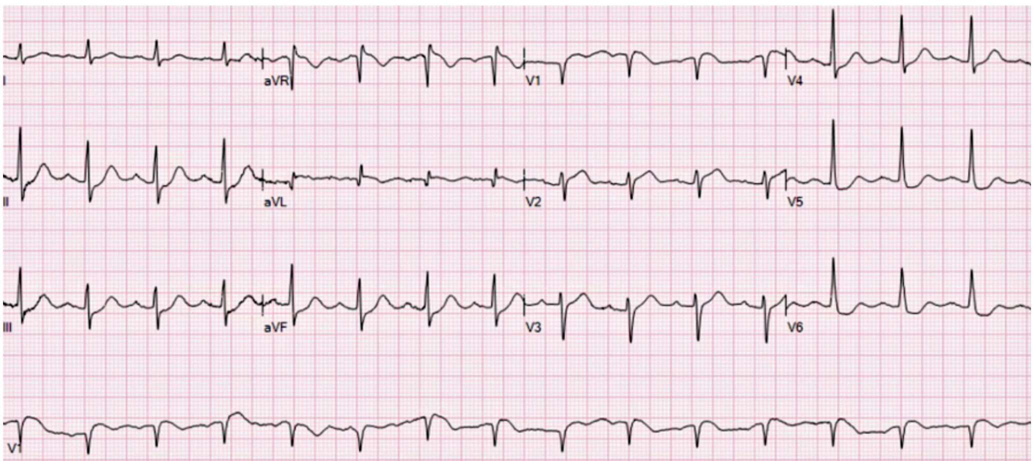

Figure 16. Case example from derivation group of an elderly male with chest pain .

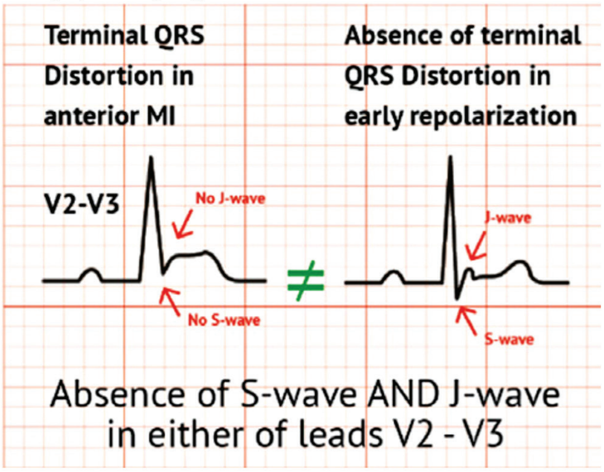

Figure 17. Terminal QRS distortion.

in V5-V6, creating a clockwise "swirl" pattern in the ST shifts of the precordial leads specificity for LAD Occlusion MI.

The derived rules for precordial swirl sign (22)

1. Narrow QRS with STD in V5-V6 and STE V1-V2
2. Normal QRS (narrow QRS and no LVH) with STD in V5-V6 and STE V1-V2
3. Narrow QRS with STD V5-V6 and T/S ratio >/= 0.40 in V2

Terminal QRS Distortion

Terminal QRS distortion is defined as a decrease in S-wave amplitude in leads with a terminal S wave and an elevation of the J point > 50% of the height of the R wave amplitude in leads with qR configuration (23).Terminal QRS distortion is not observed in early repolarization, and thus it can be useful in distinguishing STEMI from early repolarization (24).The presence of terminal QRS distortion in STEMI has been associated with a larger infarct size, impaired myocardial salvage, lower epicardial reperfusion success, low left ventricular ejection fraction (LVEF), reperfusion injury, anterior location of myocardial infarction, higher risk of re-infarction, and mortality (25-26) (Figure 17).

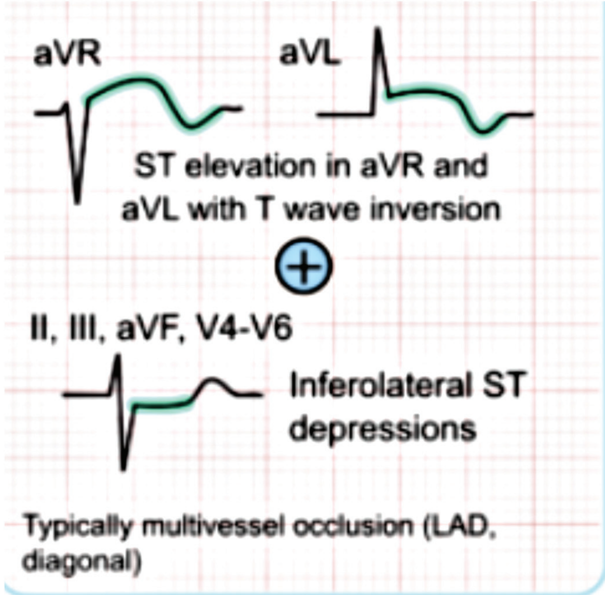

Figure 18. STsegment elevation in aVR and aVL with negative T wave and any ST-depression in inferolateral leads.

Northern Occlusion Myocardial Infarction

Is defined by any STsegment elevation in aVR and aVL with negative T wave and any ST-depression in inferior and lateral precordial leads with positive or biphasic T waves. figure 18

ST Elevation in AVR Lead (LMCA/ Proximal LAD Occlusion)

Isolated STE in the augmented vector right (aVR) lead, accompanied by multilead ST depression, as a potential indicator of STEMI due to left main coronary artery (LMCA) or proximal LAD occlusion (Figure 19).

Shark fin sign

is an ECG pattern with a giant R wave (amplitude ≥1 mV) and a QRS complex fused with the ST segment and the T wave (Figure 20).

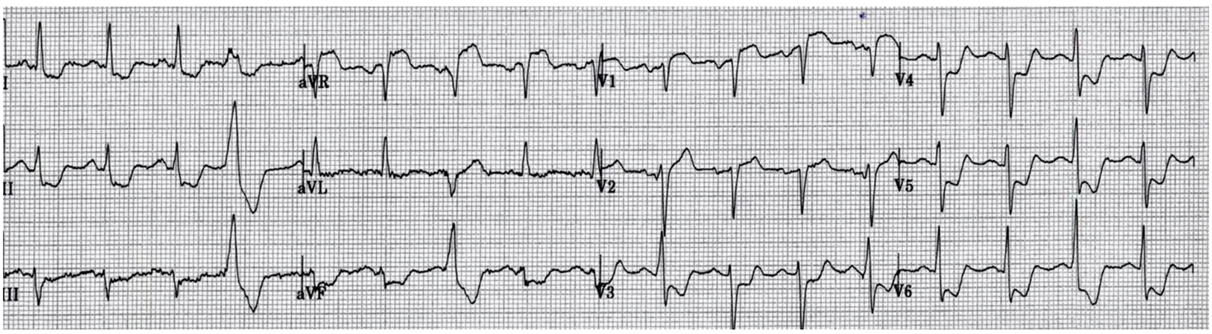

Figure 19. aVR ST elevation and inferolateral ST depression.

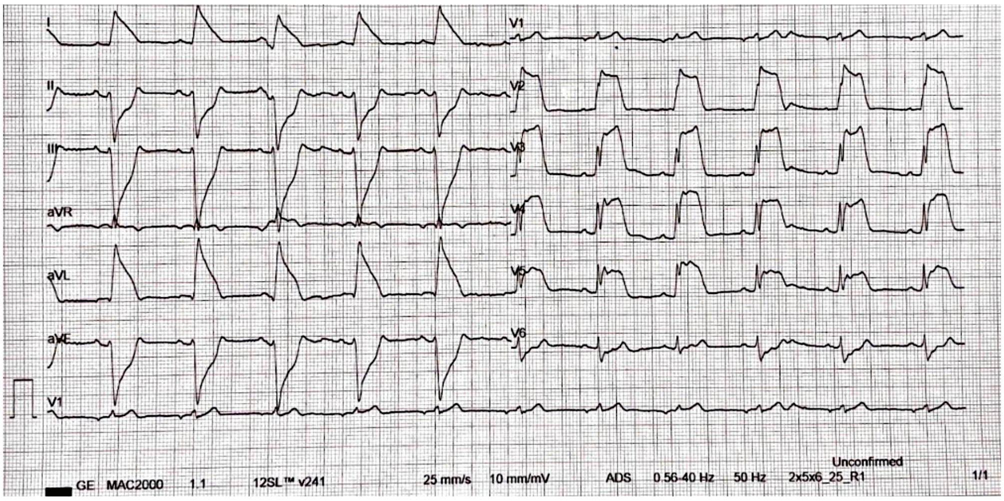

Figure 20. The electrocardiogram demonstrated a sinus rhythm with 'shark fin' morphology in leads I, aVL and in the V 2-5 leads (shark fin sign).

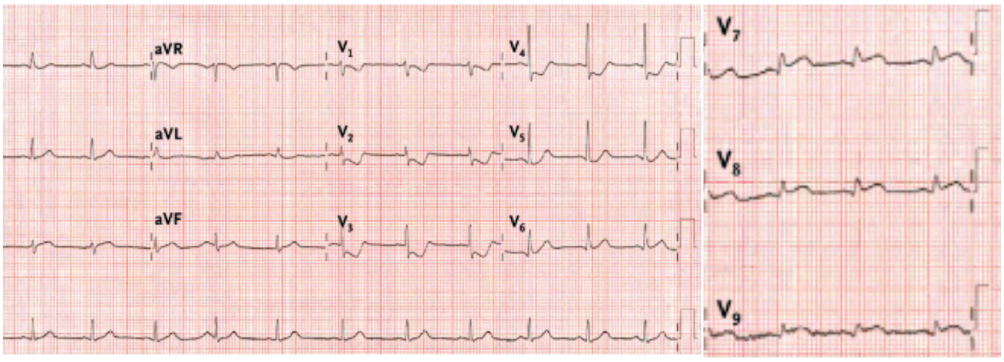

Figure 21. Electrocardiogram showing normal sinüs rhythm with ST depression in v1-4 and ST elevation in V7-9.

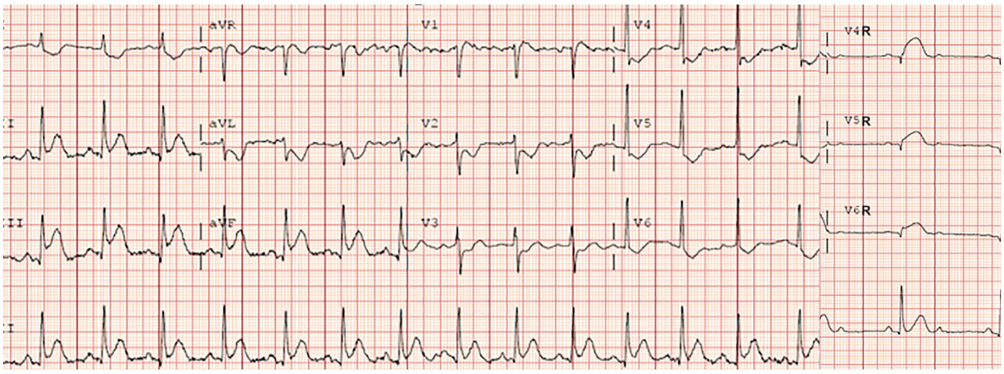

Figure 22. Electrocardiogram showing normal sinüs rhythm with STelevations in II,III,aVFandV1 and STelevations in leadsV3R–V6R.

Posterior MI

ECG findings include ST-segment depressions ≥0.5 mm in leads V_1–V_3, upright T waves, and tall R waves in V_1–V_2 (Figure 21) (27).

Right ventricular infarction (RVI)

Isolated RVI occurs seldom; approximately only 2%cases are reported on autopsy. Around one-third of patients with acute inferoposterior ST-segment elevation MI, will present with concomitant RVIST-segment elevation in V1 and V3R–V6R confirms RVI (28-29) (Figure 22).

References

1. Thygesen K, Alpert JS, Jaffe AS, et al. Fourth universal definition of myocardial infarction (2018). Circulation. 2018;138:e618-e651.
2. de Alencar Neto JN, Scheffer MK, Correia BP, et al. Systematic review and meta-analysis of diagnostic test accuracy of ST-segment elevation for acute coronary occlusion. Int J Cardiol. 2024;402: 131889.
3. Meyers HP, Bracey A, Lee D, et al. Comparison of the ST-elevation myocardial infarction (STEMI) vs. NSTEMI and occlusion MI (OMI) vs. NOMI paradigms of acute MI. J Emerg Med. 2021;60:273-284.

4. Meyers HP, Bracey A, Lee D, et al. Accuracy of OMI ECG findings versus STEMI criteria for diagnosis of acute coronary occlusion myocardial infarction. Int J Cardiol Heart Vasc. 2021;33:100767.
5. H. Pendell Meyers, Franti sek Siman, Robert Herman.Et al. Hyperacute T Waves Are Specific for Occlusion Myocardial Infarction, Even Without Diagnostic ST-Segment Elevation.JACC Adv. 2025;4:102120.
6. Sgarbossa EB, Pinski SL, Barbagelata A, et al. Electrocardiographic diagnosis of evolving acute myocardial infarction in the presence of left bundle-branch block. GUSTO-1 (Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries) Investigators. N Engl J Med 1996;334:481-7. 3.
7. Smith SW, Dodd KW, Henry TD, Dvorak DM, Pearce LA. Diagnosis of ST-elevation myocardial infarction in the presence of left bundle branch block with the ST-elevation to S-wave ratio in a modified Sgarbossa rule. Ann Emerg Med 2012;60:766-76
8. Andrea Di Marco,Marcos Rodriguez,Juan Cinca et al. New Electrocardiographic Algorithm for the Diagnosis of Acute Myocardial Infarction in Patients With Left Bundle Branch Block. J Am Heart Assoc. 2020;9:e015573.
9. Mohammed Habib. Electrocardiographic Criteria for Diagnosis of Acute Myocardial Infarction in Patients with Left Bundle Branch Block. Eurasian Journal of Critical Care. 2024;6(2): 88-90
10. de Zwaan C, Bar FW, Wellens HJ. Characteristic electrocardiographic pattern indicating a critical stenosis high in left anterior descending coronary artery in patients admitted because of impending myocardial infarction. *Am Heart J*. 1982 Apr. 103(4 Pt 2):730-6
11. Rhinehardt J, Brady WJ, Perron AD, Mattu A. Electrocardiographic manifestations of Wellens' syndrome. Am J Emerg Med 2002;20(7):638–43. [5]
12. Nisbet BC, Zlupko G. Repeat Wellens' syndrome: case report of critical proximal left anterior descending artery restenosis. J Emerg Med 2010;39(3):305–8.
13. de Winter RJ, Verouden NJ, Wellens HJ, Wilde AA, Interventional Cardiology Group of The Academic Medical Center. A new ECG sign of proximal LAD occlusion. N Engl J Med. 2008;359:207 1-3.
14. Mills RM, Young E,Gorlin R, Lesch M. Natural historyof S-T segment elevation after acute myocardial infarction.A m J Cardiol 1975;35:609–14.
15.] Berger AK,Radford MJ,Wang Y,Krumholz HM.Thrombolytic therapy in older patients. Jam Coll Cardiol 2000;36:366–74.
16. Lauren R. Klein ,Gautam R. Shroff, William Beeman, , Stephen W. Smith, Electrocardiographic criteria to differentiate acute anterior ST-elevation myocardial infarction from left ventricular aneurysm. American Journal of Emergency Medicine 33 (2015) 786–790
17. Miranda DF, Lobo AS, Walsh B, et al. New insights into the use of the 12-lead electrocardiogram for diagnosing acute myocardial infarction in the emergency department. Can J Cardiol 2018 Feb;34(2):132-145
18. Ehrin J. Armstrong, MSca, Ameya R. Kulkarni, Electrocardiographic Criteria for ST-Elevation Myocardial Infarction in Patients With Left Ventricular Hypertrophy. Am J Cardiol 2012;110:977–983
19. Emre Aslanger, OzlemYıldırımtürk, Barış Şimşek, et al. A newelectrocardiographic pattern indicating inferior myocardial infarction. Journal of Electrocardiology 61 (2020) 41–46
20. Steven Swarath , Nicole Maharaj , Andrew Hall , Jean Marie Frederick. The South African Flag Sign: An Electrocardiographic Flag for All Coronary Territories? J Investig Med High Impact Case Rep 2023 Aug 9;11:23247096231192861.
21. Frink RJ, James TN. Normal blood supply to the human his bundle and proximal bundle branches. Circulation. 1973;47:8-18.
22. Lucas Goss, Pendell Meyers, Alexander Bracey, et al. Precordial swirl sign: A new ECG pattern of left anterior descending artery occlusion myocardial infarction. Journal of Electrocardiology 91 (2025) 153931
23. Nikus K, Birnbaum Y, Eskola M, et al. Updated electrocardiographic classification of acute coronary syndromes. Curr Cardiol Rev. 2014;10:229–236.
24. Lee DH, Walsh B, Smith SW. Terminal QRS distortion is present in anterior myocardial infarction but absent in early repolarization. Am J Emerg Med. 2016;34:2182–2185.
25. Mulay DV, Mukhedkar SM. Prognostic significance of the distortion of terminal portion of QRS complex on admission electrocardiogram in ST segment elevation myocardial infarction. Indian Heart J. 2013;65:671–677. doi: 10.1016/j.ihj.2013.10.012.
26. Birnbaum Y, Herz I, Sclarovsky S, et al. Prognostic significance of the admission electrocardiogram in acute myocardial infarction. J Am Coll Cardiol. 1996;27:1128–1132.
27. Agarwal J, Khaw K, Aurignac F, et al. Importance of posterior chest leads in patients with suspected myocardial infarction, but nondiagnostic, routine 12-lead electrocardiogram. Am J Cardiol 1999;83:323-6.
28. Namana V, Balasubramanian R,HollanderG.A71-Year-Old Man With Complicated Myocardial Infarction. JAMACardiol 2016;1(6):735–6.
29. Carroll R, Sharma N, Butt A, Hussain KM.Unusual electrocardiographic presentation of an isolated right ventricular myocardial infarction secondary to thrombotic occlusion of anon-dominant right coronary artery.Angiology 2003;54(1):119–24.