ECG localization of “culprit” artery in ST Segment Elevation Myocardial Infarction using “the clock´s method”

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SOCIEDAD BOLIVIANA DE CARDIOLOGÍA
FILIAL COCHABAMBA

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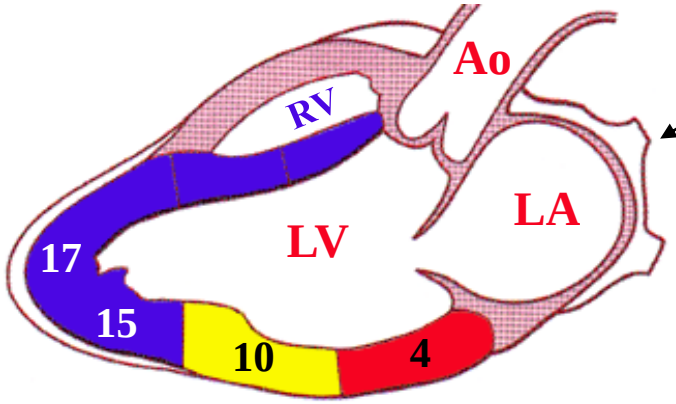
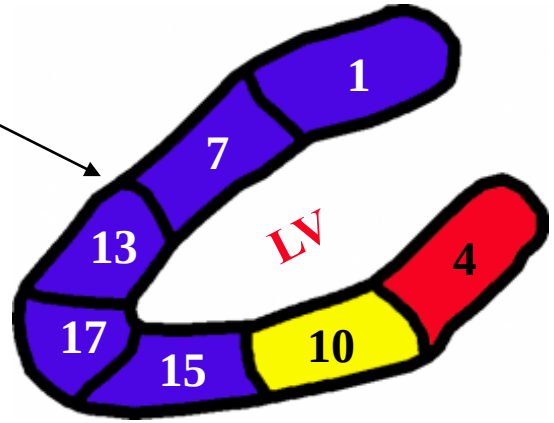
Left Ventricle myocardial segmentation, standard standard 17-segment model, and vascular territories

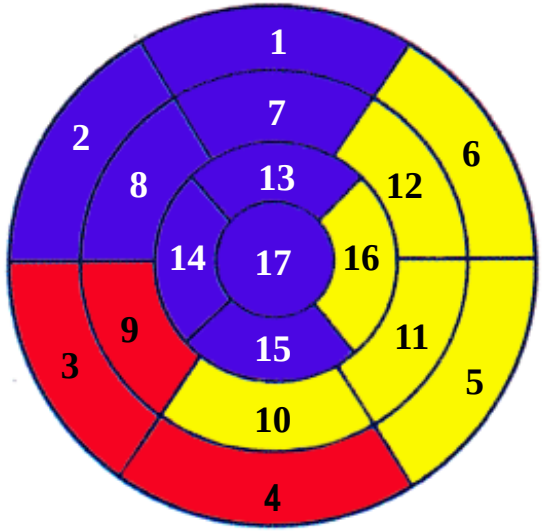


Longitudinal paraesternal



Bulls eye (apical short axis)

Anterior Wall

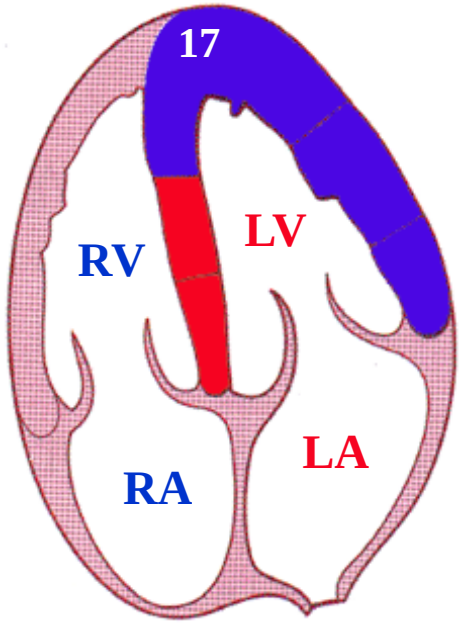


Septal Wall

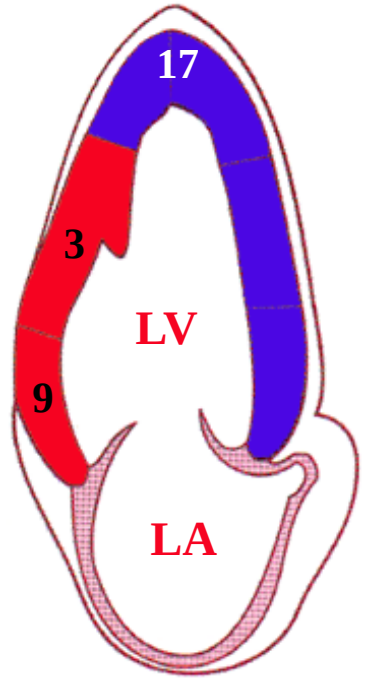
Lateral Wall

Inferior Wall

Apical four chambers



Apical two chambers



Left Anterior Descending (LAD)

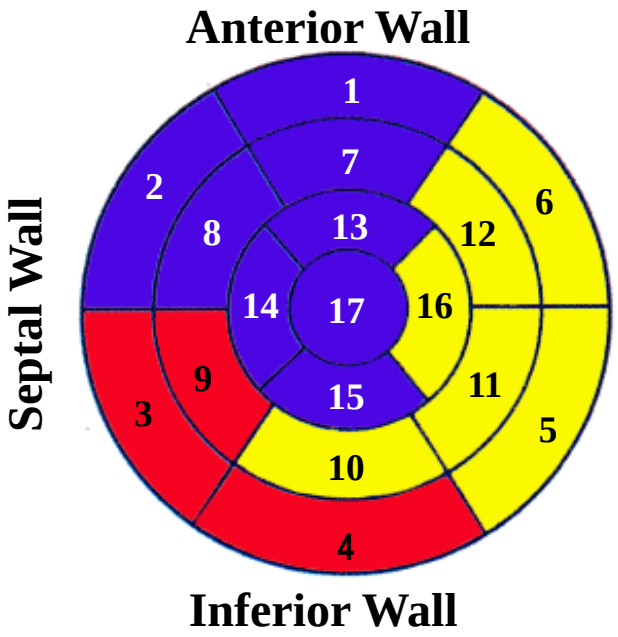
Left Circunflex (LCx)

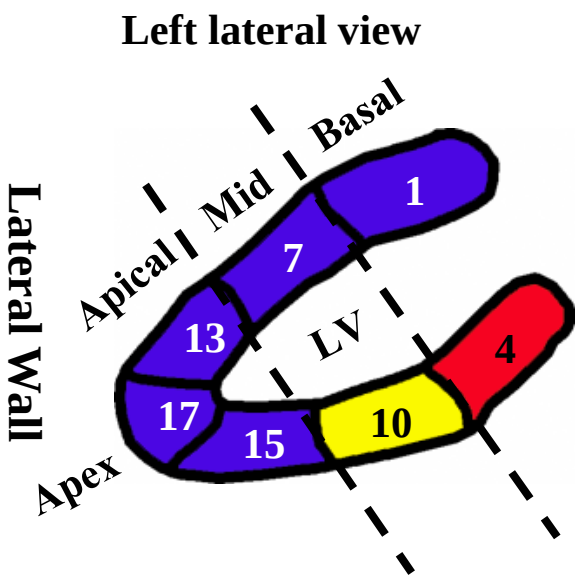
Posterior Descending (RCA or LCx)

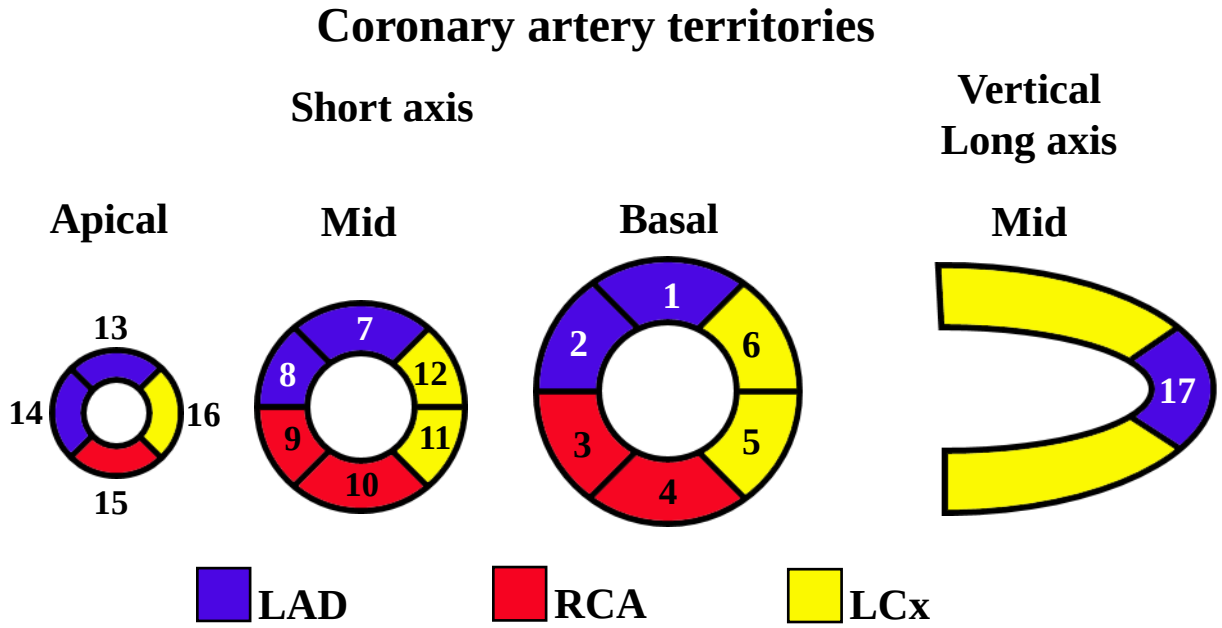
The apex is analyzed separately, usually from a vertical long-axis slice.

Ventricular segmentation heart walls with Contrast-Enhanced Cardiovascular Magnetic Resonance (CE-CMR)

Polar map short axis in “bull’s-eye”



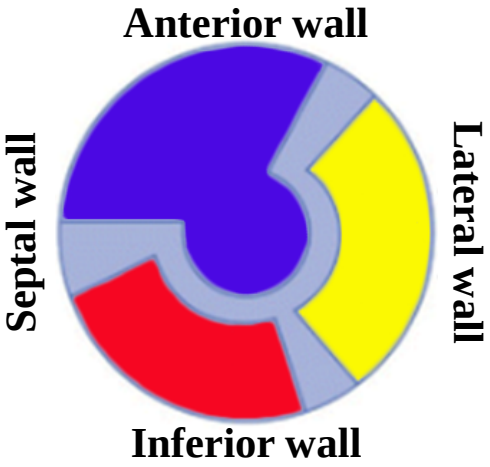




17 myocardial segments and the recommended nomenclature for tomographic imaging of the heart. Data from the individual short-axis tomograms can be combined to create a polar map plot, representing a 2D compilation of all the 3D short-axis perfusion data. Standard nomenclature for the 17 segments is outlined.

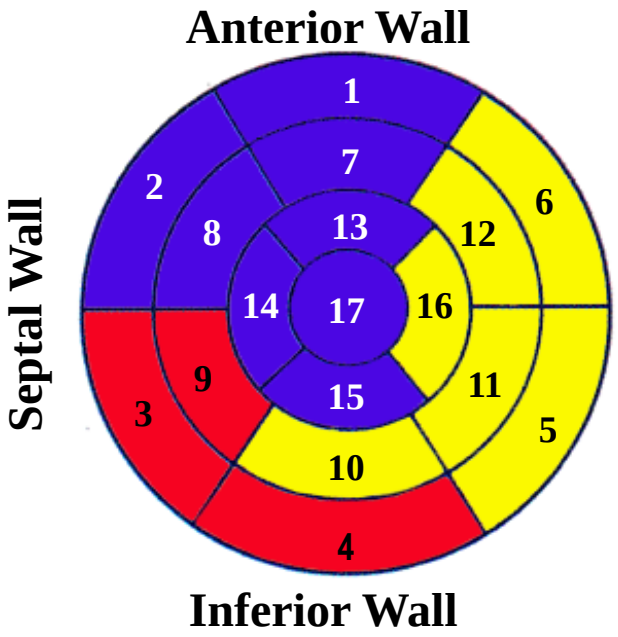
1. Basal anterior
2. Basal anteroseptal
3. Basal inferoseptal
4. Basal inferior
5. Basal inforolateral
6. Basal anterolateral
7. Mid anterior
8. Mid anteroseptal
9. Mid inferoseptal
10. Mid inferior
11. Mid inferolateral
12. Mid anterolateral
13. Apical anterior
14. Apical septal
15. Apical inferior
16. Apical lateral
17. Apex

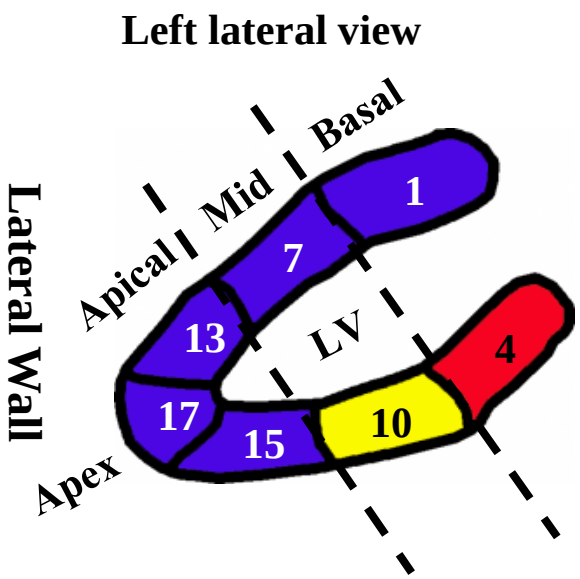
The 17 myocardial segments to the territories of the LAD, RCA, and LCx. The 2D compilation of perfusion data can then easily be assigned to specific vascular territories.

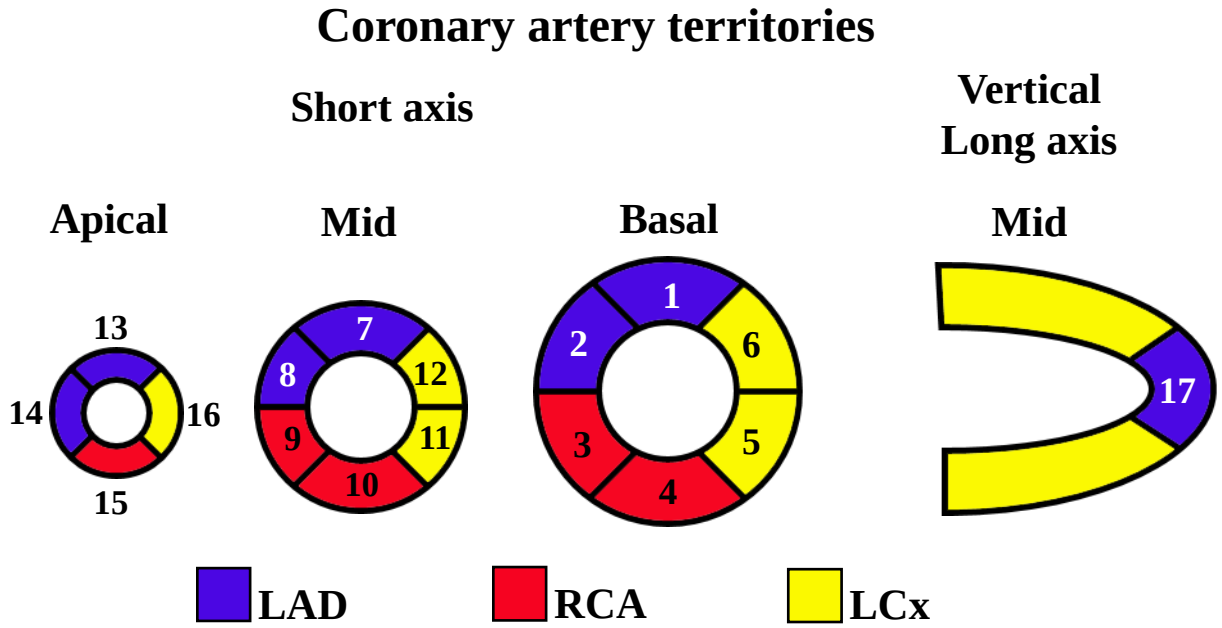


Ventricular segmentation heart walls with Contrast-Enhanced Cardiovascular Magnetic Resonance (CE-CMR)

Polar map short axis in “bull’s-eye”







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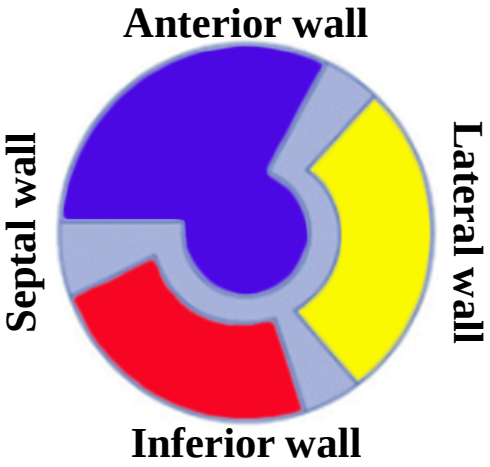
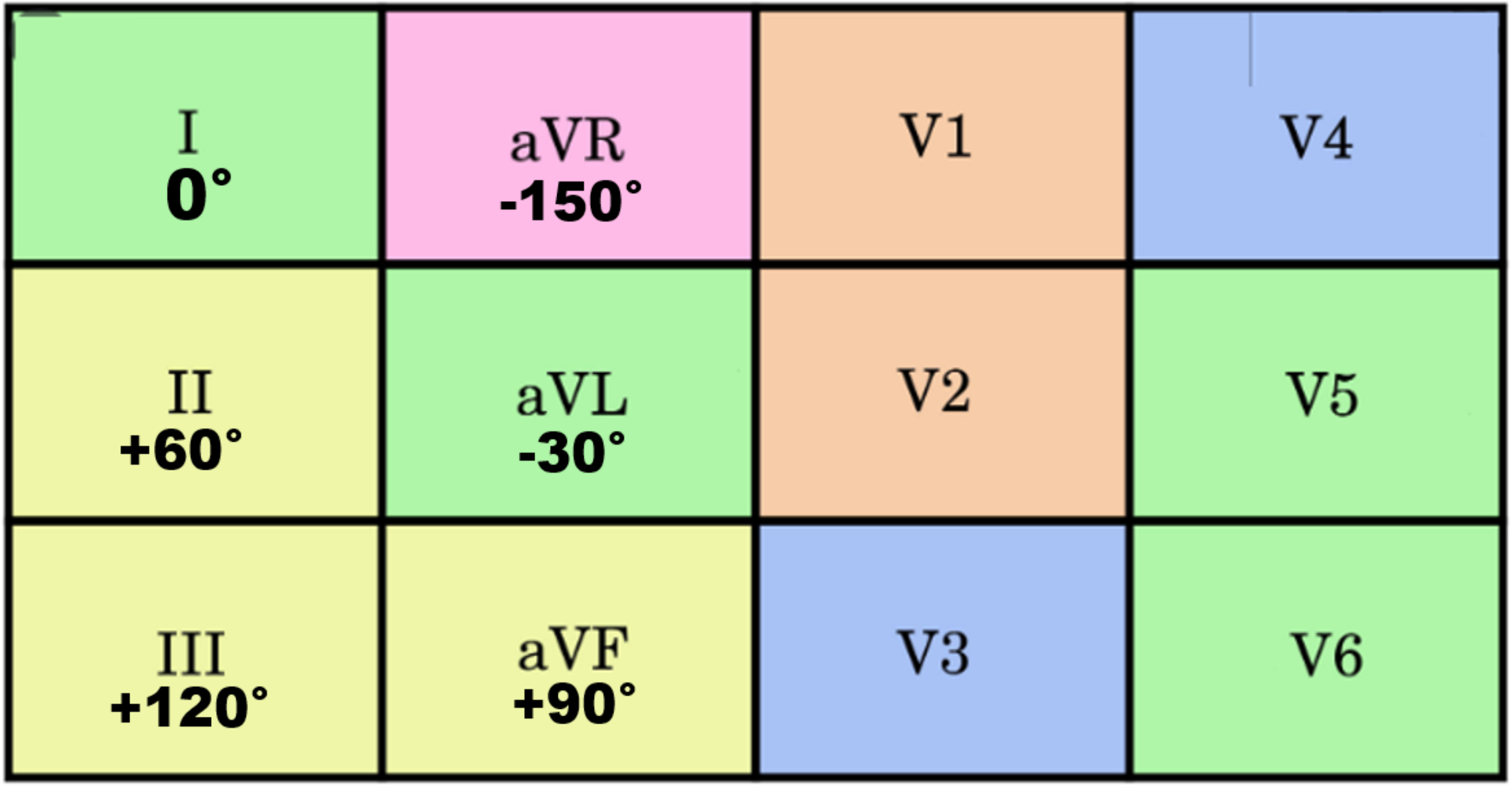


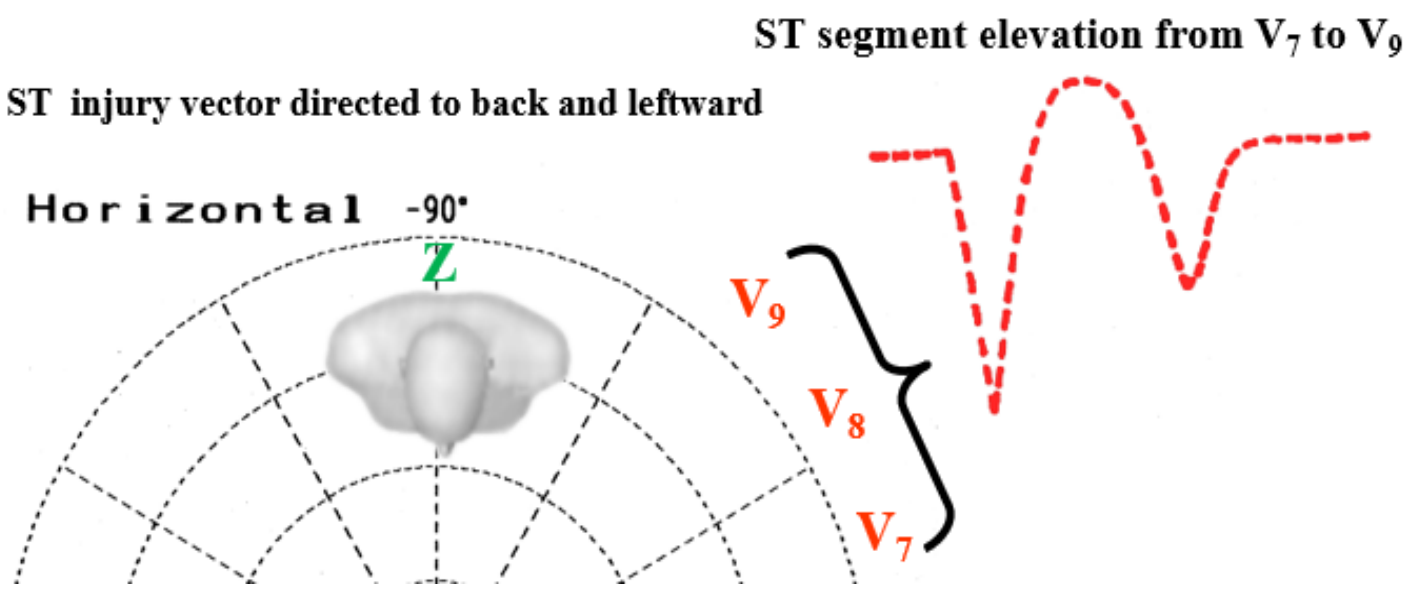
ECG Contiguous Leads of the Heart

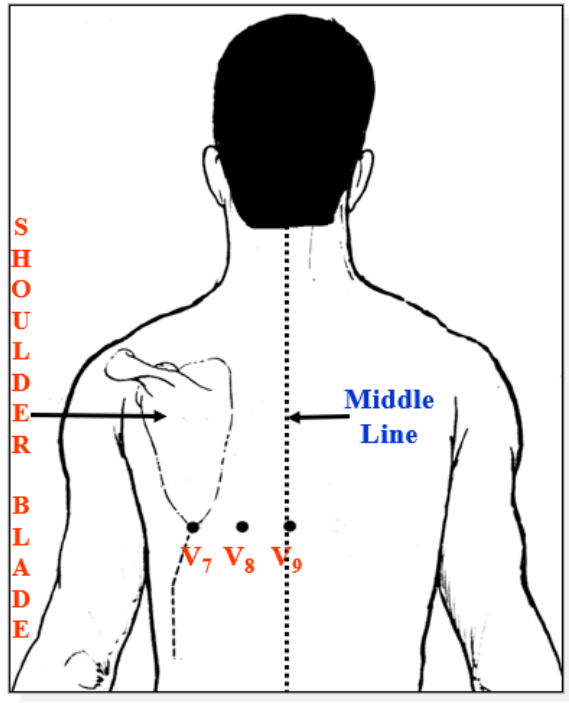


ECG reciprocal Leads of the Heart

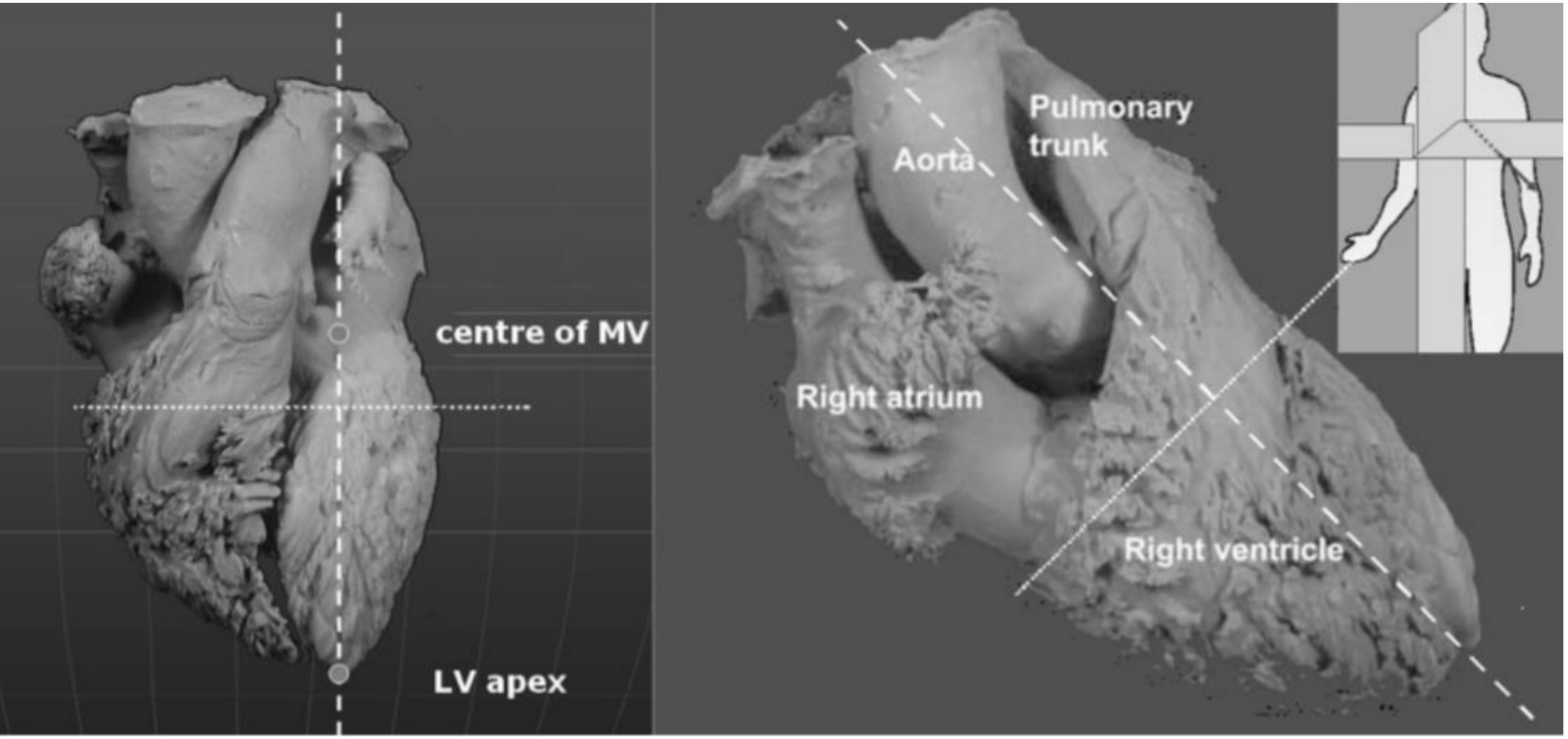
What do we mean when we say that a lead is reciprocal? It means that during an acute STEMI, when ST-segment elevation is present in leads that face the acute injury, ST-segment depression will often be present in other leads.

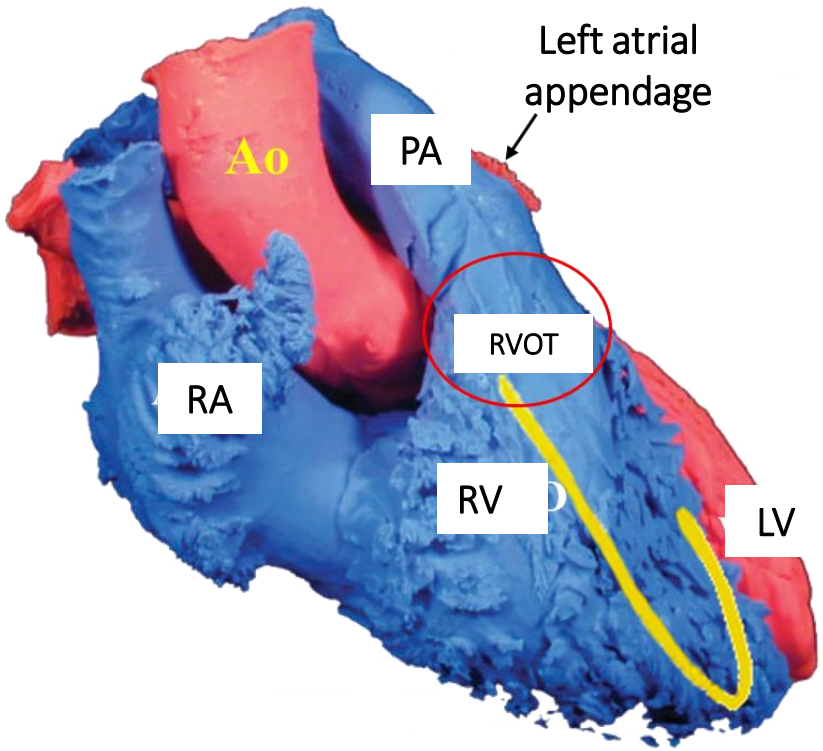
Wall	Facing	Reciprocal
Inferior	II, III and aVF	I and aVL
Anterior	V1, V2, V3, V4	None
Septal	V1, V2	V7, V8, V9





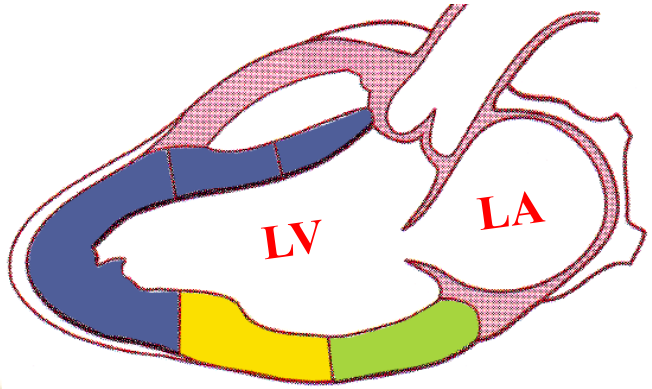
Current nomenclature of heart wall segmentation with Contrast-Enhanced Cardiovascular Magnetic Resonance

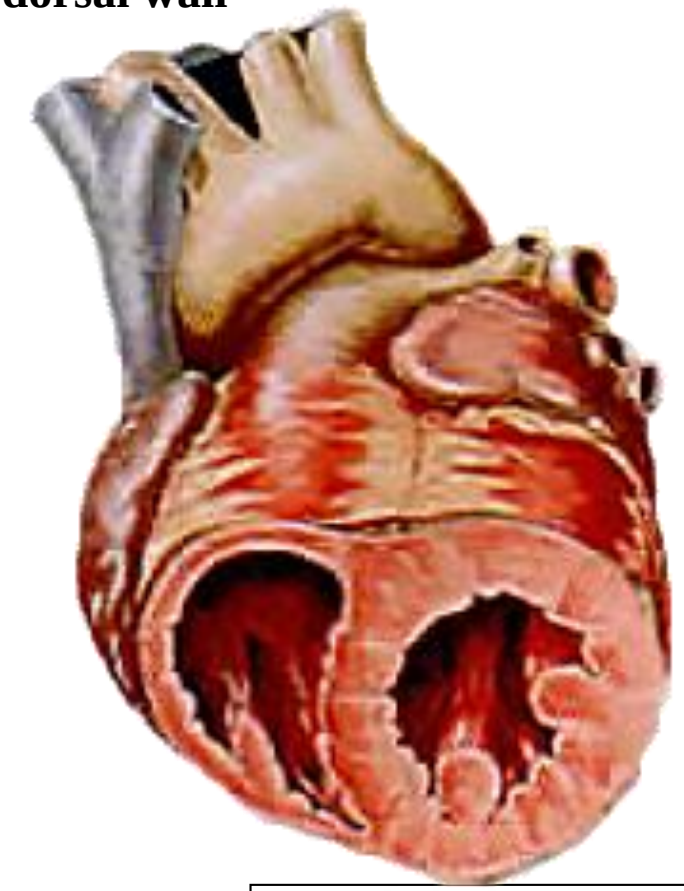


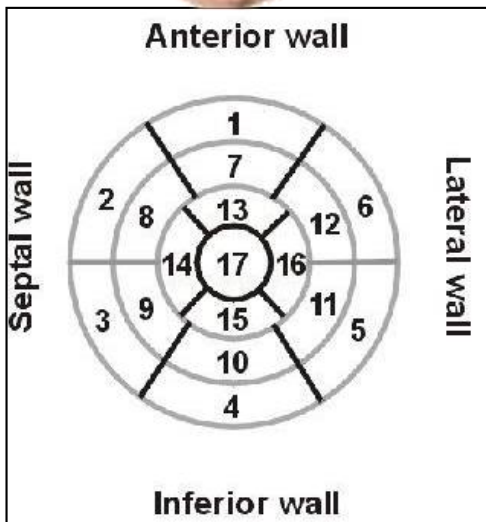


The left panel shows the heart in its "Valentine" position, with the long axis of the left ventricle and its defining points (dashed line) and a short axis (dotted line). In the right panel, we have positioned the heart in attitudinally appropriate fashion, showing the angulation of the ventricular axes relative to the axes of the body.

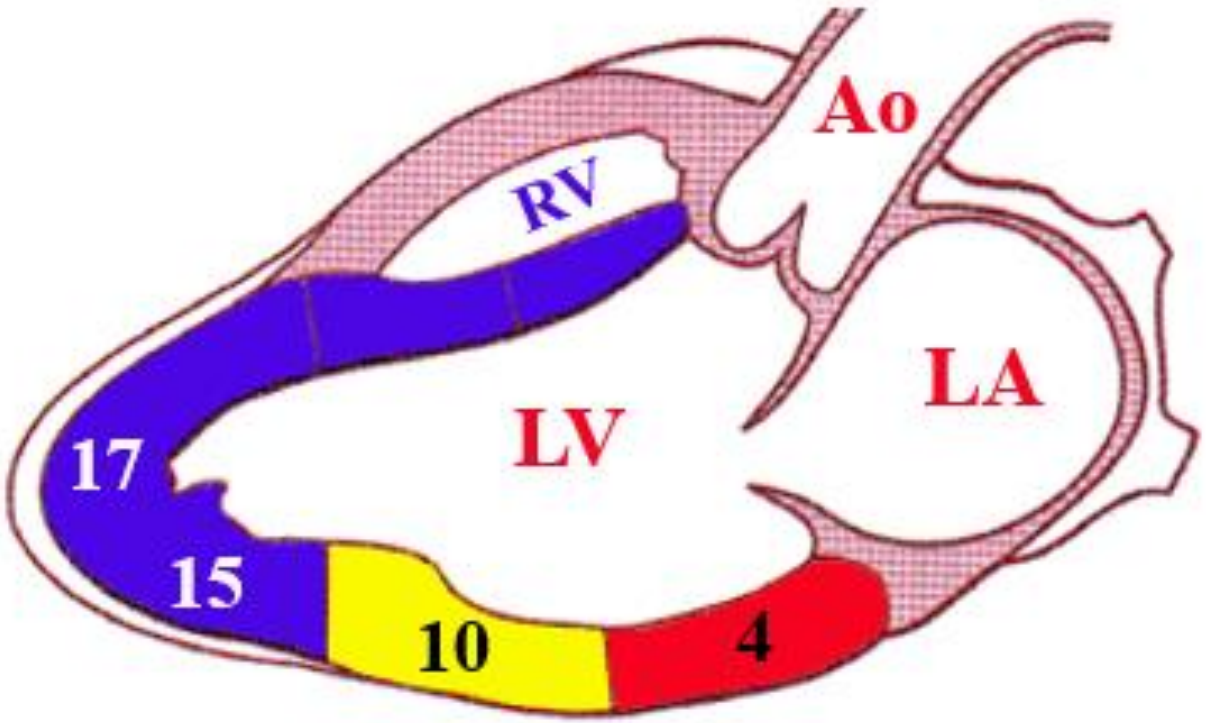
Demonstration of the inexistence of the true, strictly posterior or dorsal wall

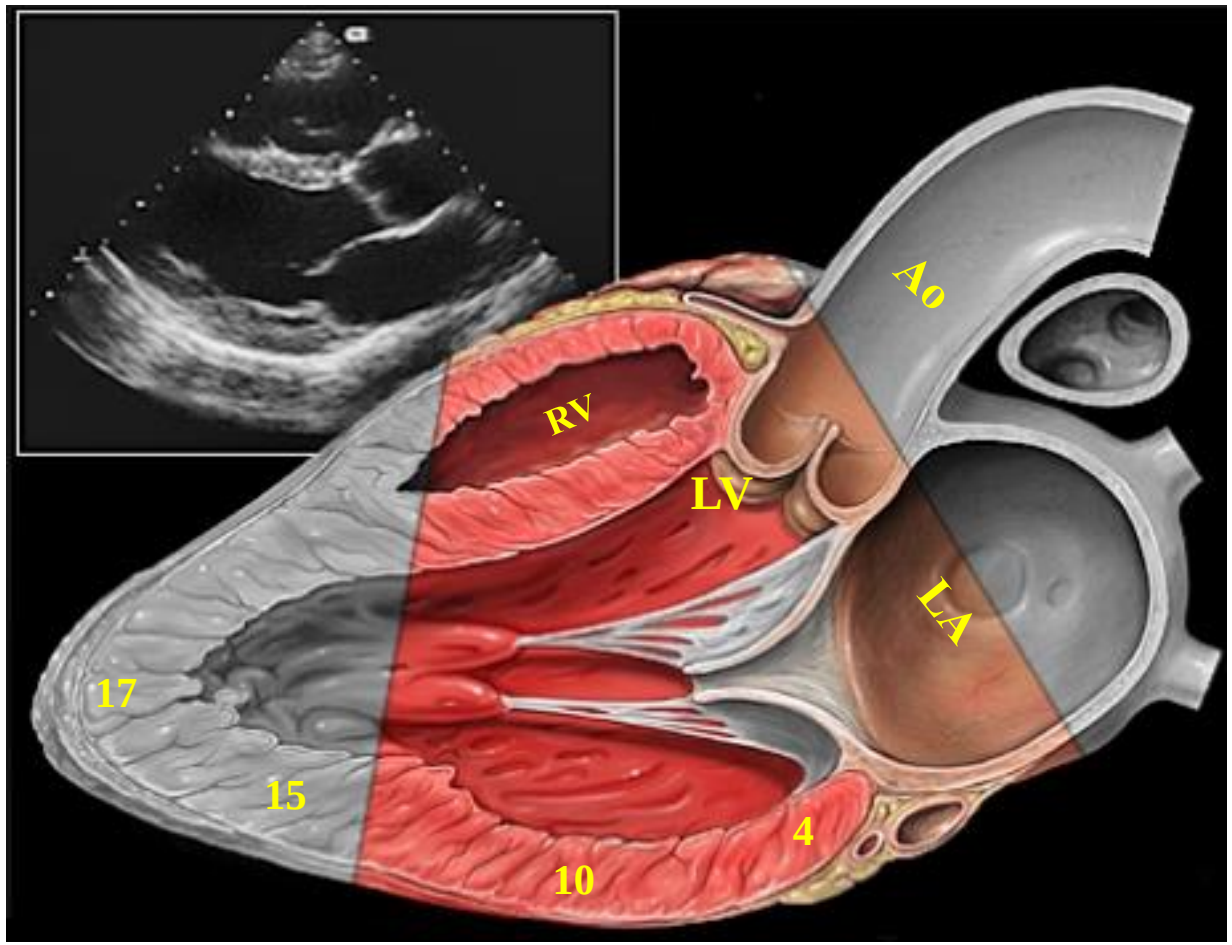






Segment number 4 correspond to the basal inferior wall, not dorsal.


Ao
RV
LA
LV
17
15
10
4


Ao
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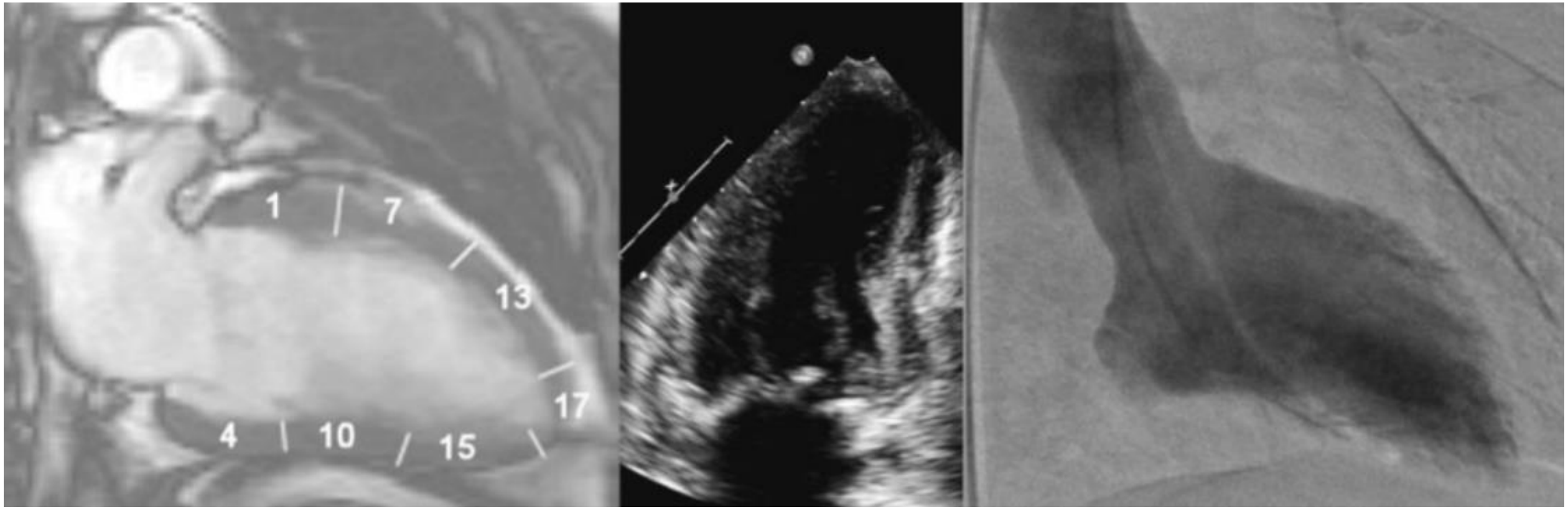


The left panel shows the vertical long axis image, with its segmental pattern, as obtained using magnetic resonance imaging. The middle panel shows the apical two chamber echocardiographic view, while the right panel shows a left ventricular angiogram in right anterior oblique projection.

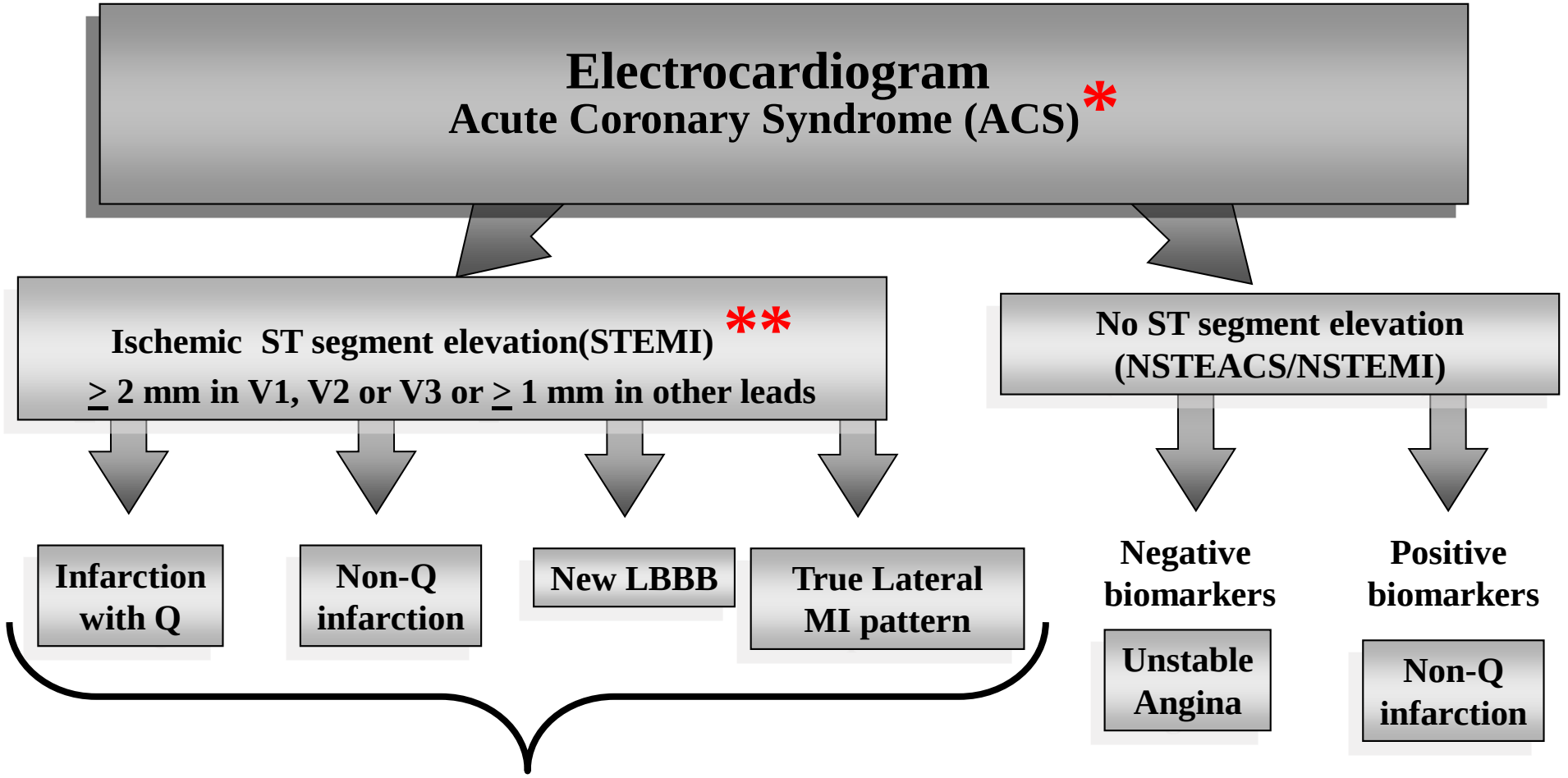
Conclusion

Today, the terms posterior and high lateral infarction are incorrect and should be changed to lateral wall and limited anterolateral wall MI.

Recommendations

Historically, the terms true and strictly posterior MI have been applied when the basal part of the LV wall that lies on the diaphragm was involved. However, although in echocardiography the term posterior is still used in reference to other segments of the LV, it is the consensus of this report to recommend that the term posterior be abandoned and that the term inferior be applied to the entire LV wall that lies on the diaphragm. This decision regarding change in terminology achieves agreement with the consensus of experts in cardiac imaging appointed by the AHA21 and thereby provides great advantages for clinical practice. However, a global agreement, especially with an echocardiographic statement, is necessary.(1)

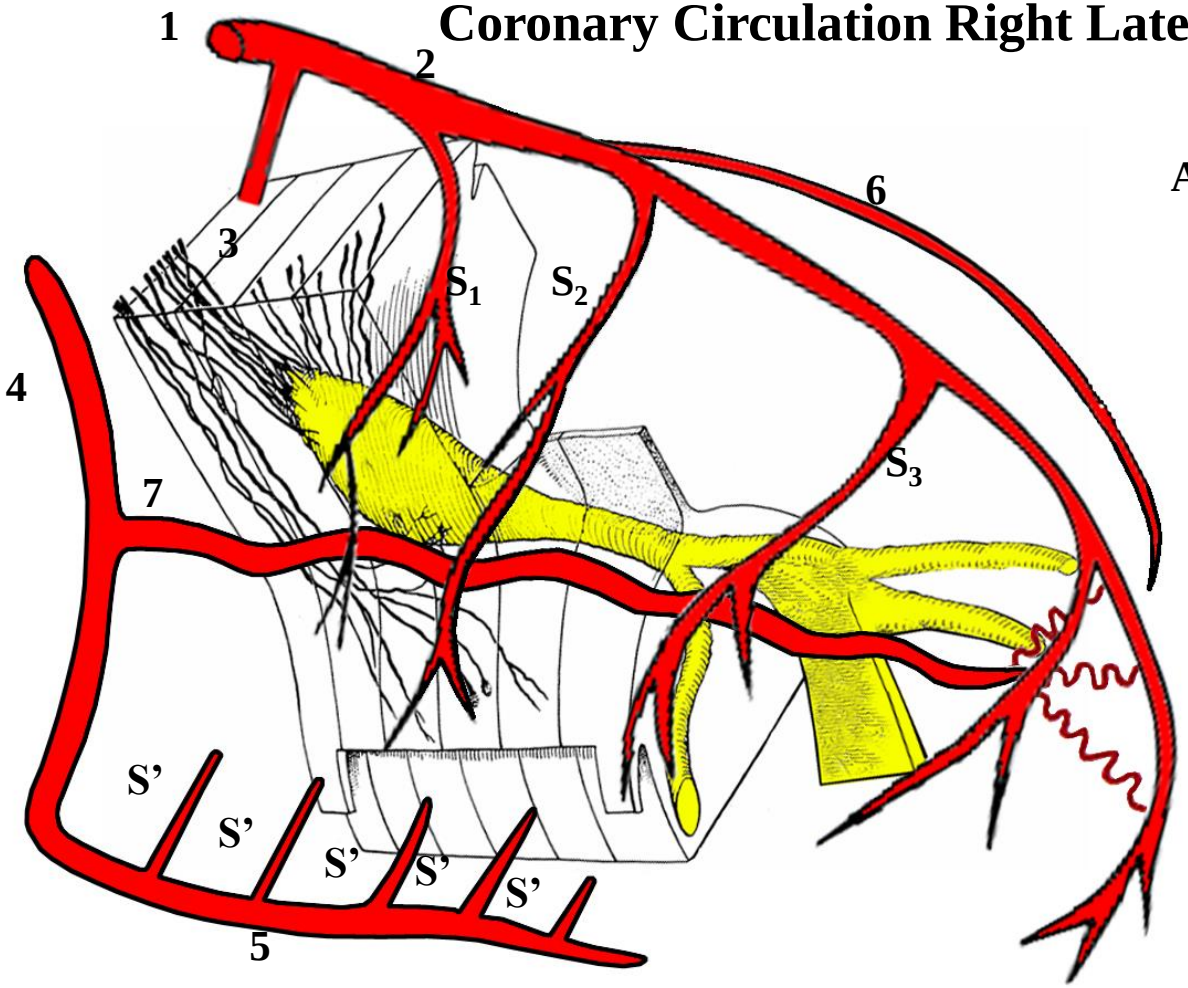
1. *Antoni Bayés de Luna 1, Galen Wagner, Yochai Birnbaum, Kjell Nikus, Miguel Fiol, et al., International Society for Holter and Noninvasive Electrocardiography. A New Terminology for Left Ventricular Walls and Location of Myocardial Infarcts That Present Q Wave Based on the Standard of Cardiac Magnetic Resonance Imaging: A Statement for Healthcare Professionals From a Committee Appointed by the International Society for Holter and Noninvasive Electrocardiography. Circulation. 2006 Oct 17;114(16):1755-60. doi: 10.1161/CIRCULATIONAHA.106.624924*



***ACS** is a broad, clinically defined, "umbrella" term that encompasses patients presenting with ischemic discomfort who have evidence of MI or are felt to be at high risk of MI in the immediate future.

****S-T elevation myocardial infarction (STEMI)** or "current of injury", is defined by the occurrence of new or presumed new ST elevation in ≥2 contiguous leads that is ≥0.2 mV in right precordial leads (V_1, V_2, and V_3) and >0.1 mV in other leads or the occurrence of new onset LBBB pattern.

Coronary Circulation Right Lateral View

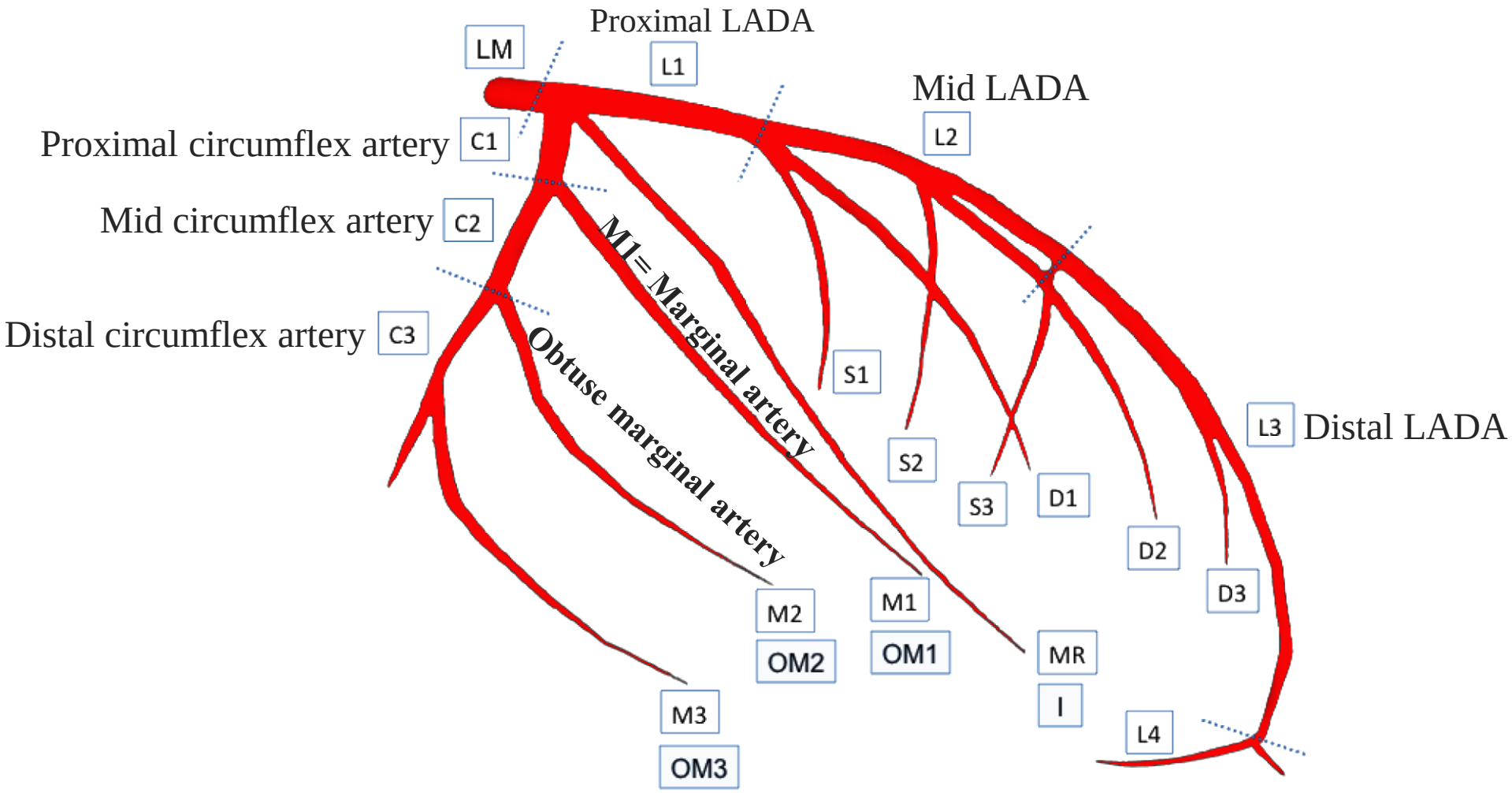


Anterior Septal Perforator Branches

S_1: First Septal Perforator branch
S_2: Second Septal Perforator
S_3: Third Septal Perforator

S': Posterior Septal Perforators

1. Left Main Coronary Artery (**LMCA)**
2. Left Anterior Descending Artery (**LAD)**
3. Left Circumflex Coronary Artery (**LCx)**
4. Right Coronary Artery (**RCA)**
5. Posterior Descending Artery. In this case is supplied by the RCA, then the coronary circulation can be classified as "right-dominant“ (PDA)
6. First Diagonal (D1)
7. Acute Marginal (**AM)**



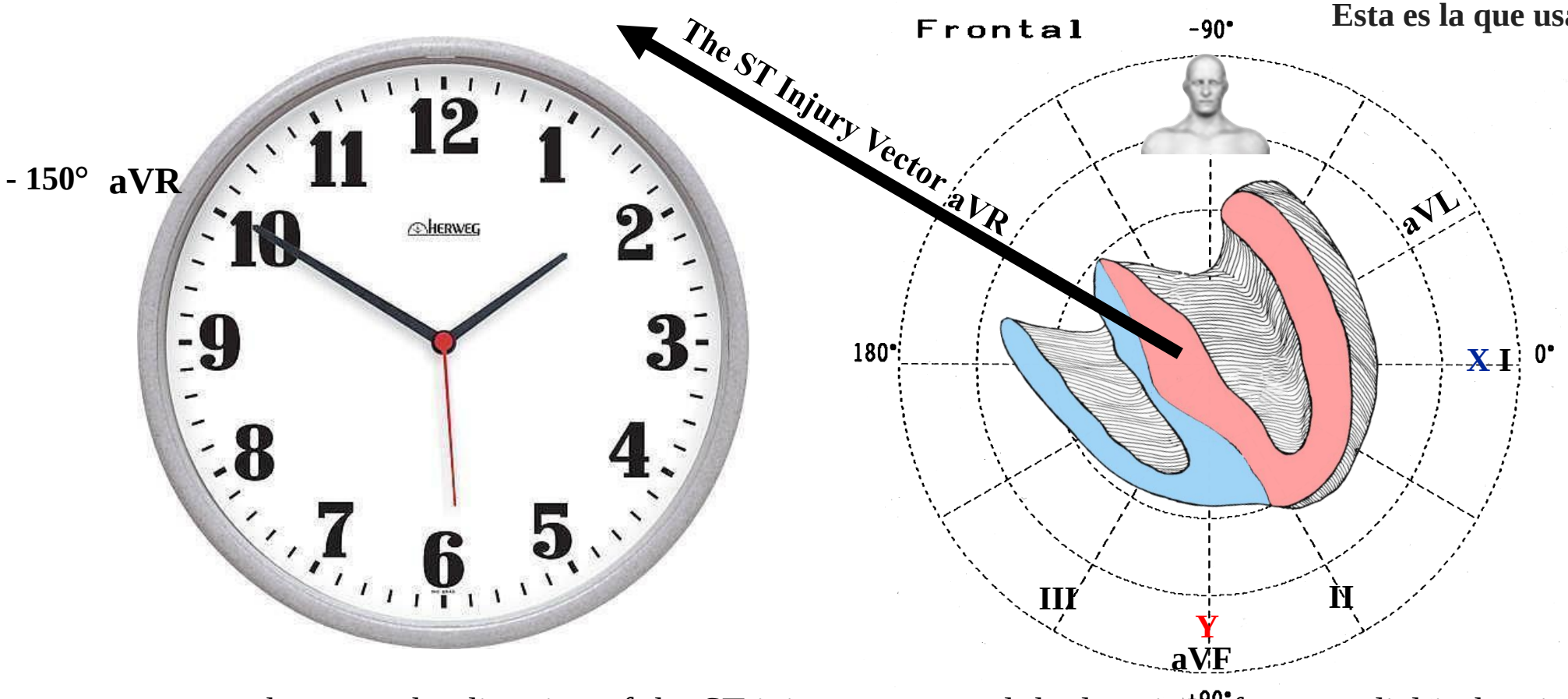
LM= Left main**; L1=** Proximal left anterior descending artery**; L2=** Mid left anterior descending artery; **L3=** Distal left anterior descending artery; **L4=** The left anterior descending artery terminus on the inferior wall; **D1=** First diagonal artery**; D2=** Second diagonal artery; **D3=** Third diagonal artery; The diagonal branches come off the LAD and run laterally to supply the anterolateral wall of the left ventricle. The first diagonal branch serves as the boundary between the proximal and mid portion of the LAD

S1, S2, S3= Septal arteries; **MR=** Median ramus; **C1=** Proximal circumflex artery; **C2=** Mid circumflex artery; **C3=** Distal circumflex artery; **C4= Left posterolateral artery; M1, M2, M3 =** Marginal arteries; **OM1-OM3=** Obtuse marginal arteries.

Left Main Coronary Artery (LMCA) occlusion: injury vector direction in the frontal plane

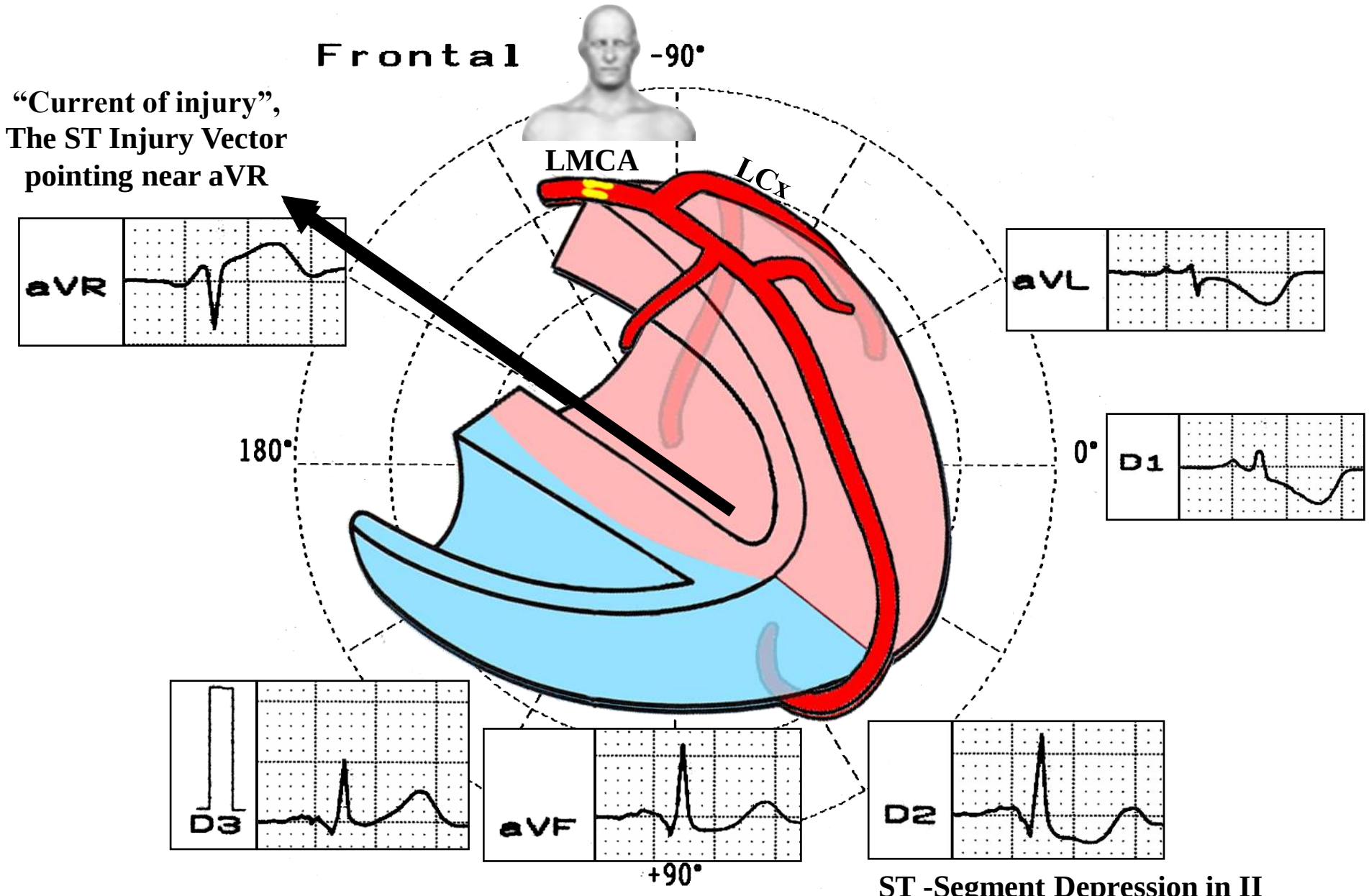
The ST Injury Vector, "Current of injury", injury vector pointing near aVR (-150°)

La manecilla más larga es la que marca los minutos, por eso se le llama minutero Esta es la que usaremos.



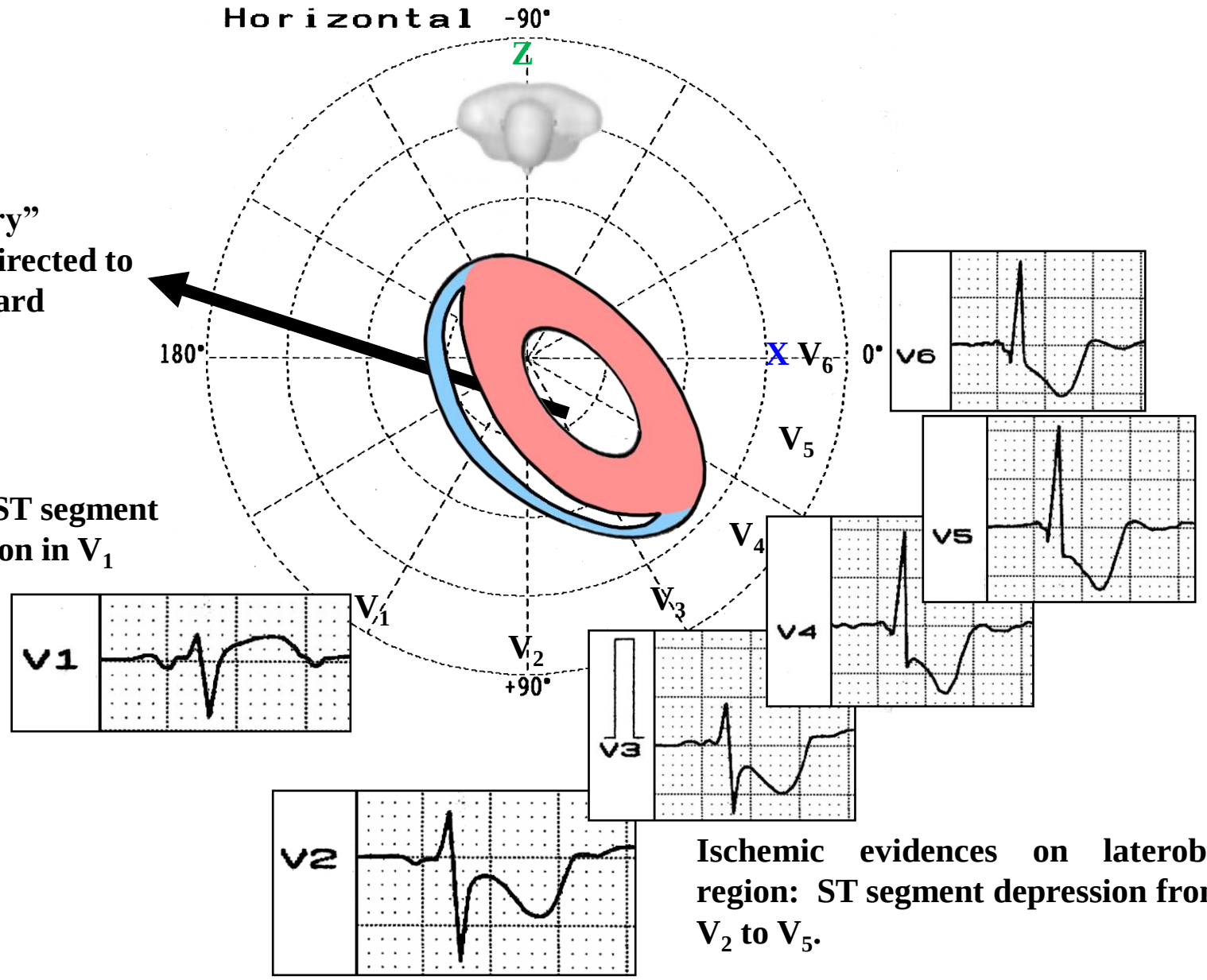
There is a strong agreement between the direction of the ST injury vector and the location of myocardial ischemia. The ST injury vector may be the key to higher diagnostic accuracy for inferobasal transmural ischemia and may help distinguishing between RCA and LCX occlusions in the acute phase (**Mads P Andersen 1, Christian J Terkelsen, Jacob T Sørensen, Anne K Kaltoft, Søren S Nielsen, Johannes J Struijk, Hans E Bøtker. The ST Injury Vector: Electrocardiogram-Based Estimation of Location and Extent of Myocardial Ischemia. J Electrocardiol. Mar-Apr 2010;43(2):121-31.**).

Left Main Coronary Artery (LMCA) occlusion: ECG pattern



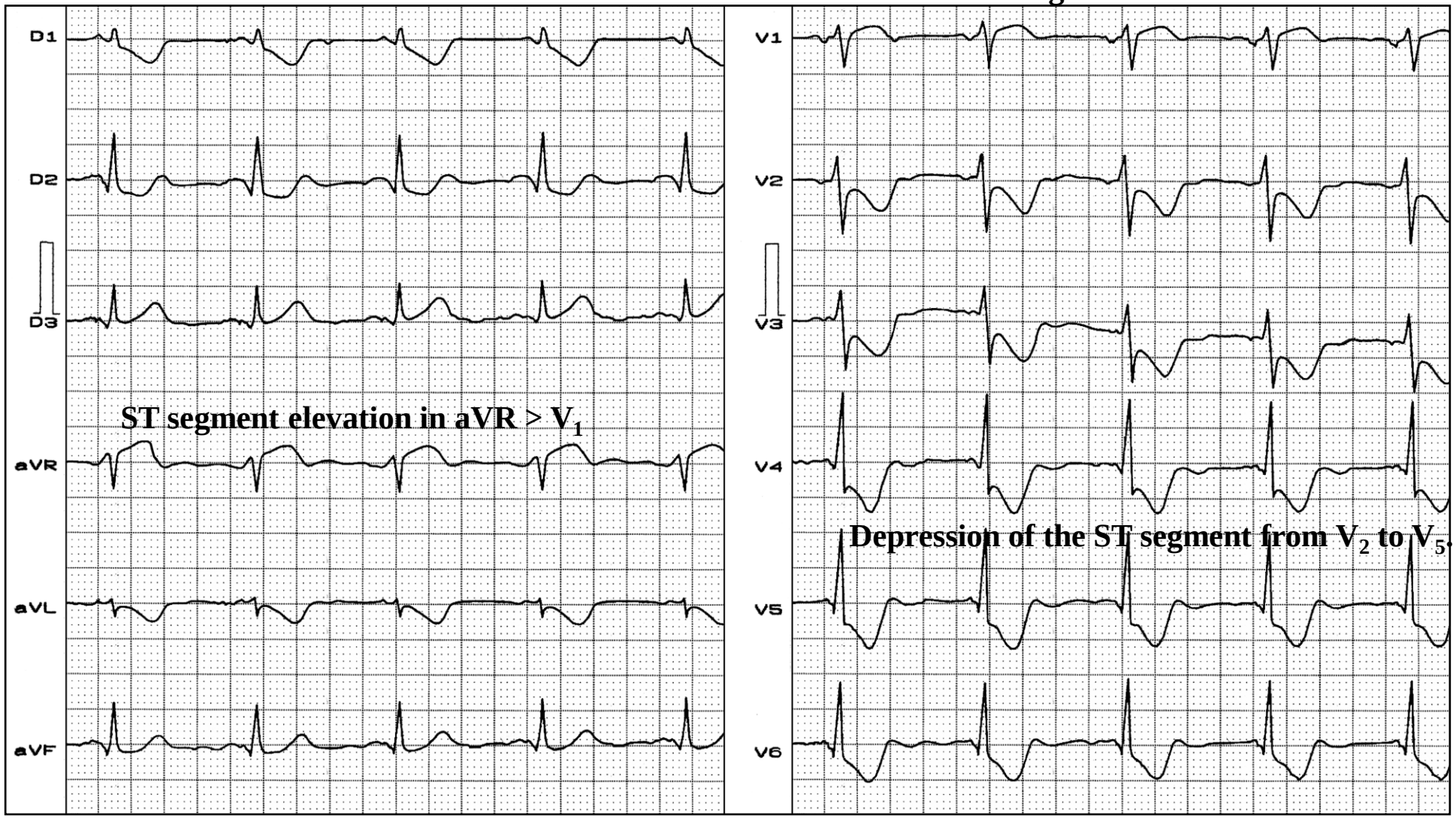
“current of injury”
The ST injury vector directed to right and backward

Minimal ST segment elevation in V_1

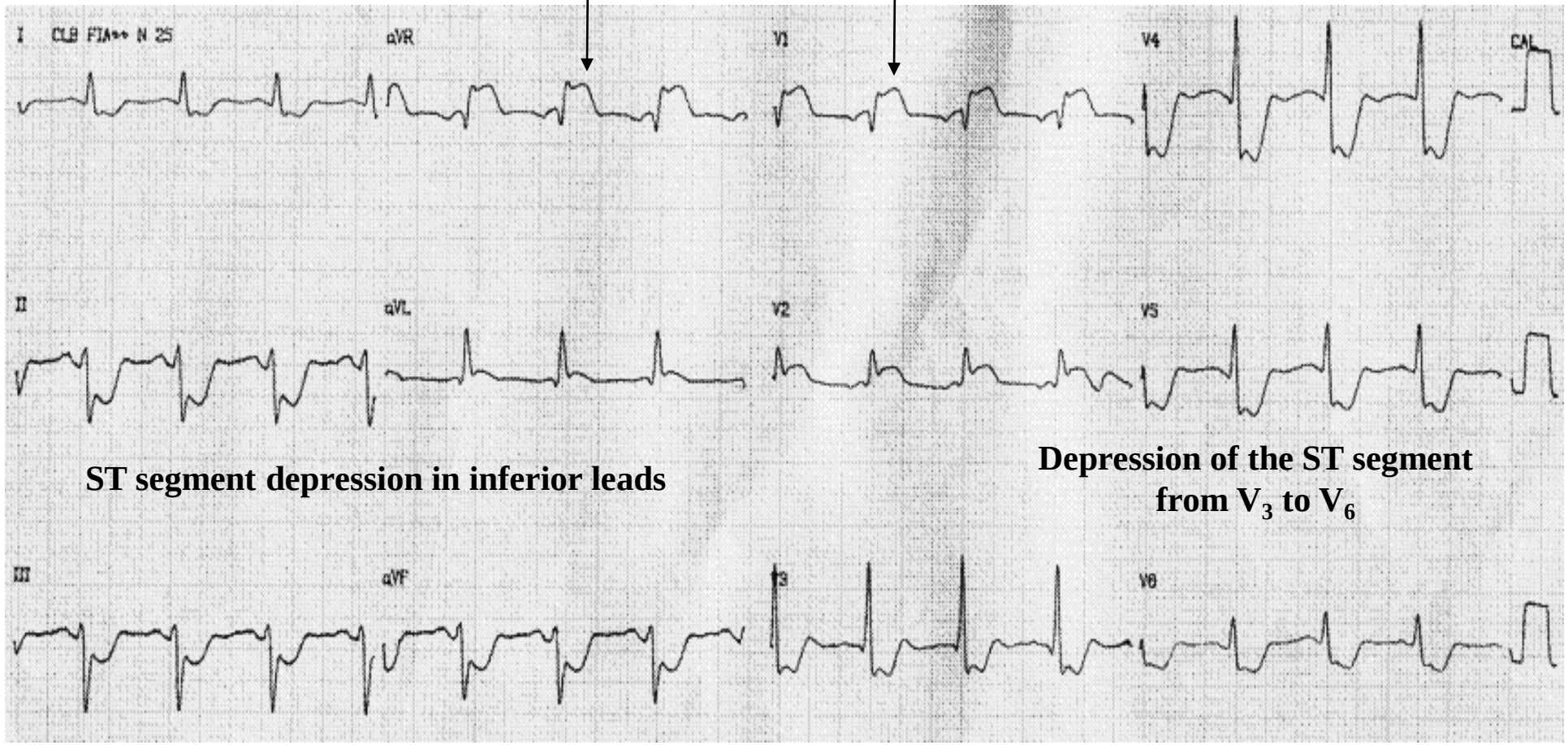


Ischemic evidences on laterobasal region: ST segment depression from V_2 to V_5.

Typical ECG pattern of LMCA Occlusion. Diffuse ST segment depression in the inferolateral leads



ST segment elevation in aVR > V_1

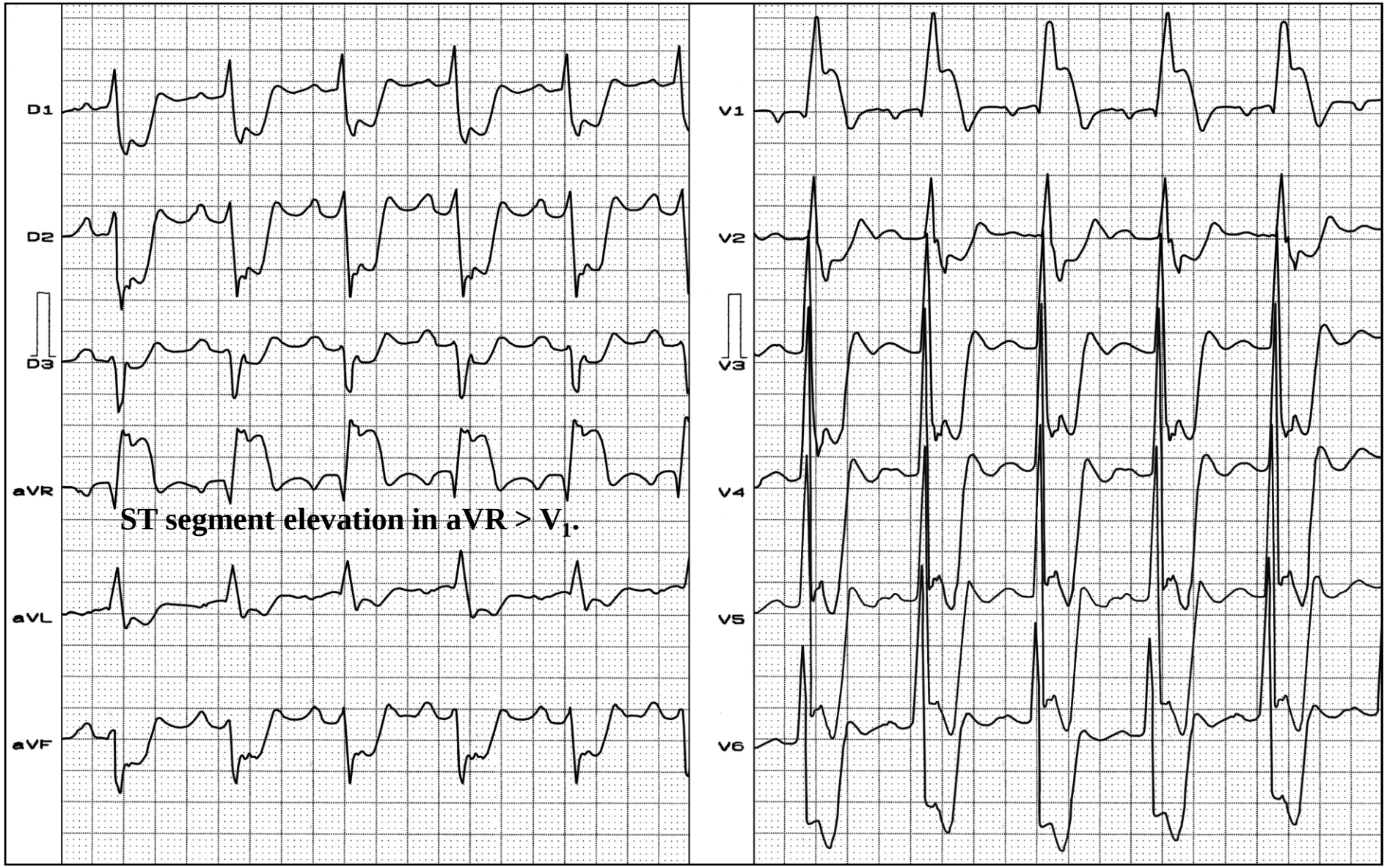


ST segment depression in inferior leads

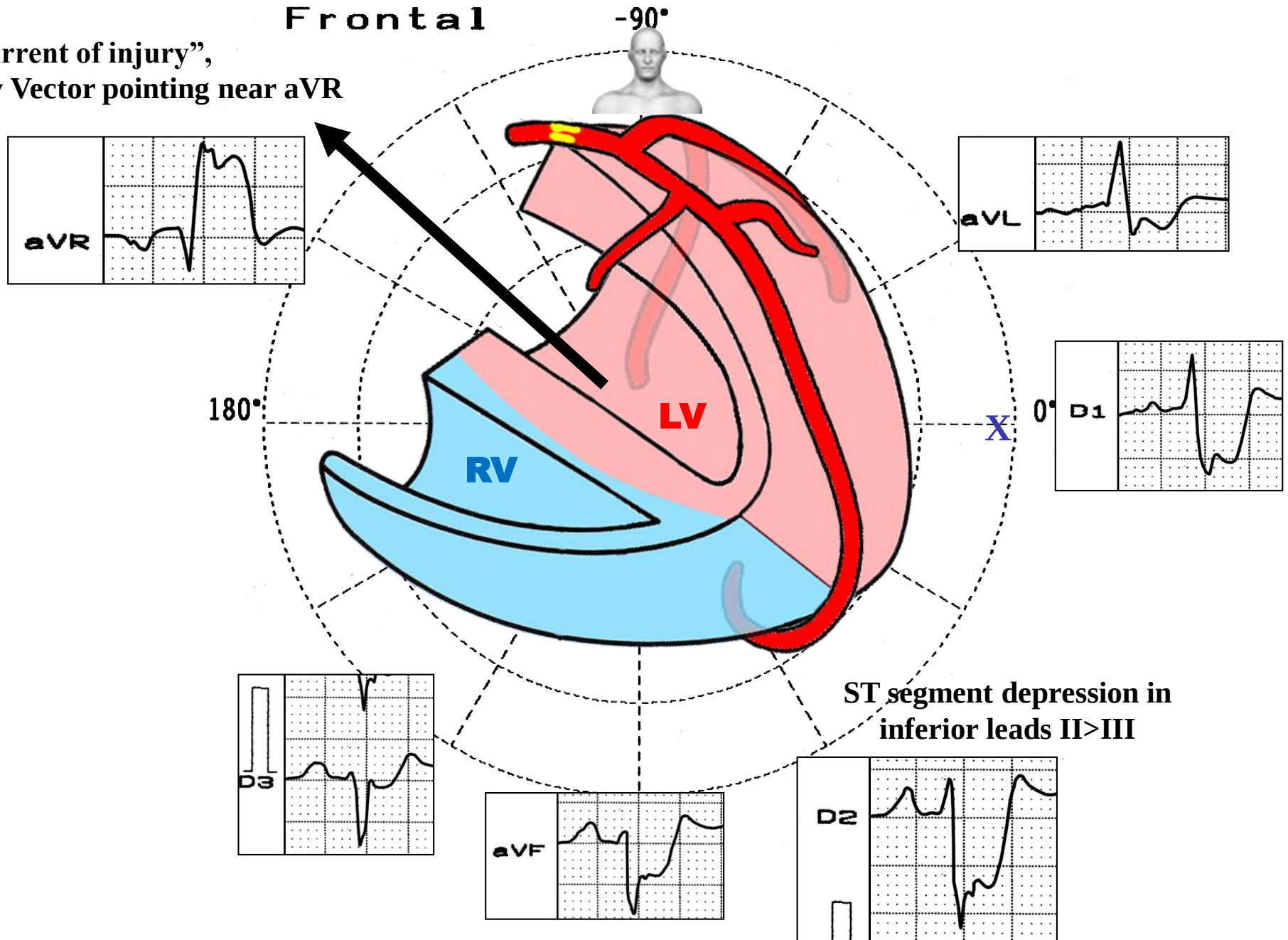
Depression of the ST segment from V_3 to V_6

Clinical features: Acute Coronary Syndrome associated with cardiogenic shock consequence of total occlusion of LMCA. Primary Angioplasty was performed, with immediately hemodynamic stabilization.

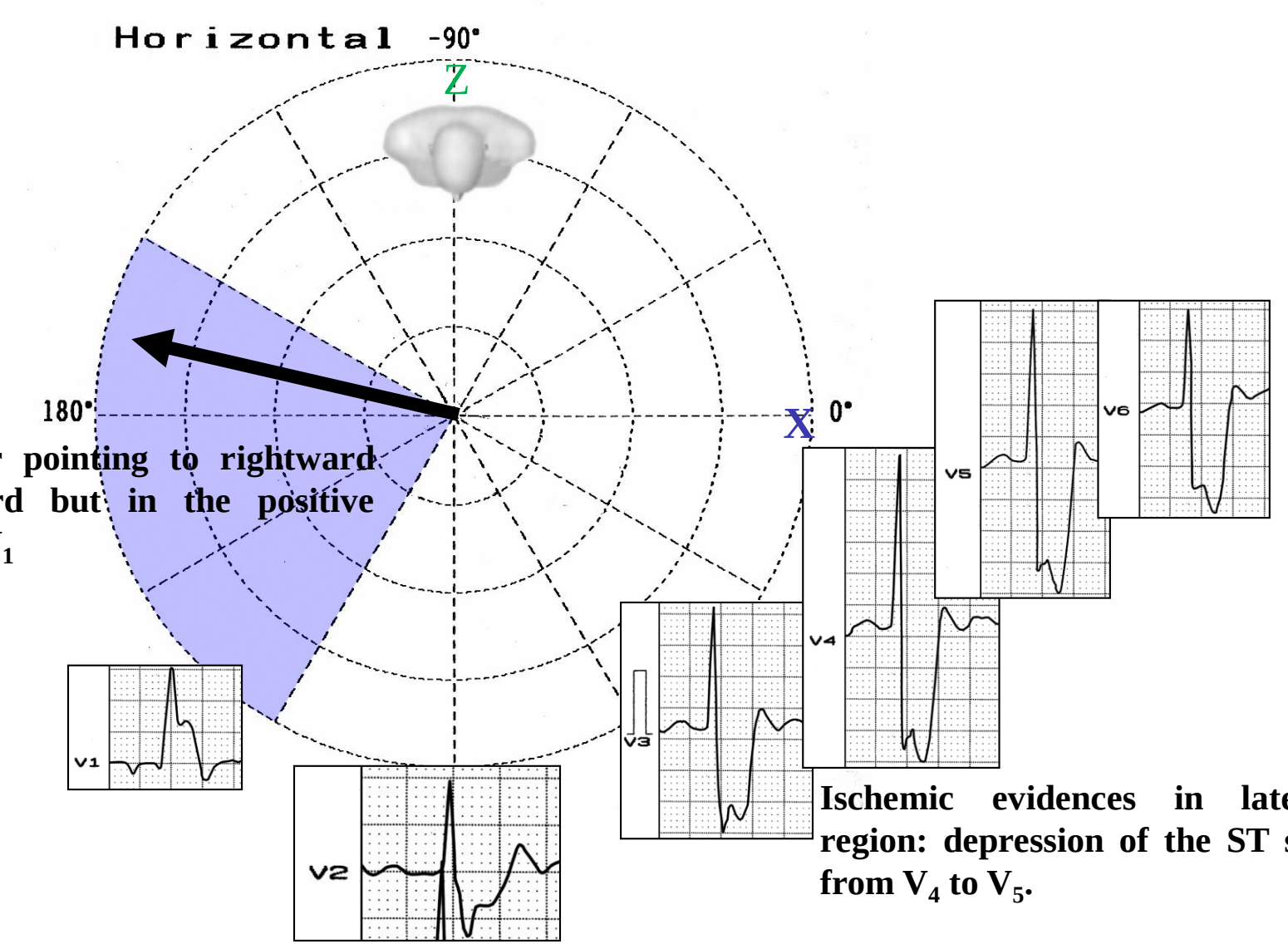
LMCA Occlusion complicated with CRBBB.



“Current of injury”,
The ST Injury Vector pointing near aVR



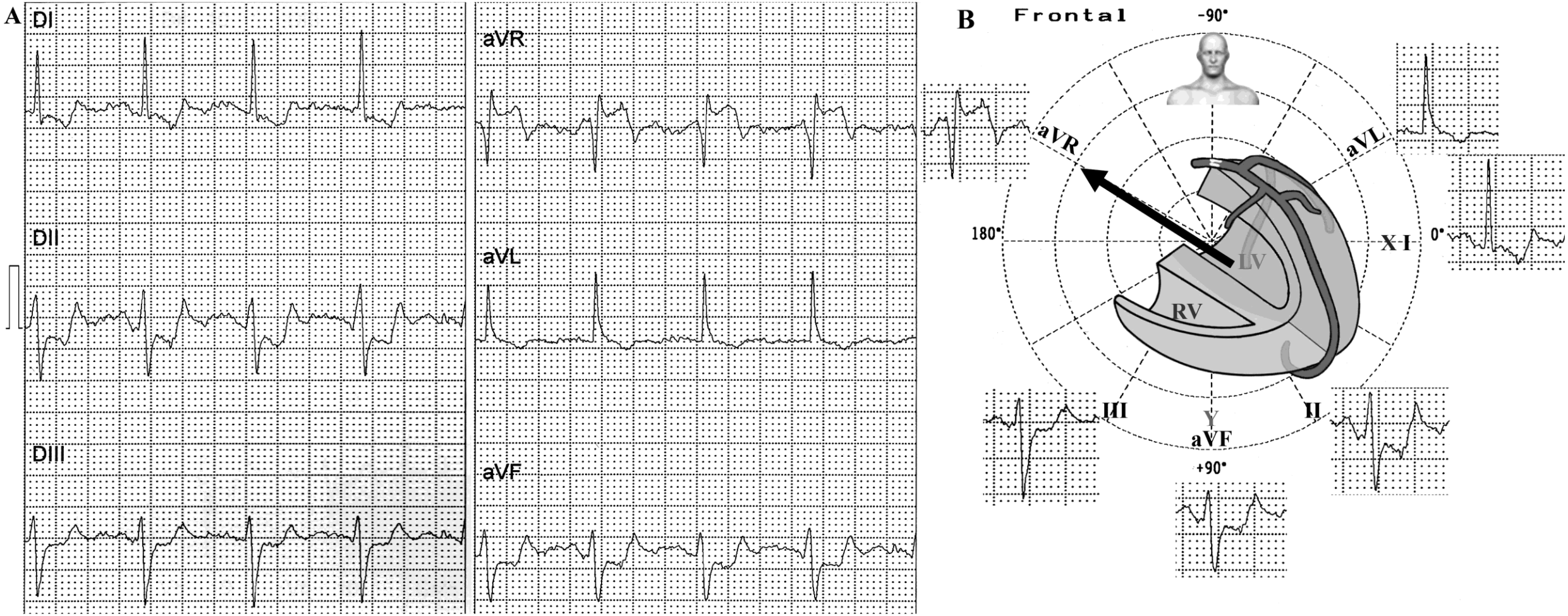
ST segment depression in inferior leads II>III



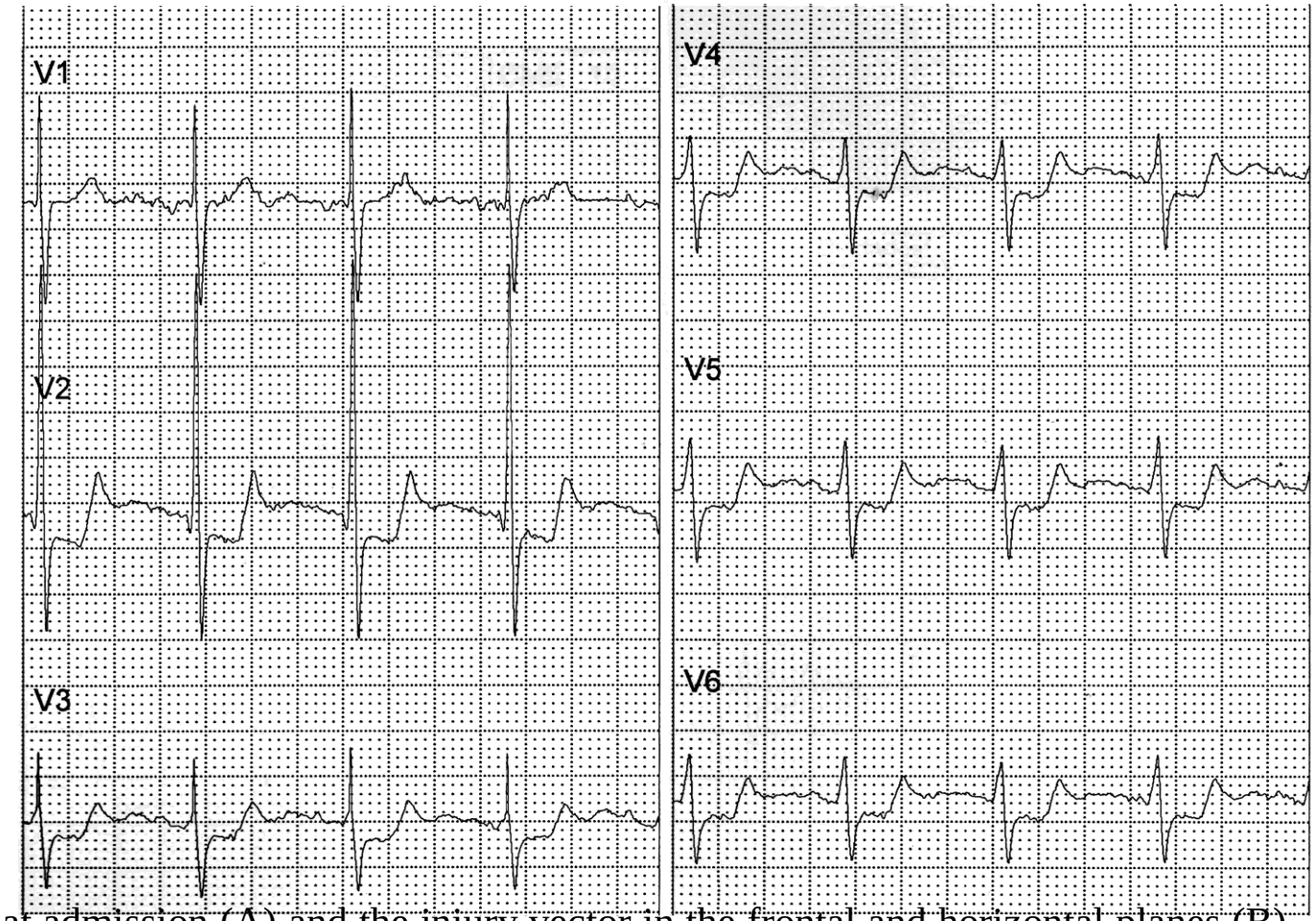
Injury vector pointing to rightward and backward but in the positive quadrant of V_1

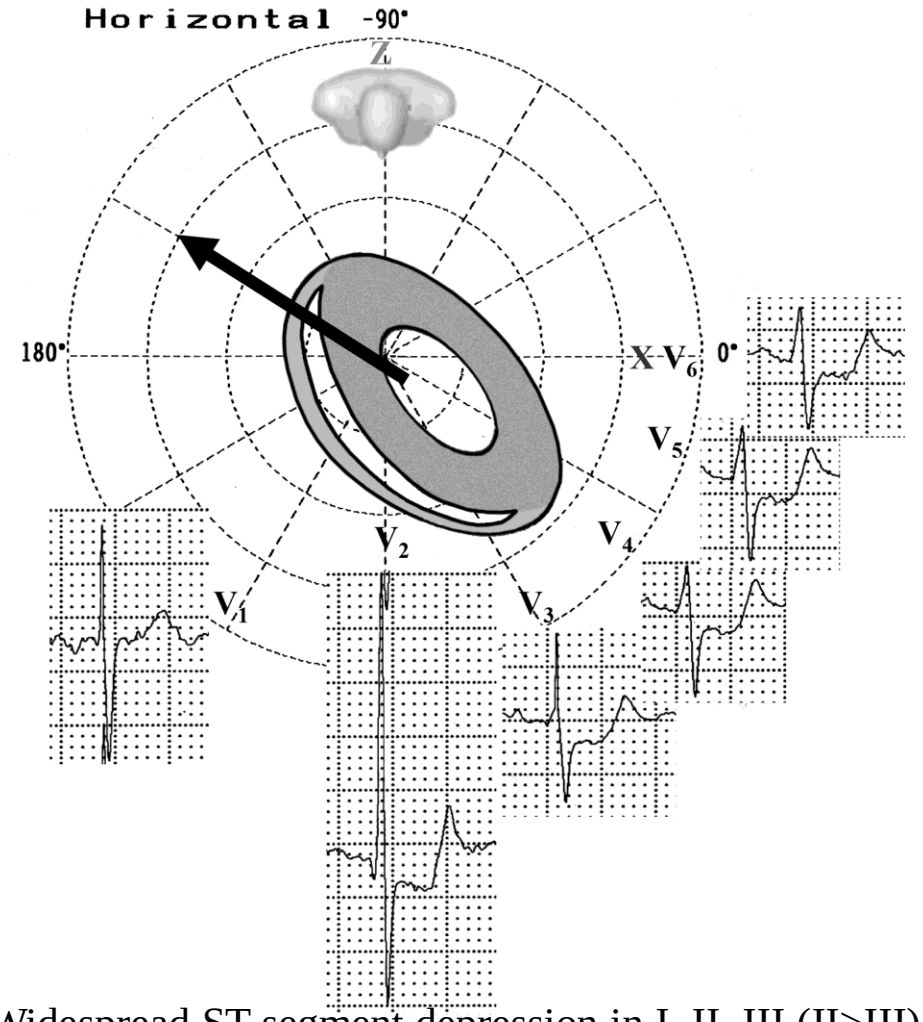
Ischemic evidences in laterobasal region: depression of the ST segment from V_4 to V_5.

Positive quadrant of V_1.
The ST segment injury vector is located inside of a positive quadrant of V_1



ECG at admission (A) and the injury vector in the frontal and horizontal planes (B). A) Widespread ST-segment depression in I, II, III (II>III) and VF and from V2 to V6 waves. Diffuse ST-segment depression in the inferolateral leads (≥7 leads with ST-depression) and reciprocal ST-segment elevation in the aVR lead. In addition, atypical left anterior fascicular block (LAFB), QRS axis -40°, SIII>SII, and absence of initial q wave in I and aVL by absence of the first left middle septal vector (in typical LAFB the first 10-20 ms vectors are directed to +120°).4 B) Frontal plane (FP): The ST injury vector (arrow) is directed upward and rightward pointing towards the aVR lead (-150°). When this vector is located between -90° and ±180° in the FP, it is indicative of LMCA obstruction in up to 100% of cases;5 ST-segment depression in the inferior leads with STII>STIII; Horizontal plane: the ST injury vector is directed to the right and leftward (arrow), perpendicular to V1. ST segment depression from V2 to V6.





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Left Main Coronary Artery (LMCA) occlusion electrocardiographic criteria

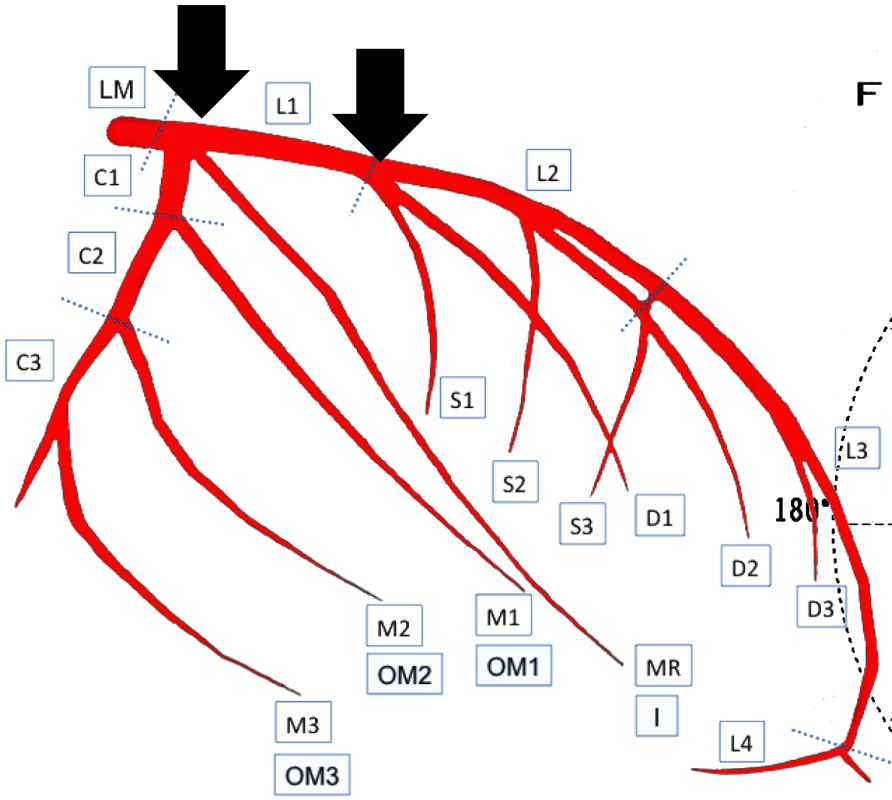
1. **ST segment elevation in aVR, and V_1**
2. **ST segment elevation in aVR > V_1**
3. **Ischemic evidences in laterobasal region: depression of the ST segment in inferior leads and from V_4 to V_5.**
4. **Depression of ST segment in V_6 > ST segment elevation in V_1.**
5. **Eventually complicate with intraventricular conduction disturbance RBBB, LAFB and/or LSFB.**

ST Elevation in aVR

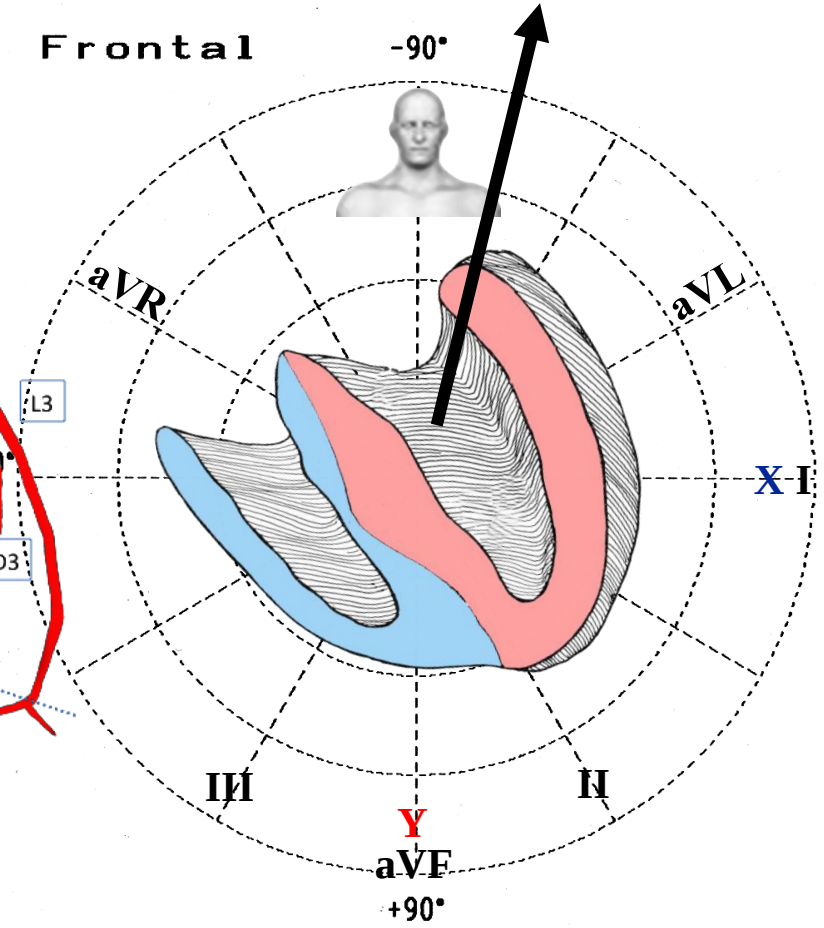
NOTE: ST elevation in aVR is not entirely specific to LMCA occlusion.

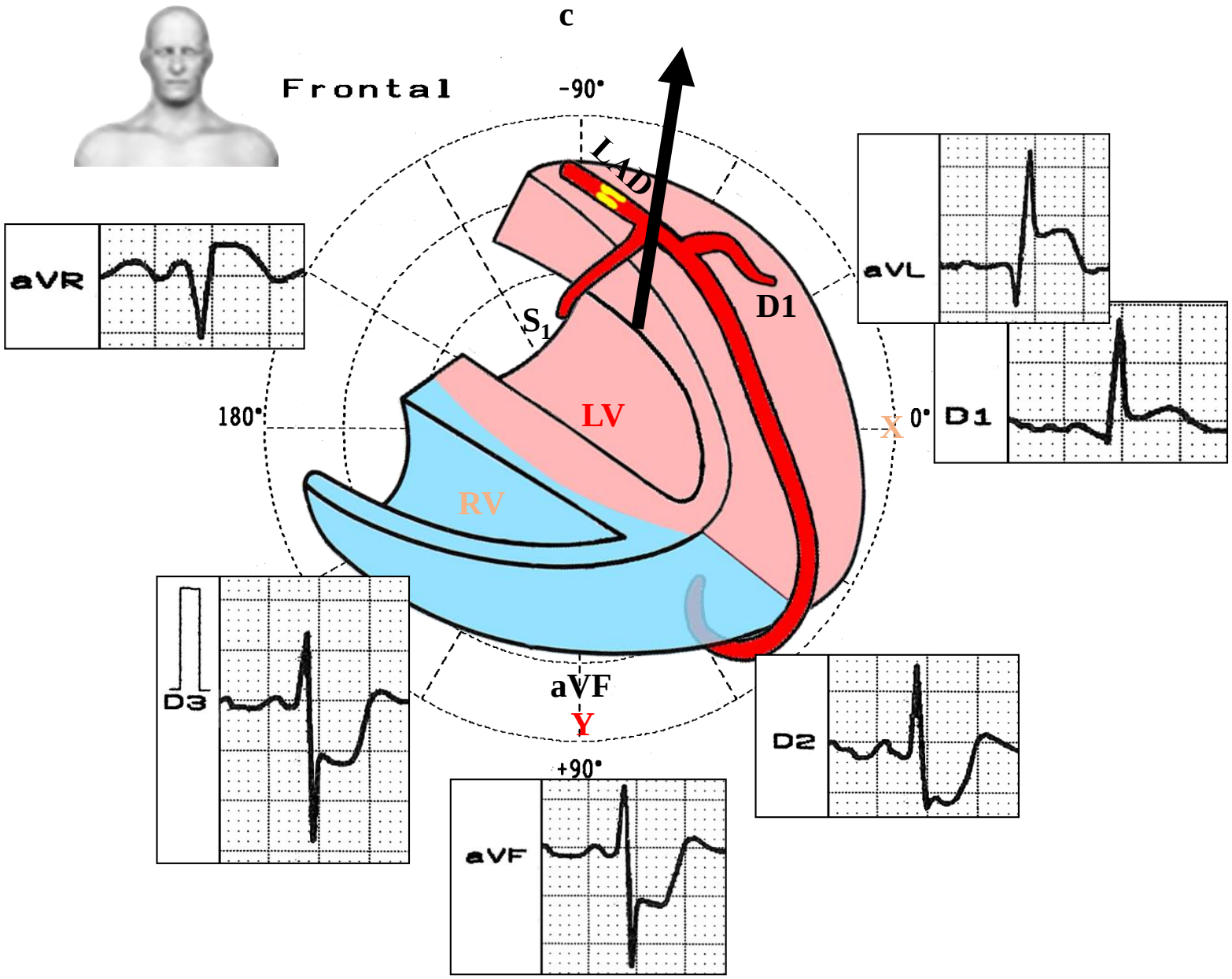
- ✓ **ST Elevation in aVR may also be seen with:**
- ✓ **Proximal LAD occlusion**
- ✓ **Severe triple-vessel disease (3VD)**
- ✓ **Diffuse subendocardial ischemia – e.g. due to O2 supply/demand mismatch, following resuscitation from cardiac arrest**

Proximal left anterior descending coronary artery occlusion before its first septal perforator branch (S_1)

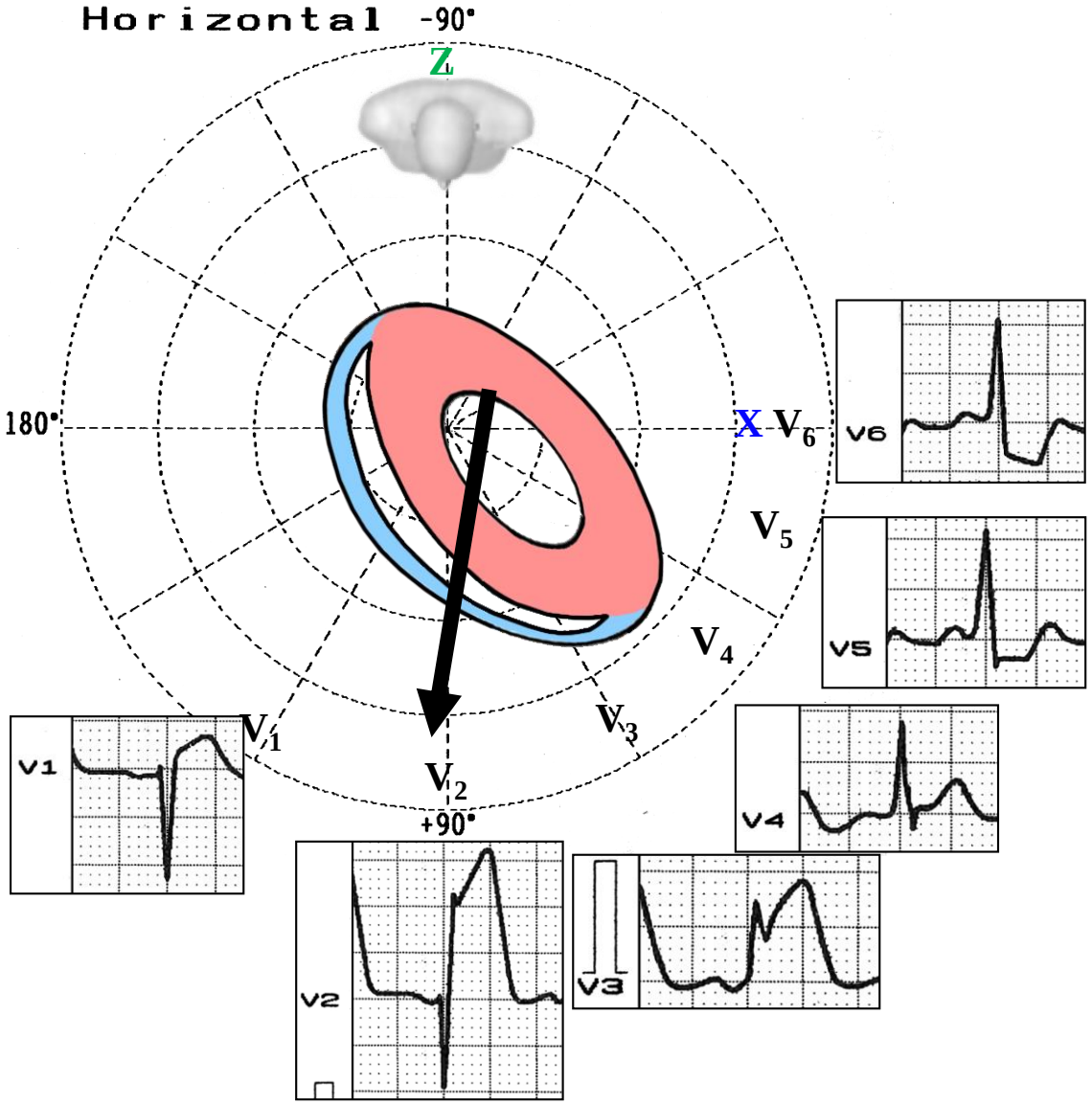


The ST Injury Vector pointing up and slightly to the left



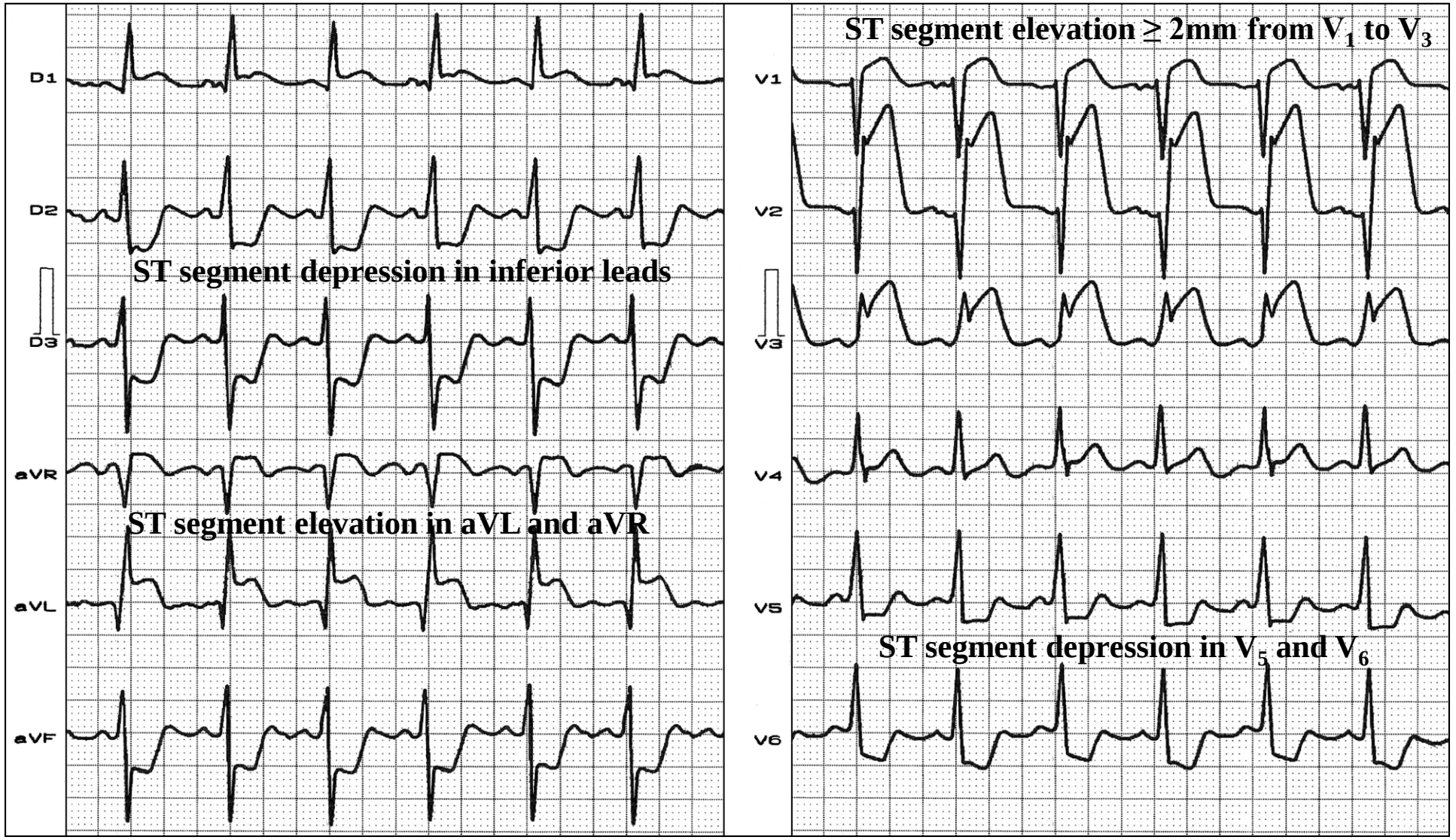


ST segment elevation in aVL and aVR and ST segment depression in inferior leads.

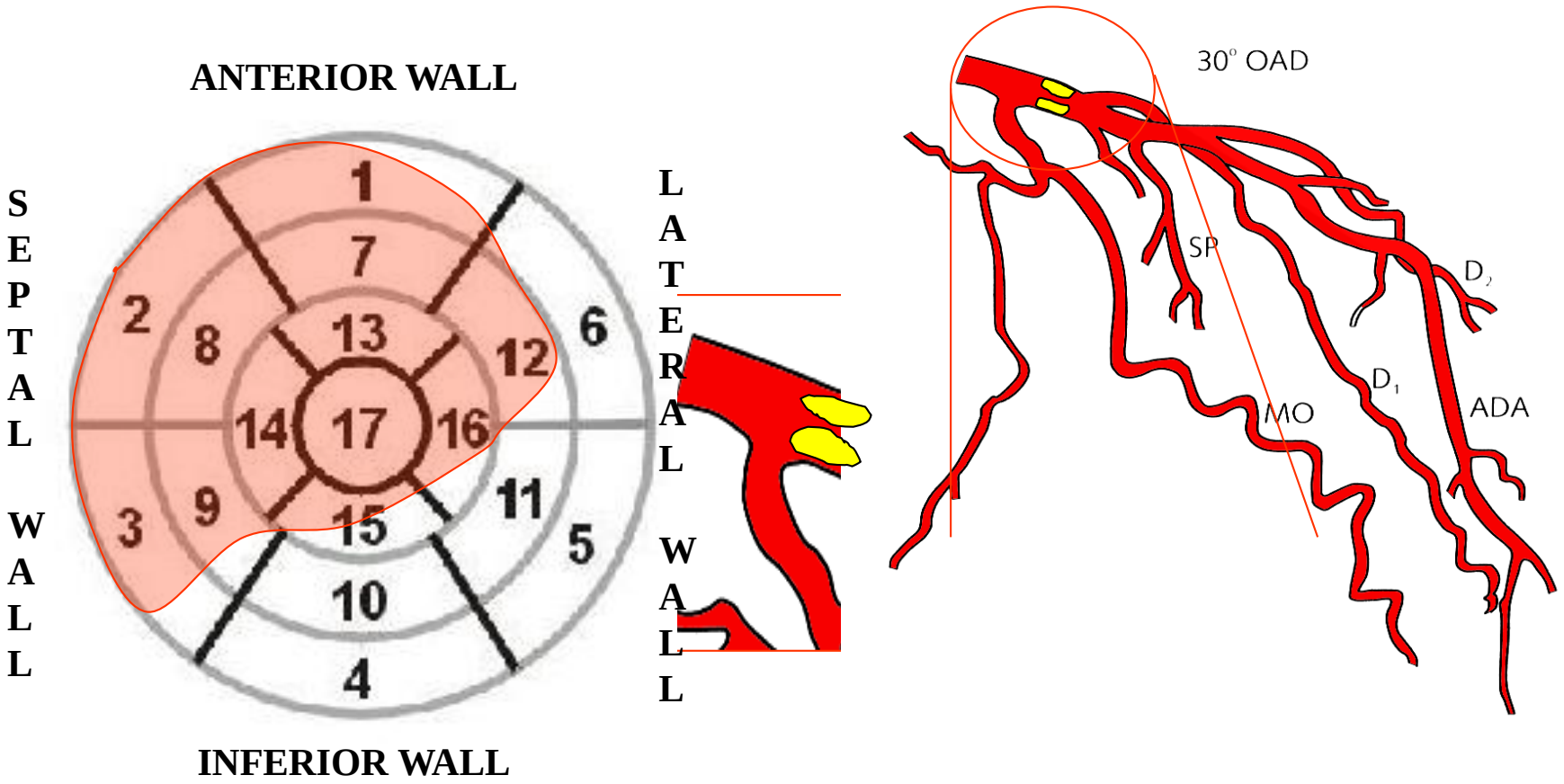


ST segment elevation ≥2 mm from V_1 to V_3 (injury vector directed to front). ST segment depression in V_5 and V_6 or isoelectric. Eventually complicated with CRBBB and/or LAFB and/or LSFB.

AMI consequence of LAD occlusion before the first septal perforator branch (S_1) and the first diagonal branch (D1)

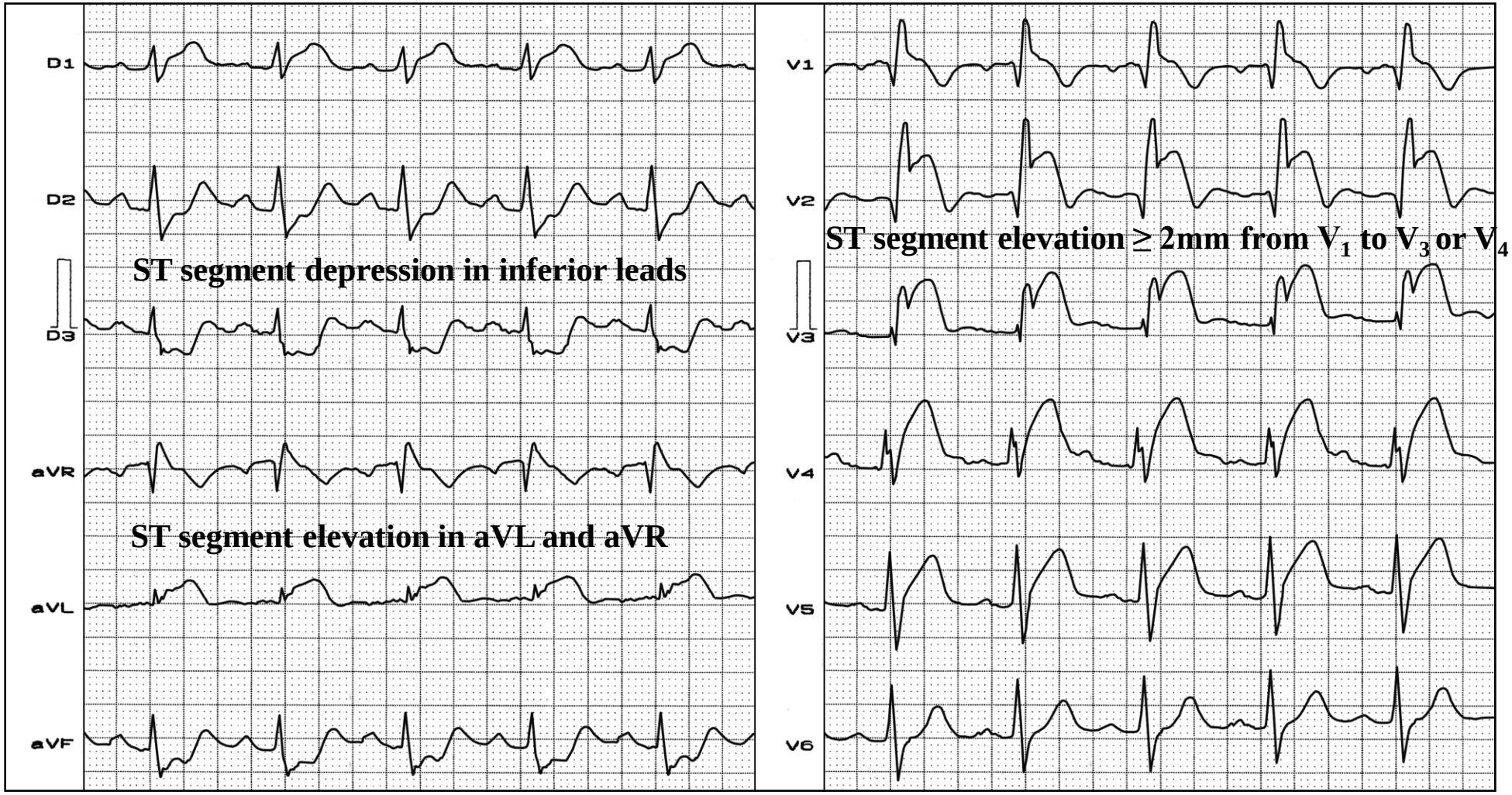


Extensive Anterior Myocardial Infarction (A-3)

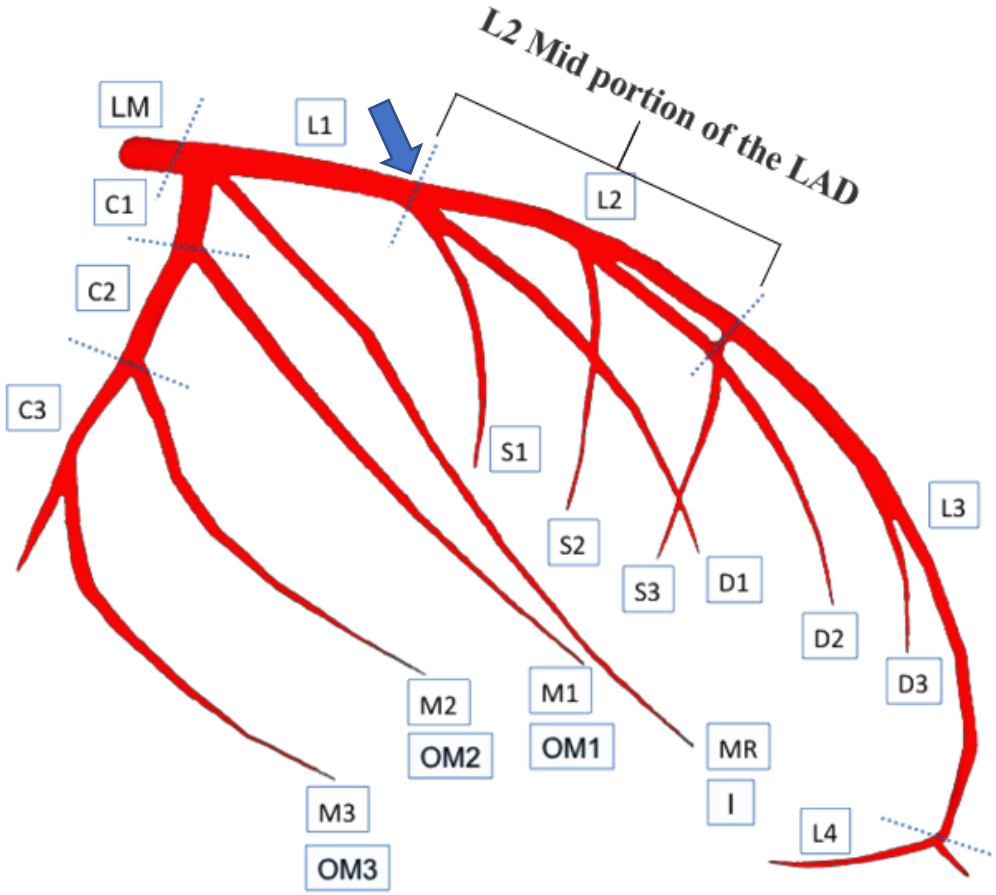


ECG pattern:
Q from V1 through V6, VL, possibly I and VL

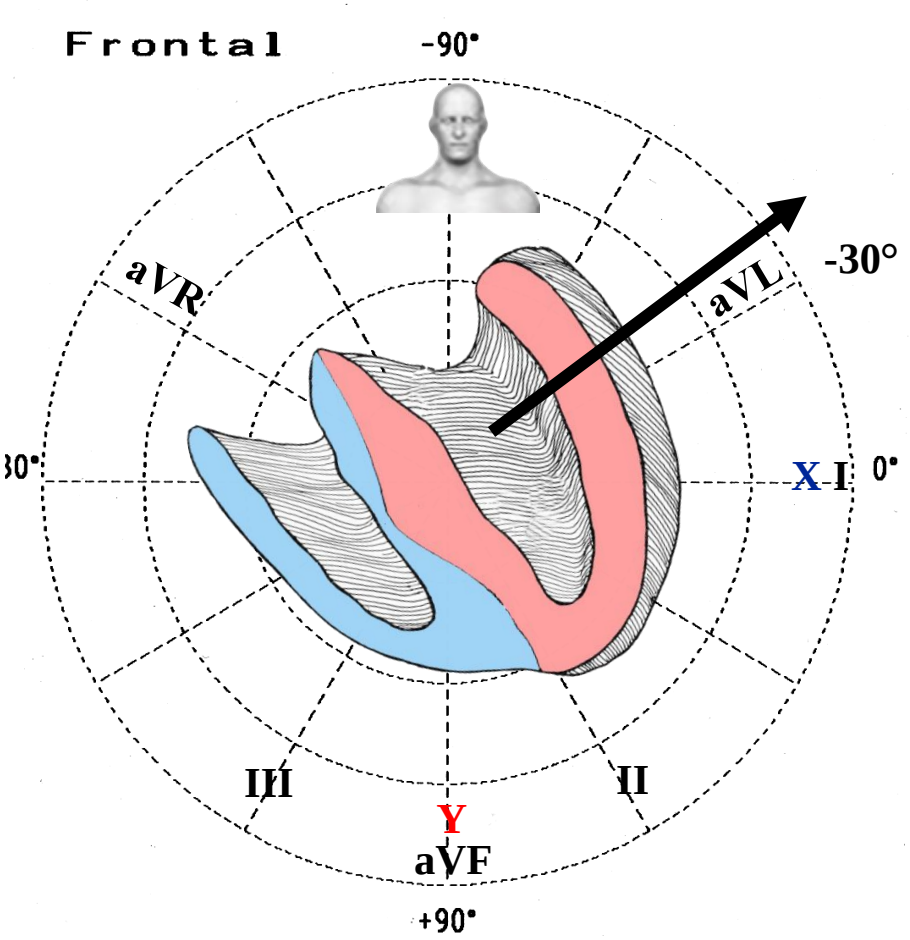
AMI consequence of proximal LAD occlusion before S_1 complicated with RBBB

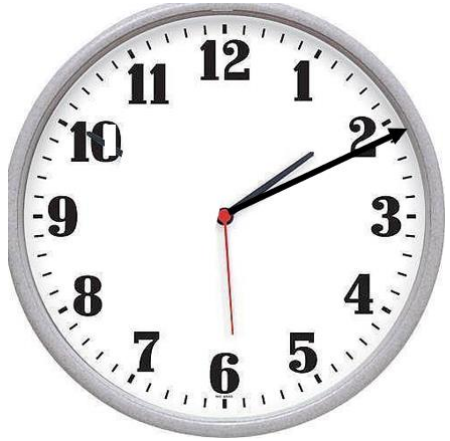


Left Anterior Descending Artery (LAD) occlusion after first septal perforator (S_1) and first diagonal branch (D1)

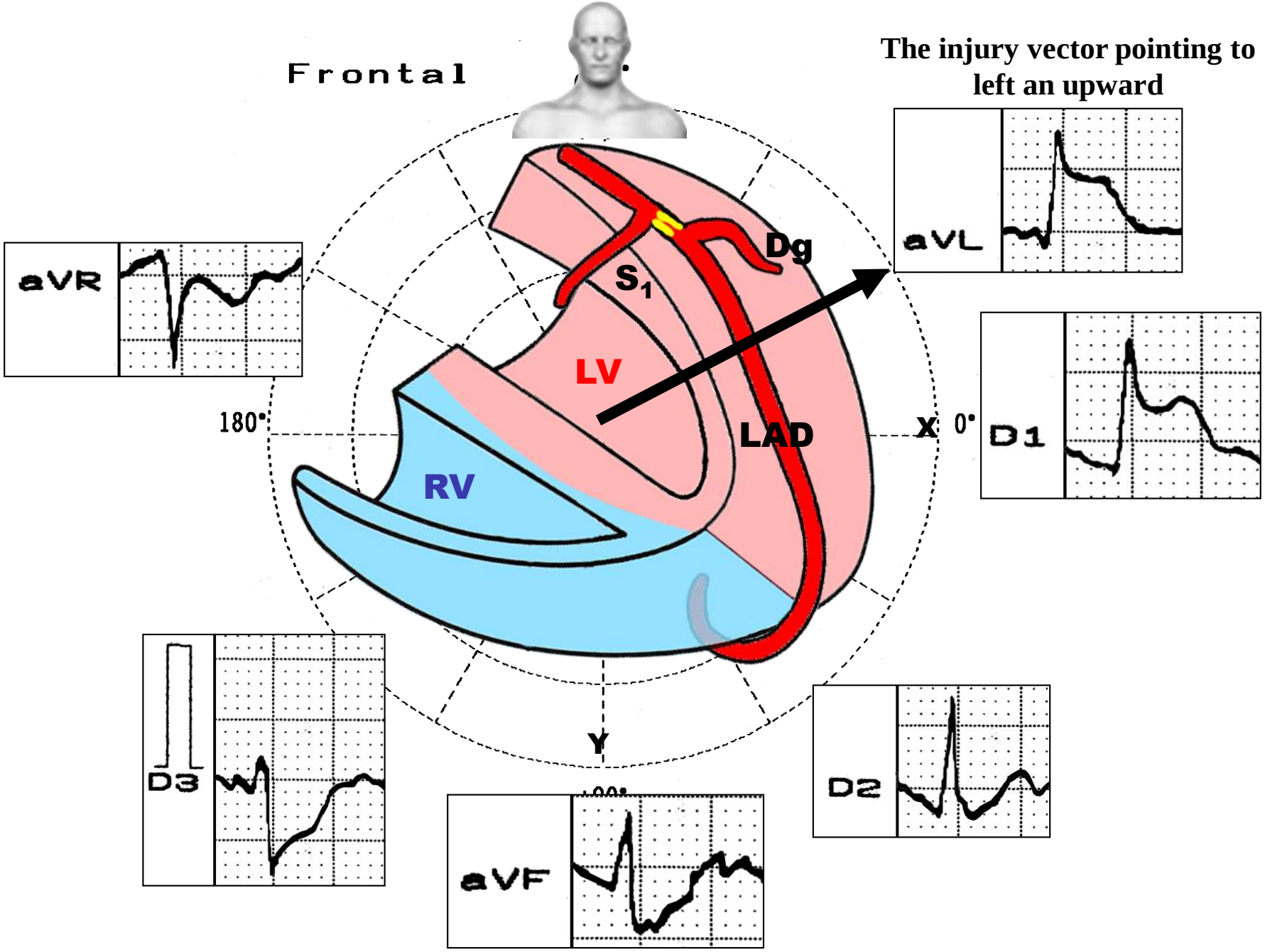


The ST Injury Vector pointing up and to the left near aVL -30°

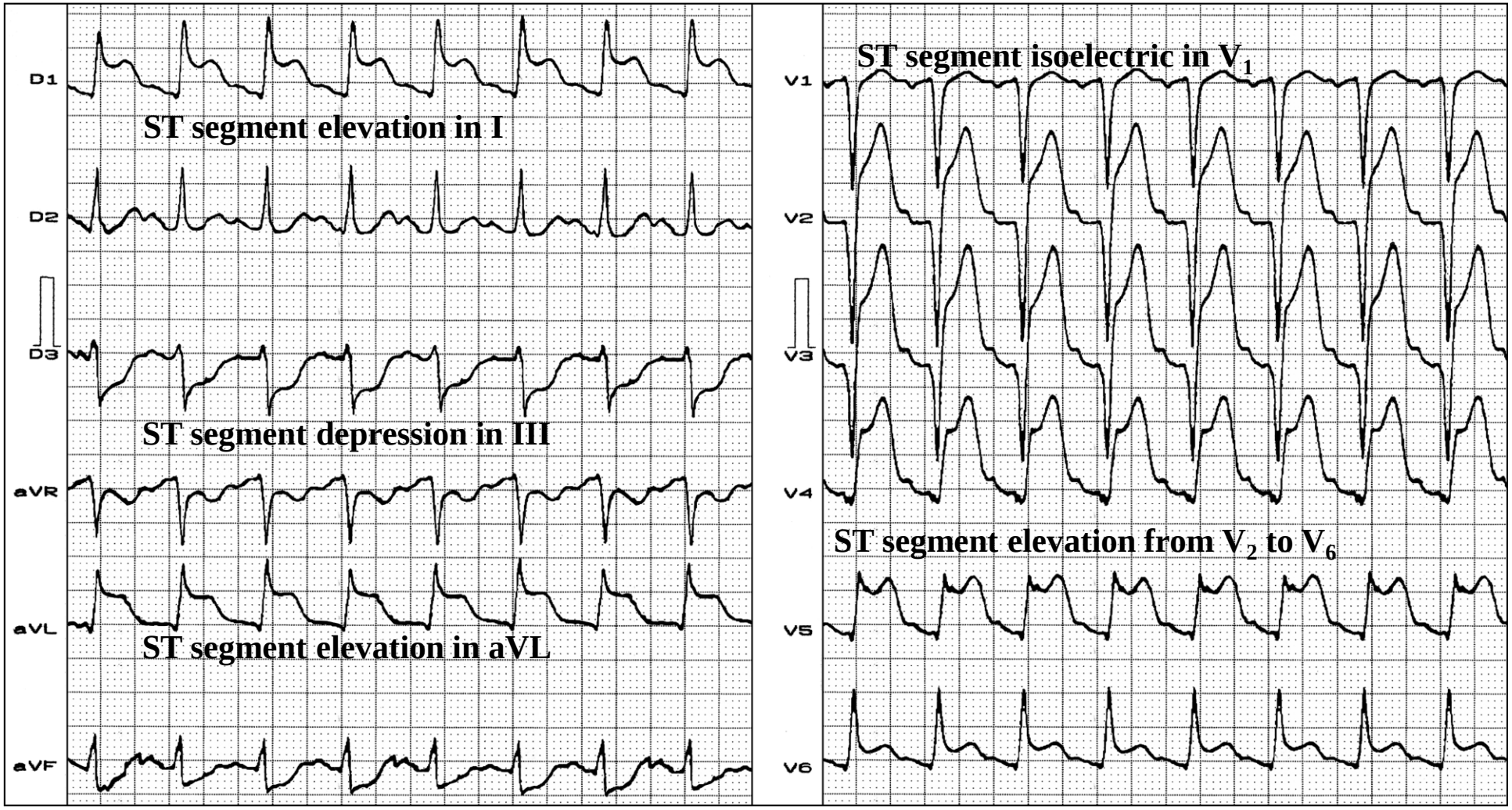




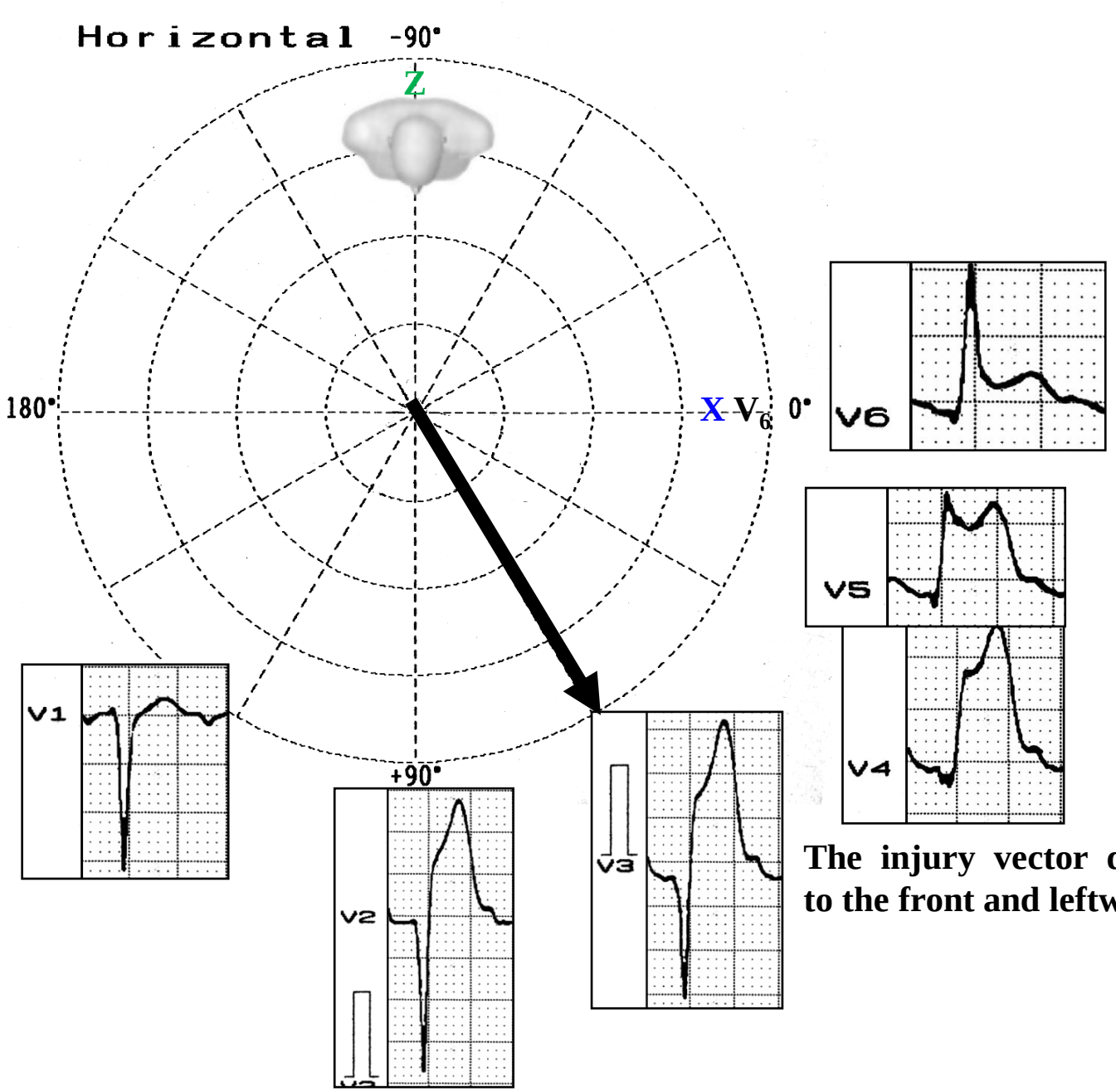
Left Anterior Descending Artery (LAD) occlusion after both first septal perforator branch (S1) and first diagonal branch(D1): mid portion of the LAD **obstruction** The first diagonal branch serves as the boundary between the proximal and mid portion of the LAD



ST segment elevation in I and aVL. ST segment depression in III

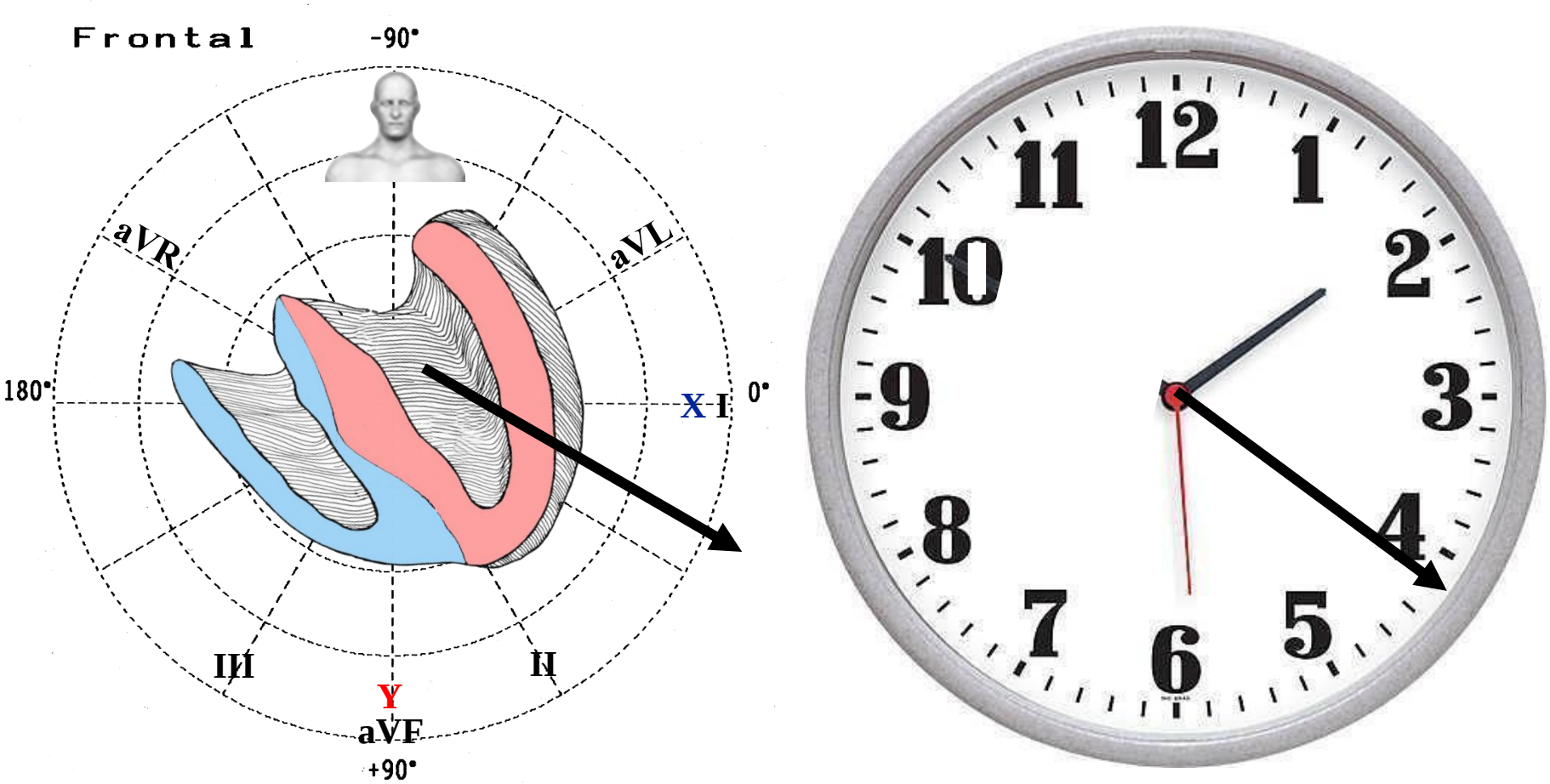


AMI caused by occlusion of LAD after the first septal perforator and before the first diagonal branch

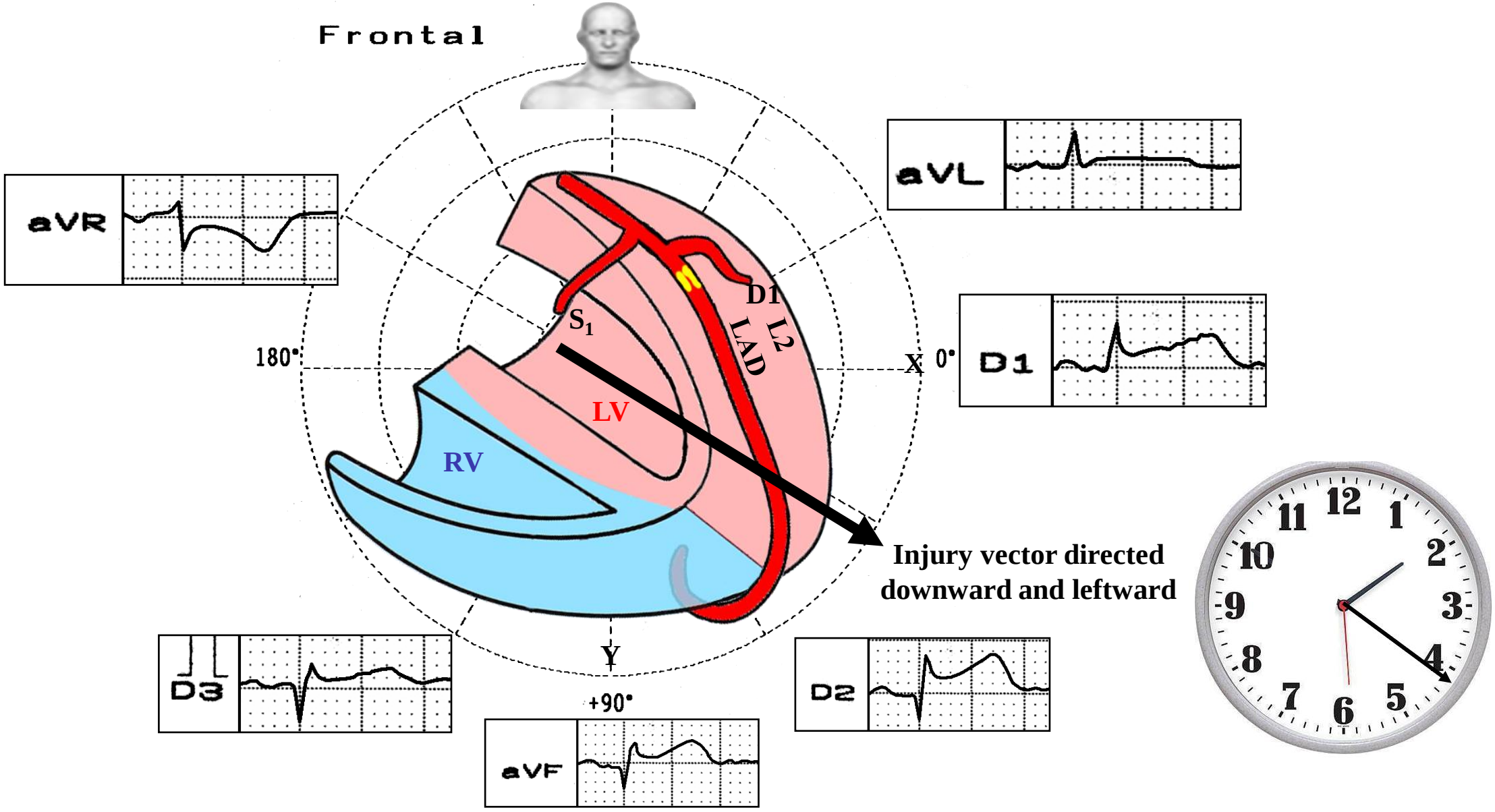


The injury vector directed to the front and leftward

ST segment elevation from V_2 to V_6 and isoelectric in V_1

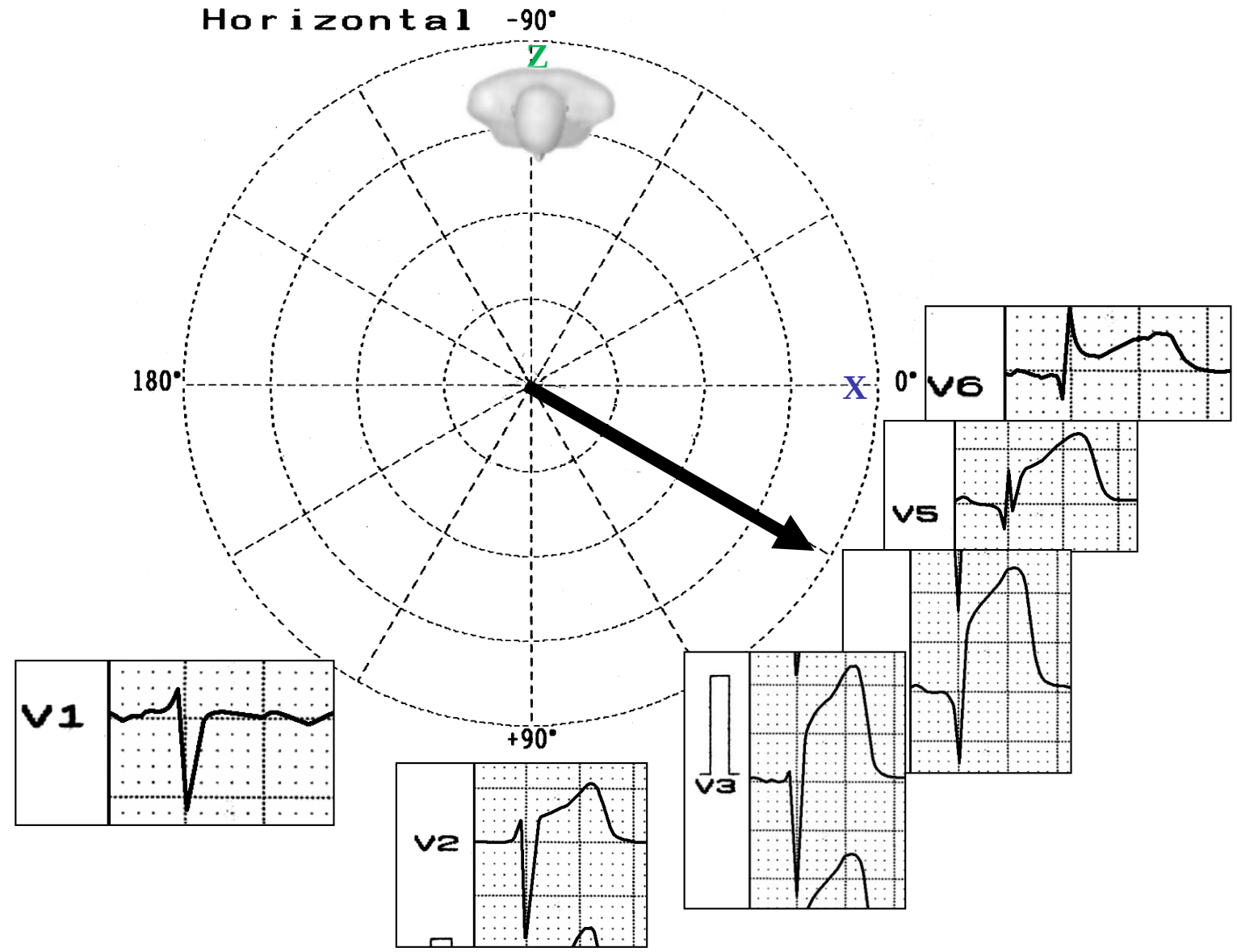


Left Anterior Descending Artery (LAD) occlusion after both first septal perforator branch (S1) and first diagonal branch (D1): mid portion of the LAD obstruction The first diagonal branch serves as the boundary between the proximal and mid portion of the LAD

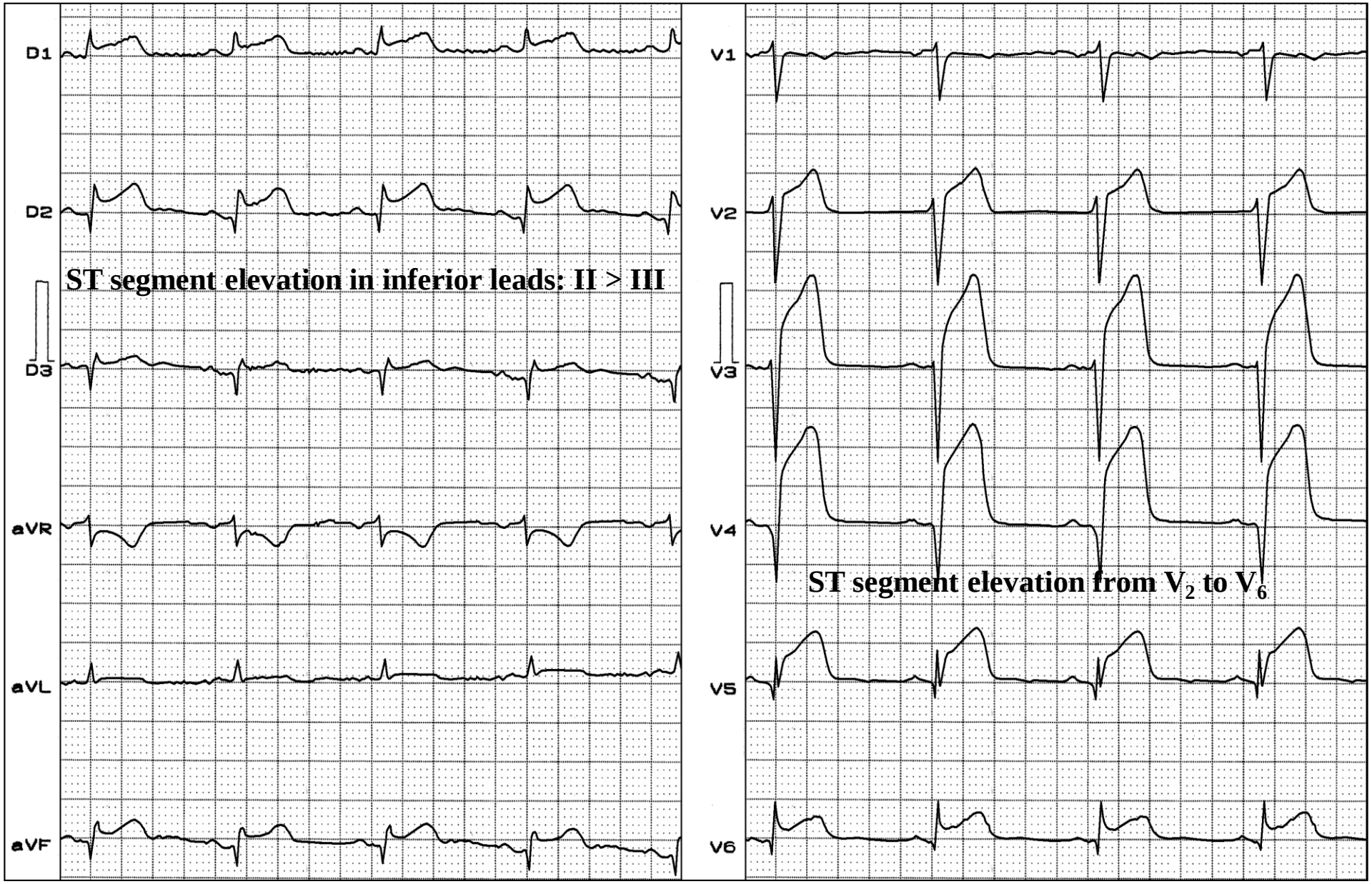


ST segment elevation in inferior leads, II > III and ST segment depression in aVR

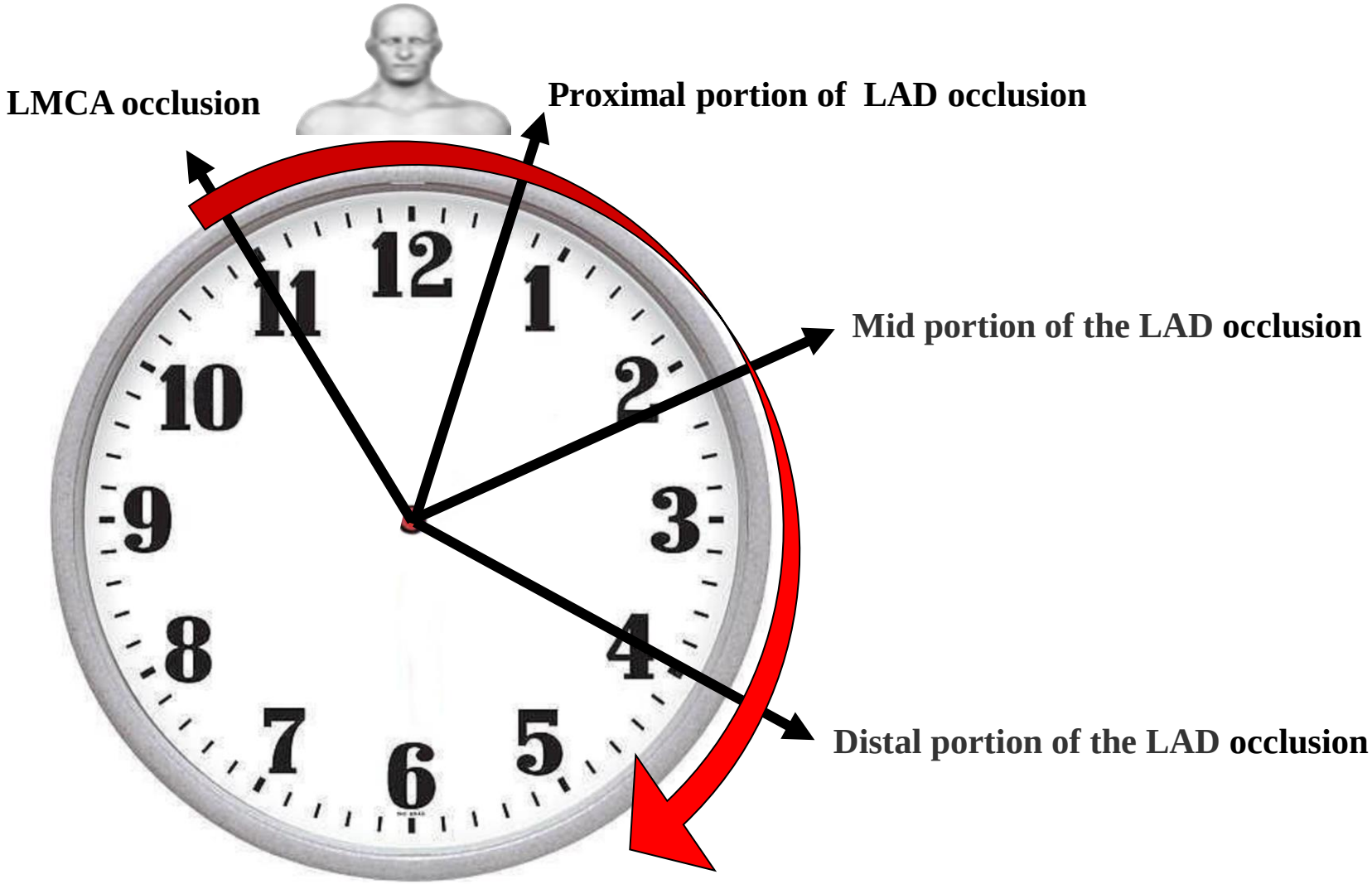
Left Anterior Descending Artery (LAD) occlusion after both first septal perforator branch (S1) and first diagonal branch (D1): mid portion of the LAD obstruction HP



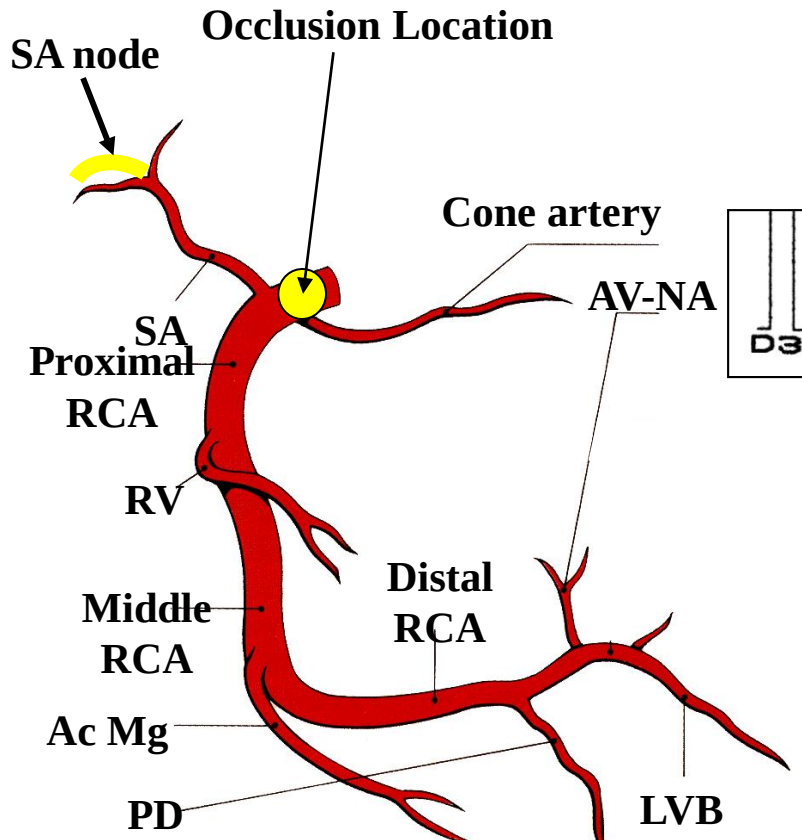
The ST injury vector directed to front and leftward: ST segment elevation form V_2 to V_6

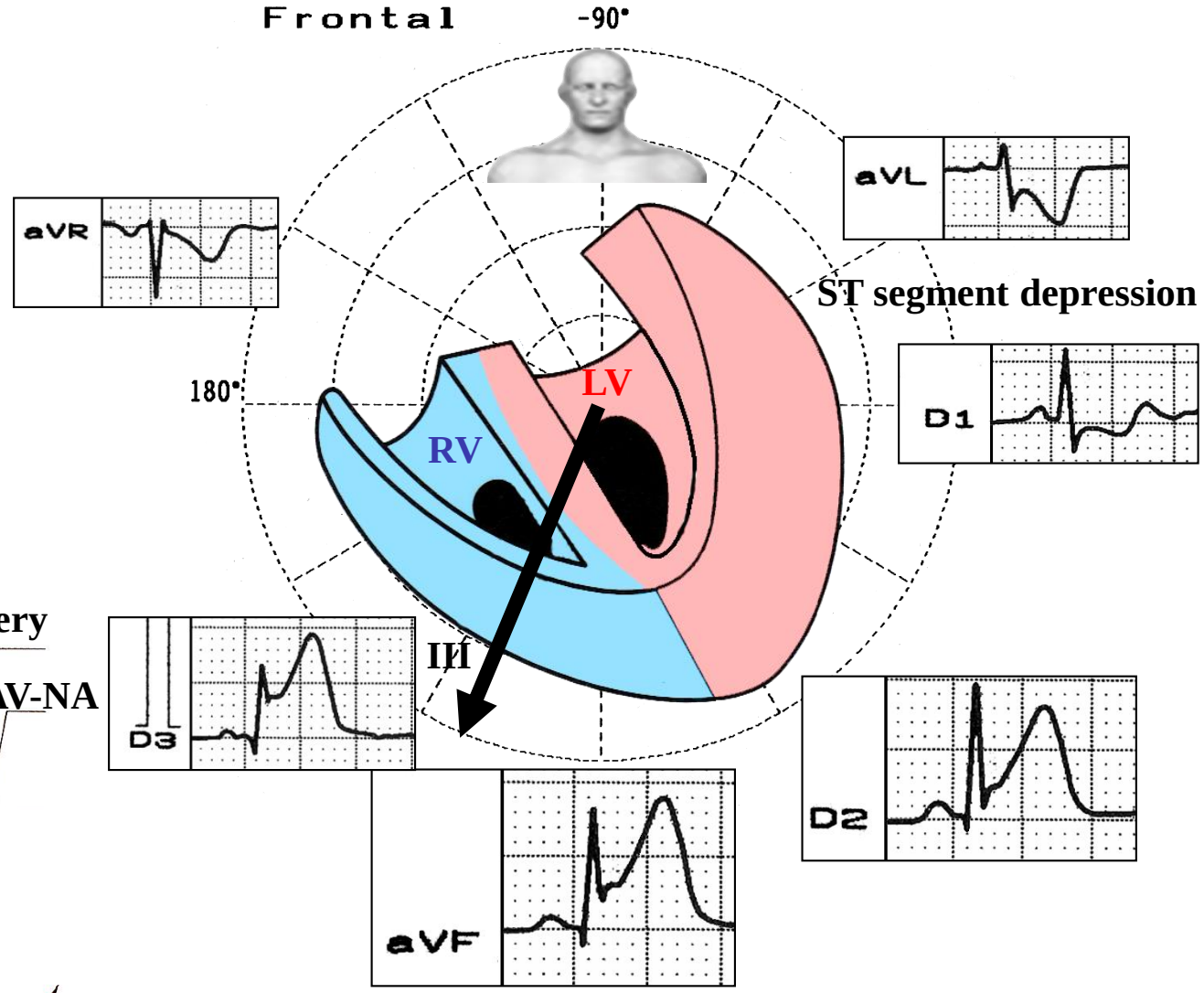

D1
D2
D3
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
ST segment elevation in inferior leads: II > III
ST segment elevation from V2 to V6

Summary of LMCA and LAD occlusion ST injury vector deviation in the Frontal Plane



Proximal occlusion of Right Coronary Artery (RCA)

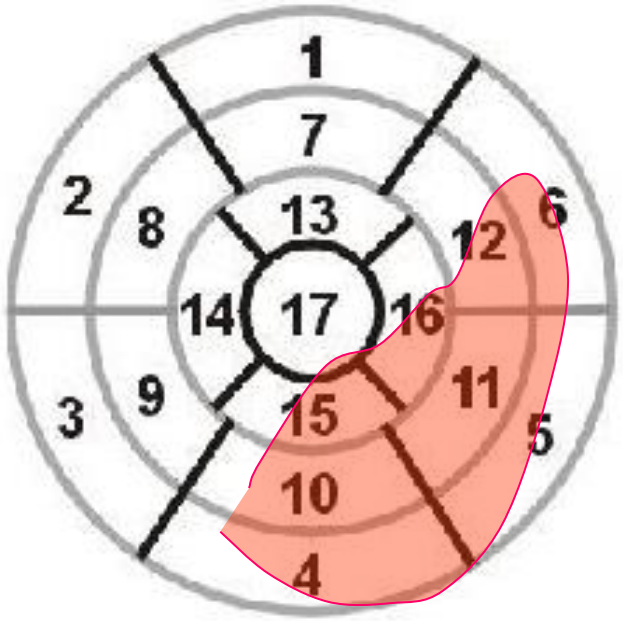


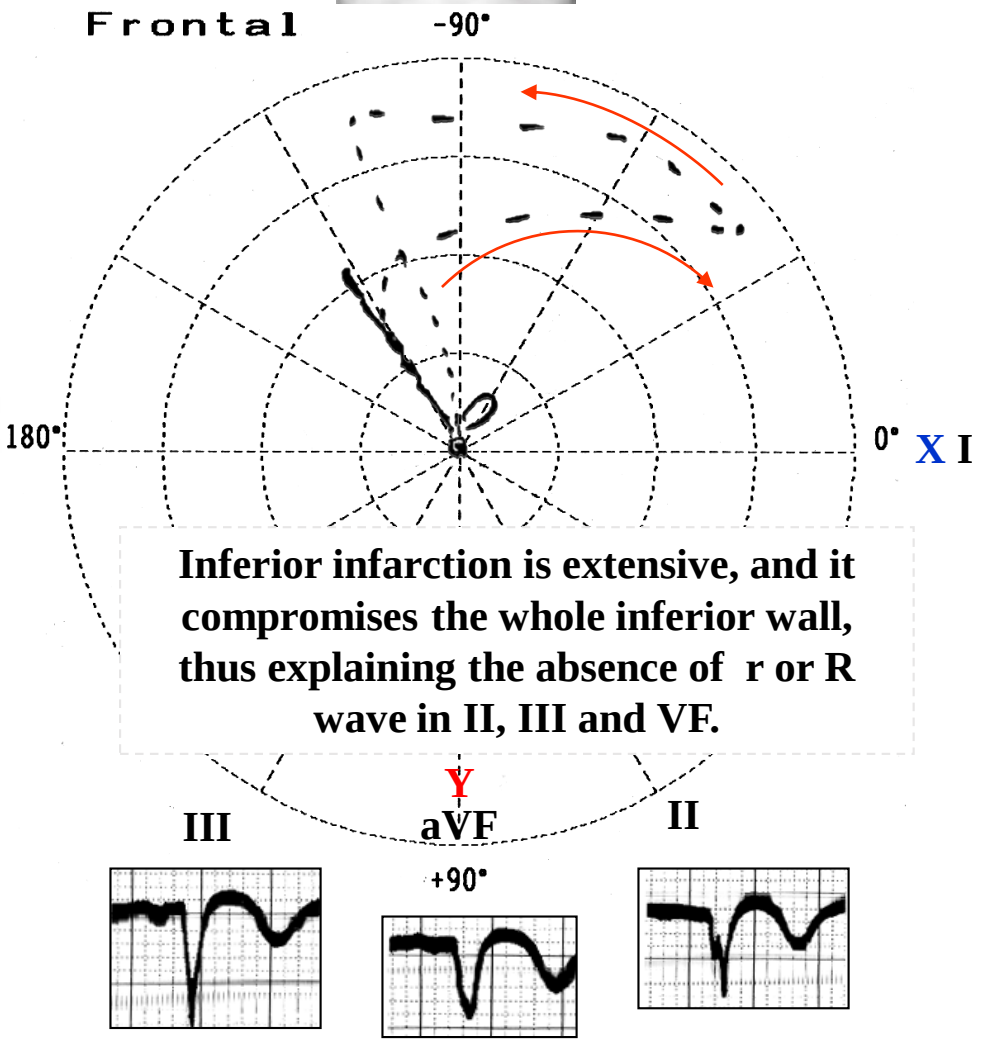


ST segment depression

ST segment elevation in inferior leads SIII>SII

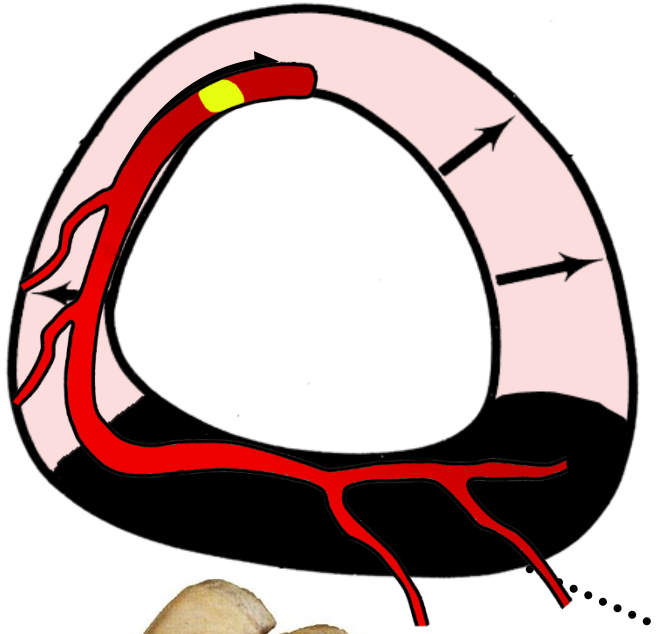
Inferolateral Myocardial Infarction



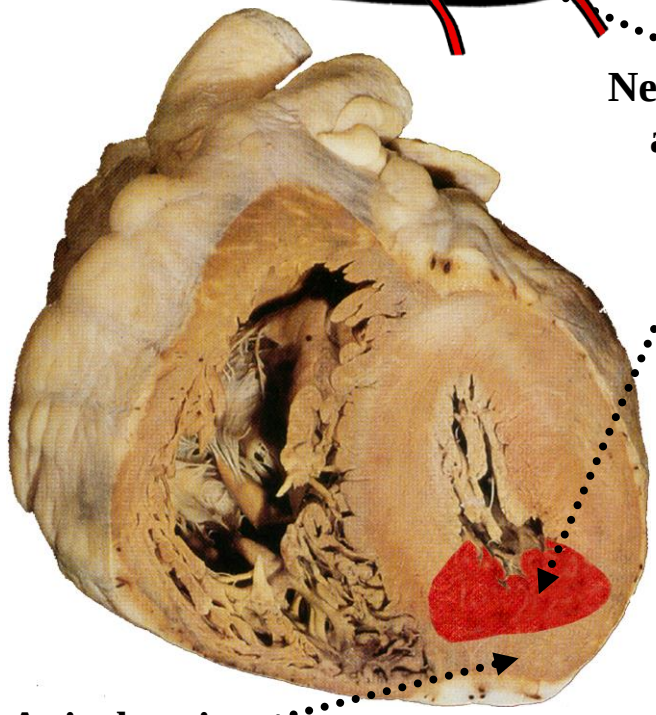


Inferior infarction is extensive, and it compromises the whole inferior wall, thus explaining the absence of r or R wave in II, III and VF.

QS in the three inferior leads



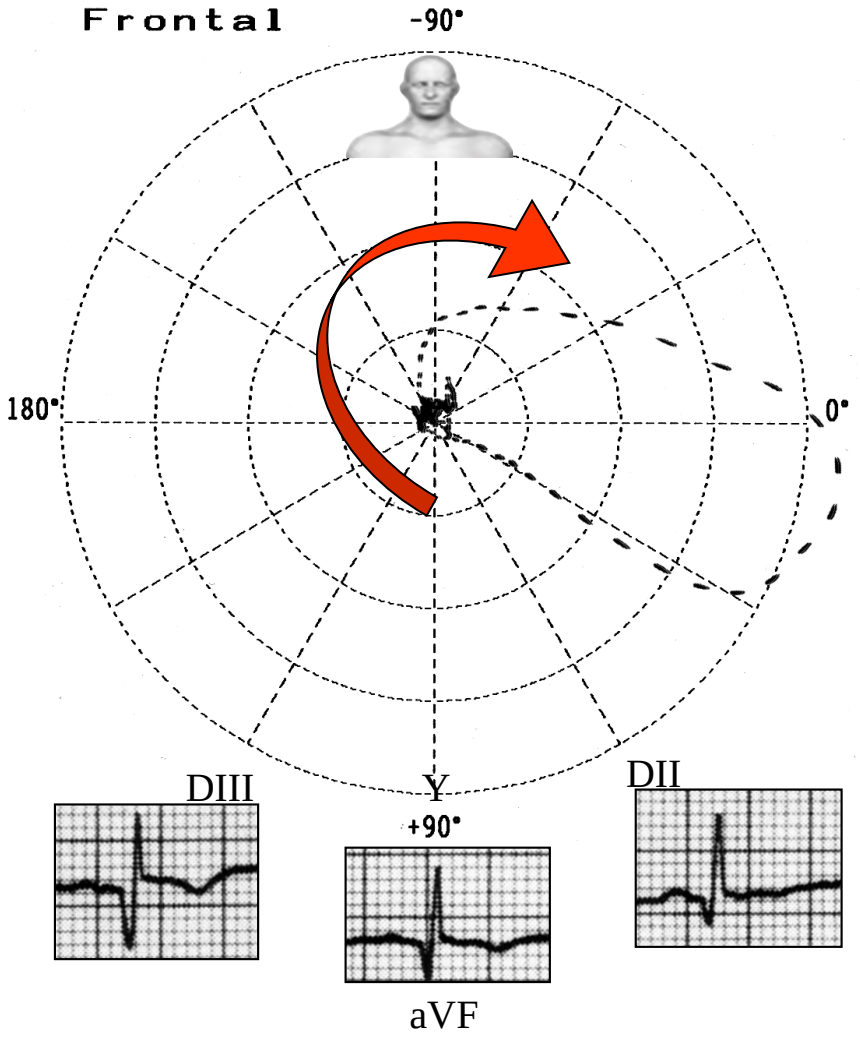
Necrosis area



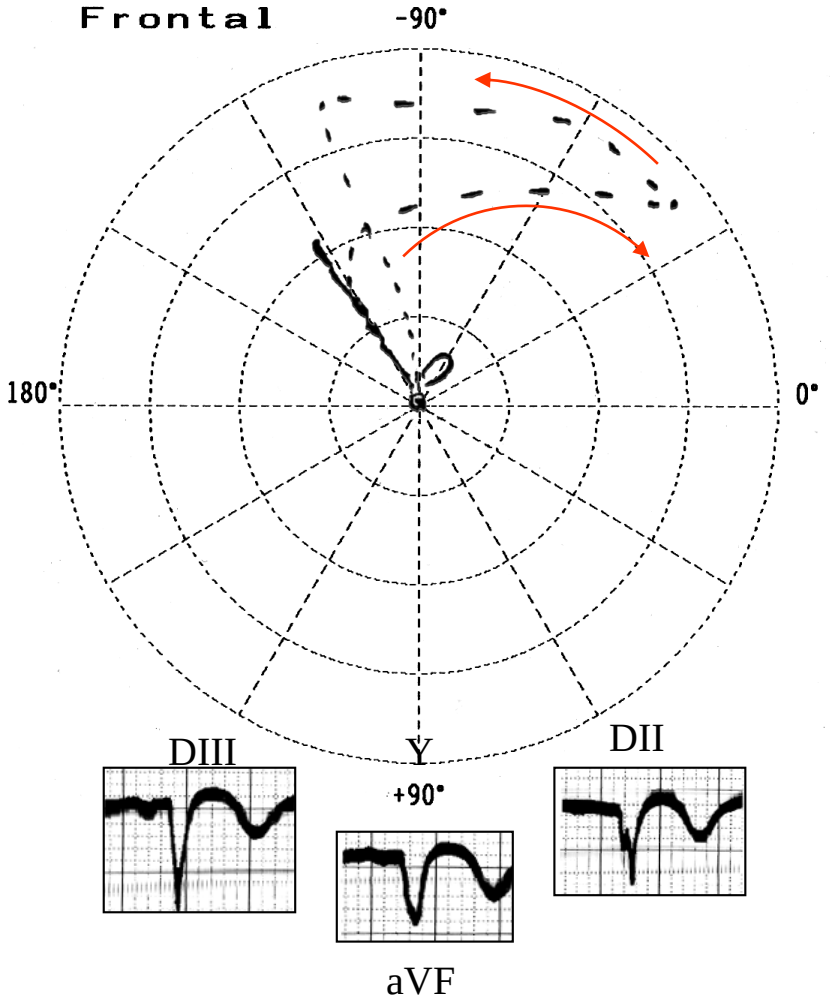
Apical region

Diaphragmatic Infarction

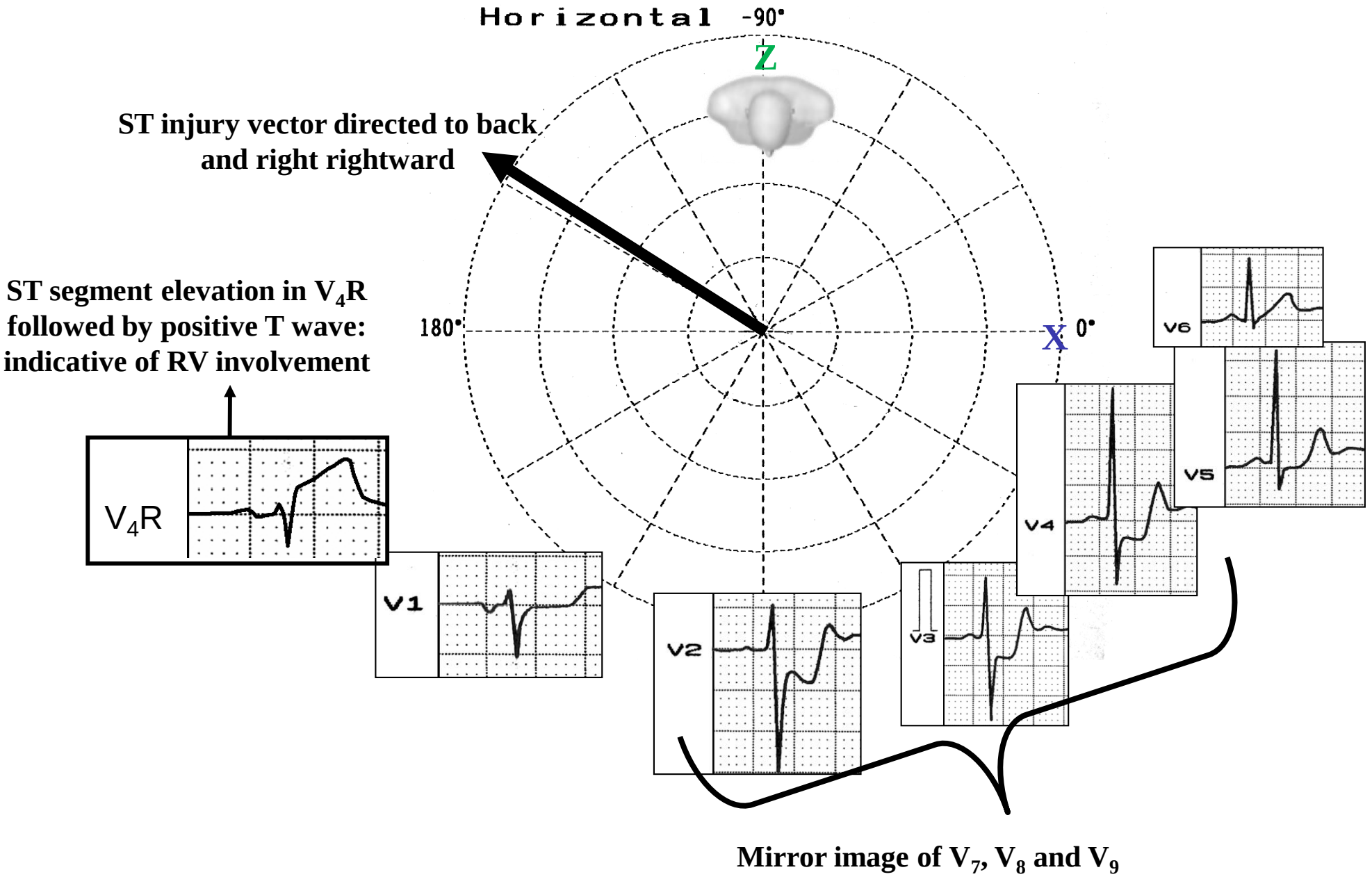
Non-extensive



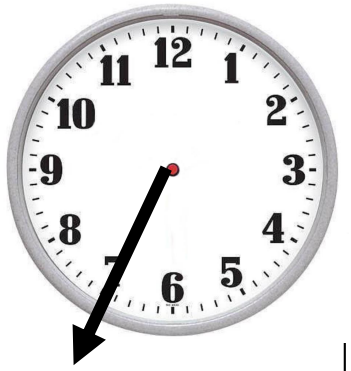
Extensive

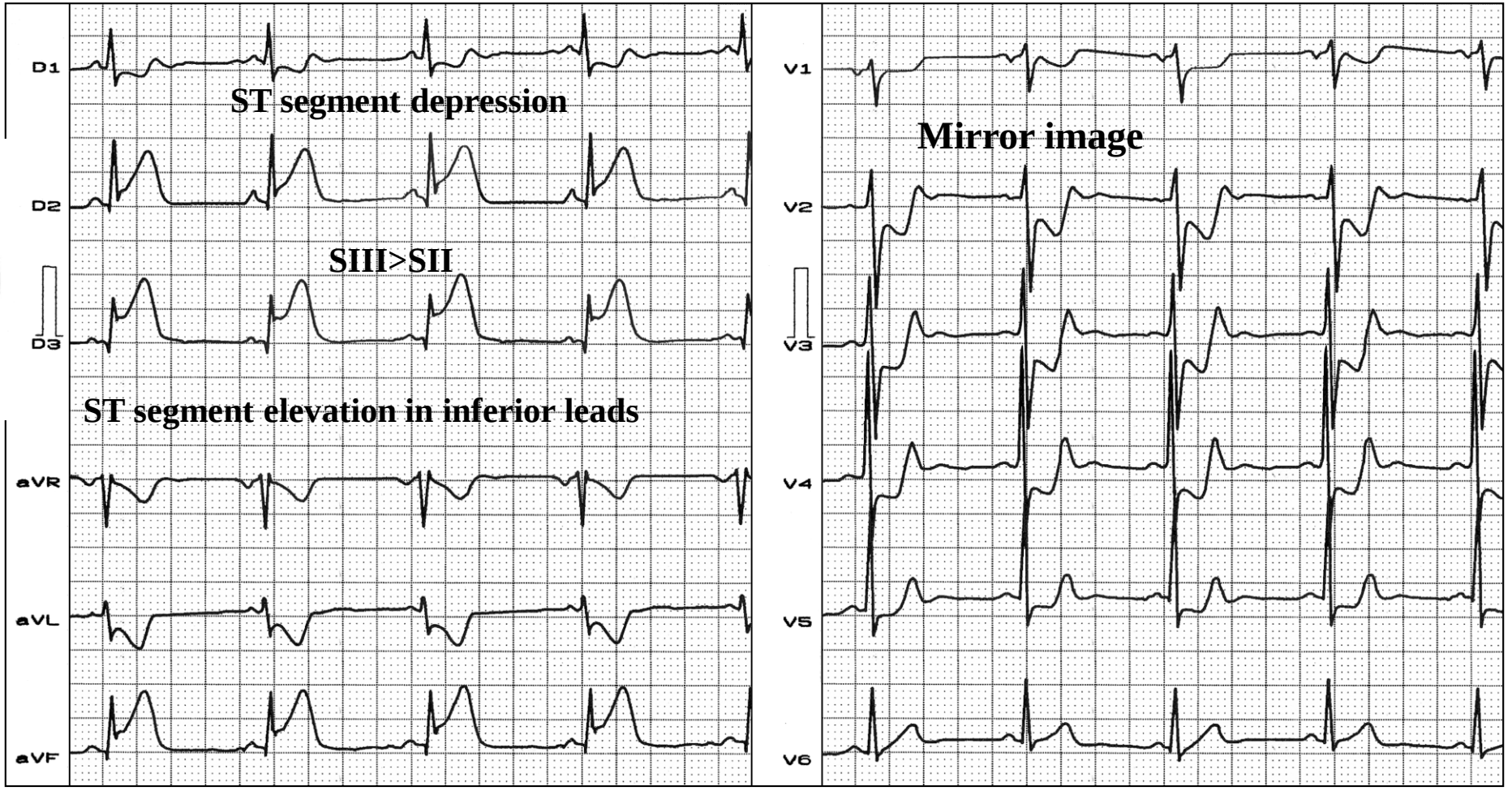


ECG/VCG correlation in the frontal plane of non-extensive and extensive inferior infarction.

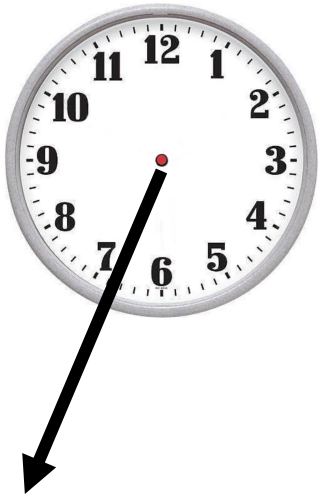

Horizontal -90°
Z
X
180°
0°
ST injury vector directed to back and right rightward
ST segment elevation in V4R followed by positive T wave: indicative of RV involvement
V4R
V1
V2
V3
V4
V5
V6
Mirror image of V7, V8 and V9

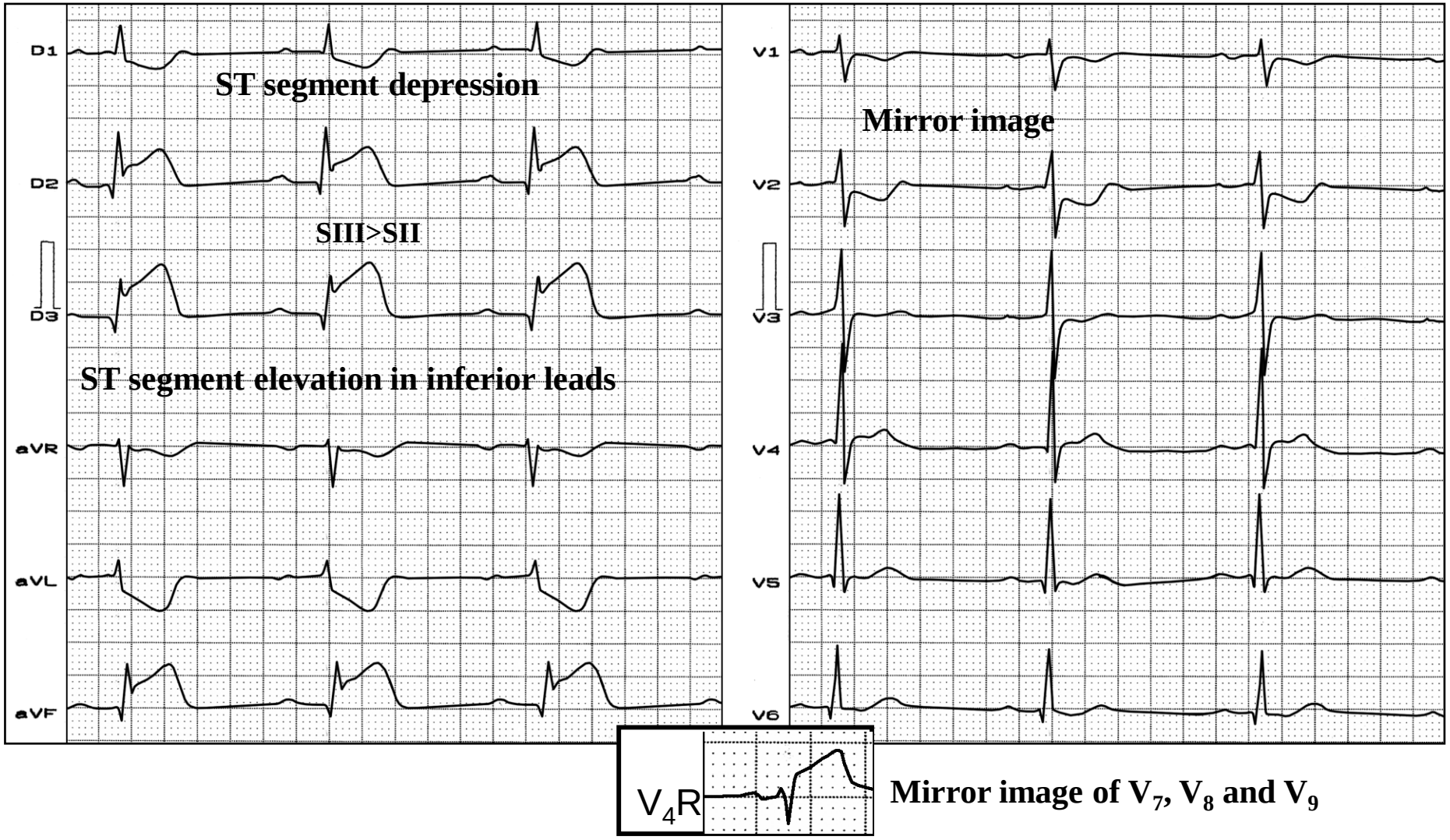
Proximal RCA occlusion



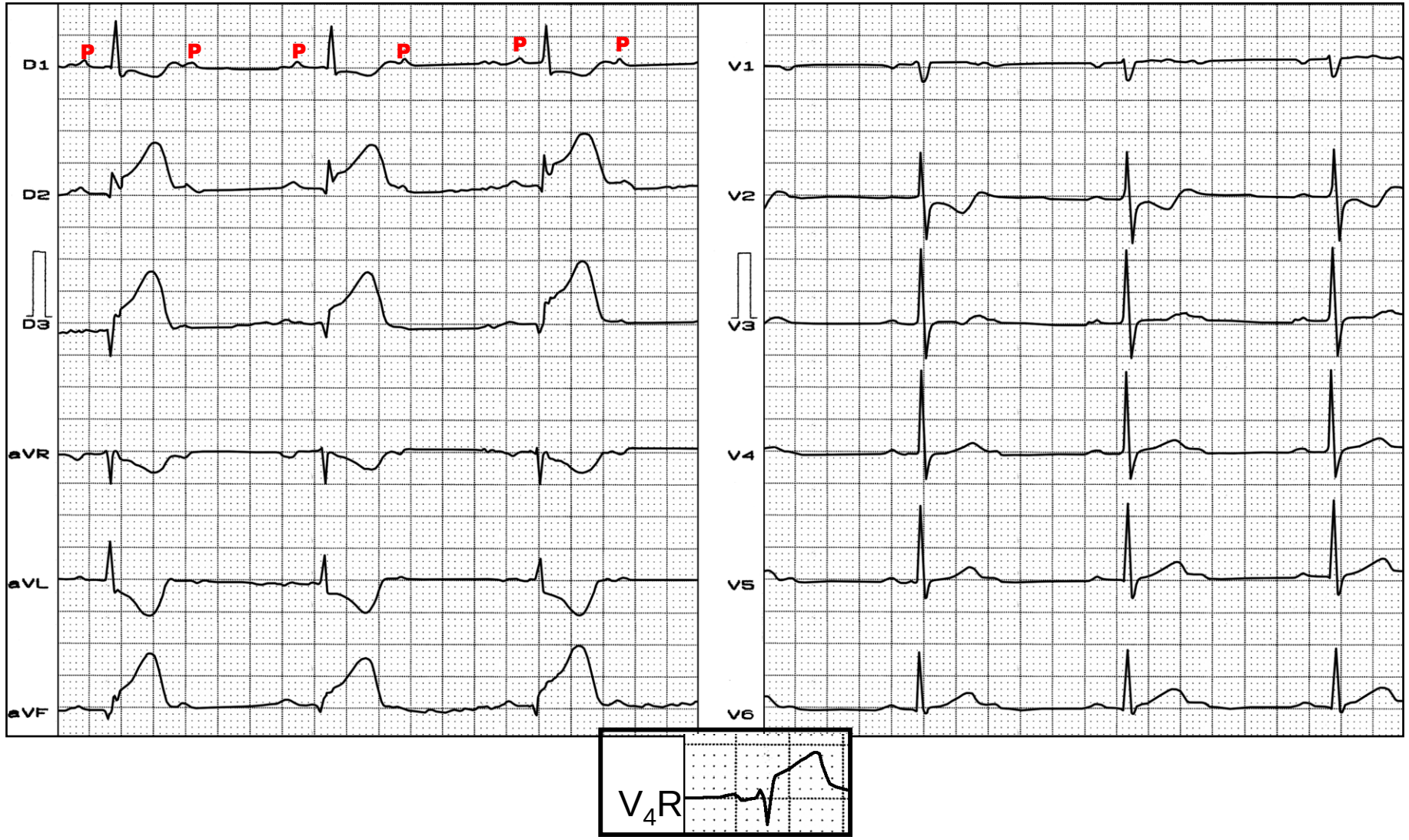


Mirror image of V_7, V_8 and V_9

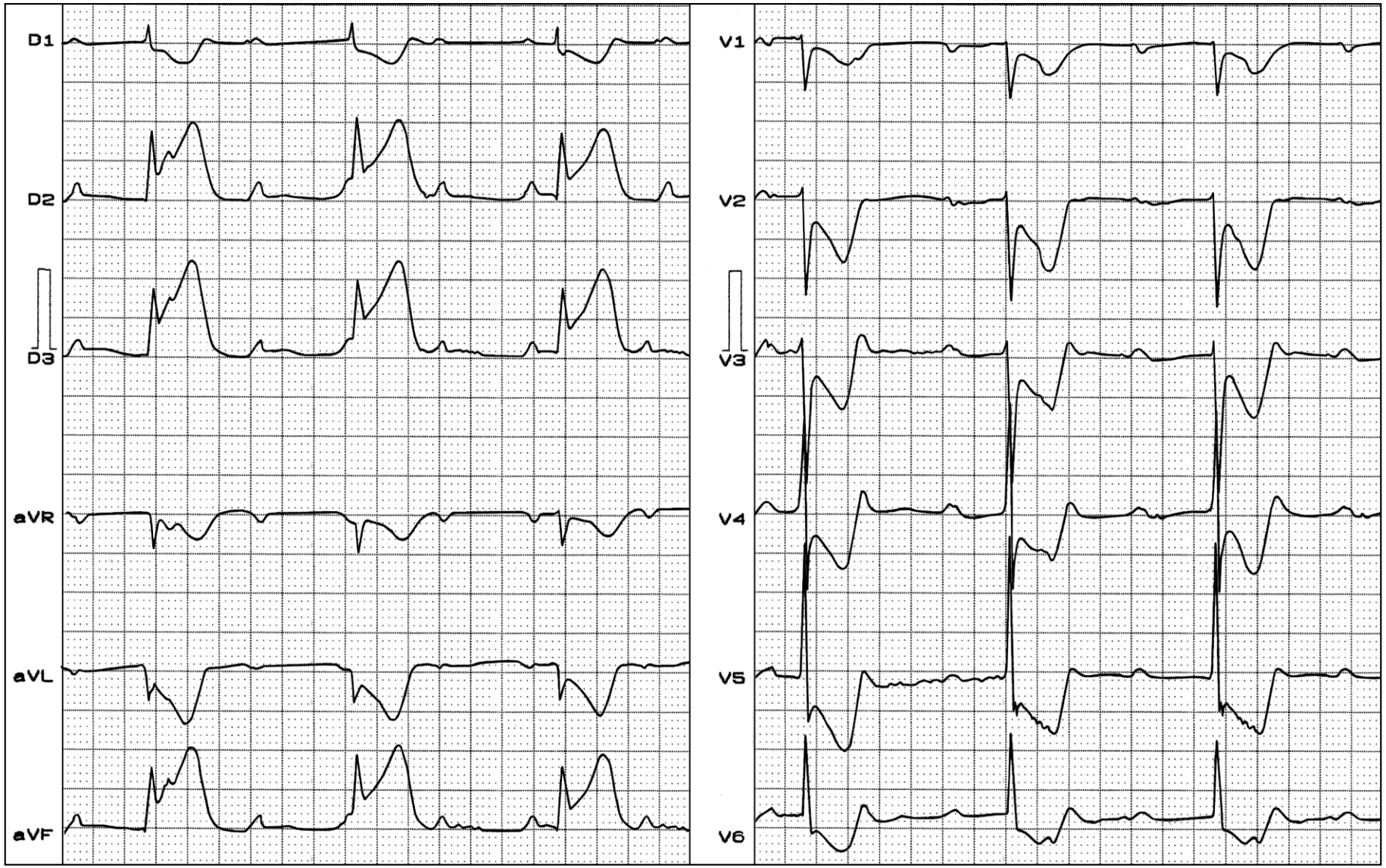




AMI consequence of proximal RCA occlusion complicated with sinus bradicardia, first-degree AV block and RV envolvement: ST segment elevation followed by positive T wave in V_4R.

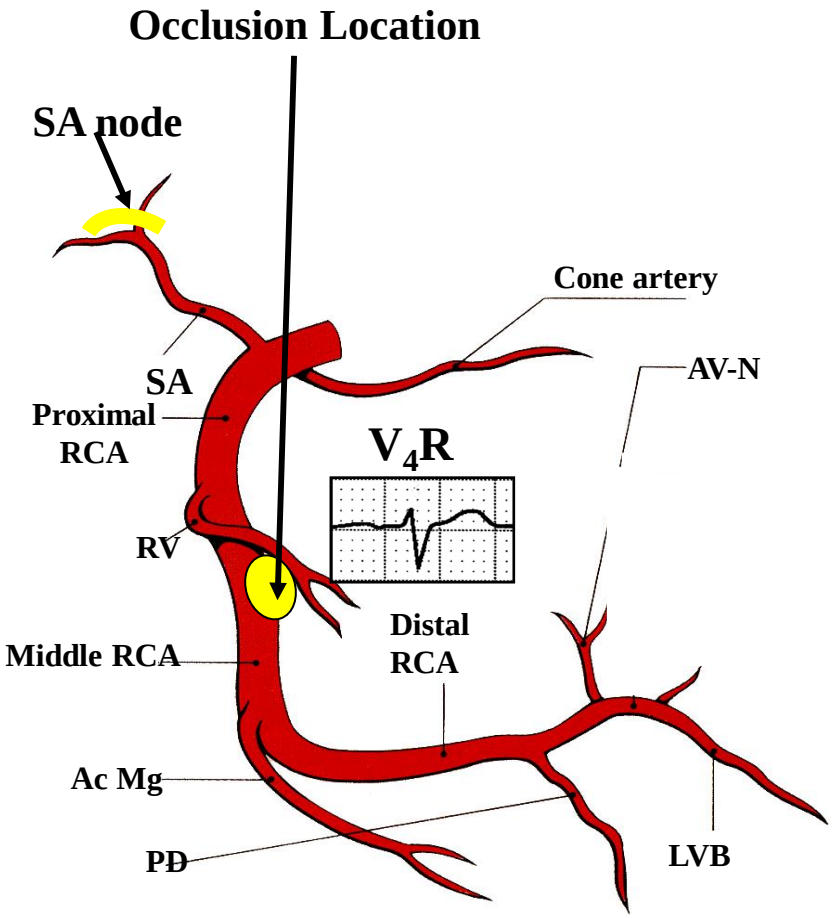


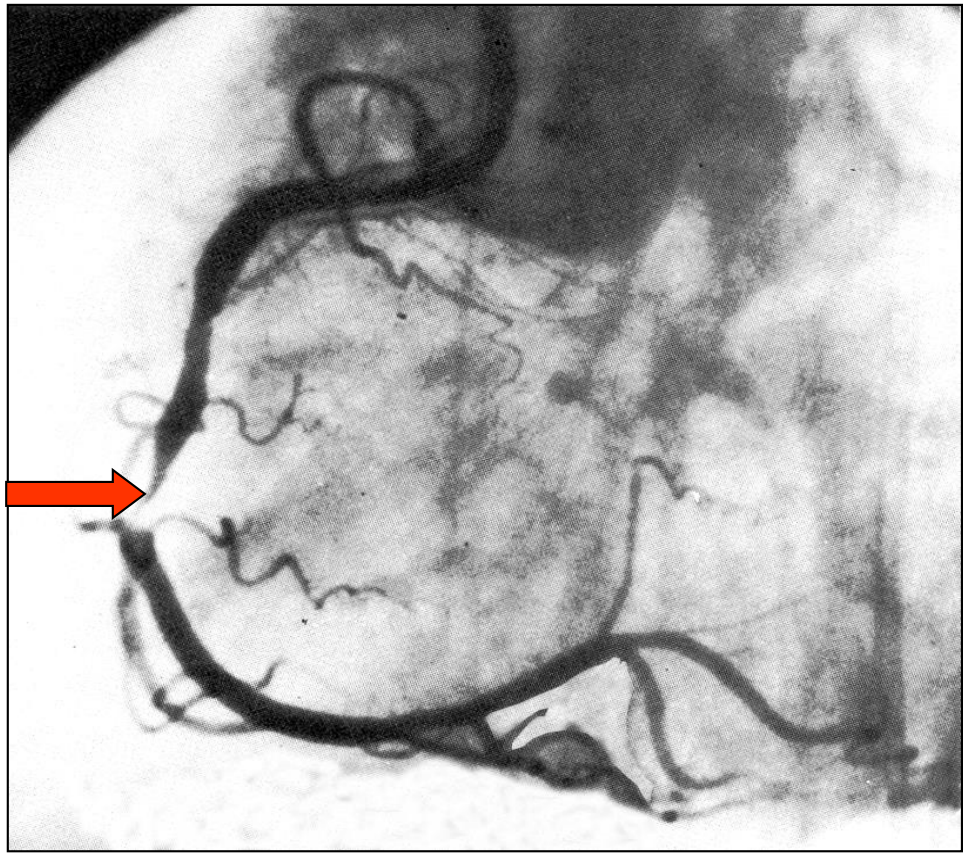
AMI consequence of proximal occlusion RCA complicated with 2:1 AV block and right ventricular envolvement: ST segment elevation in V4R followed by positive T wave.



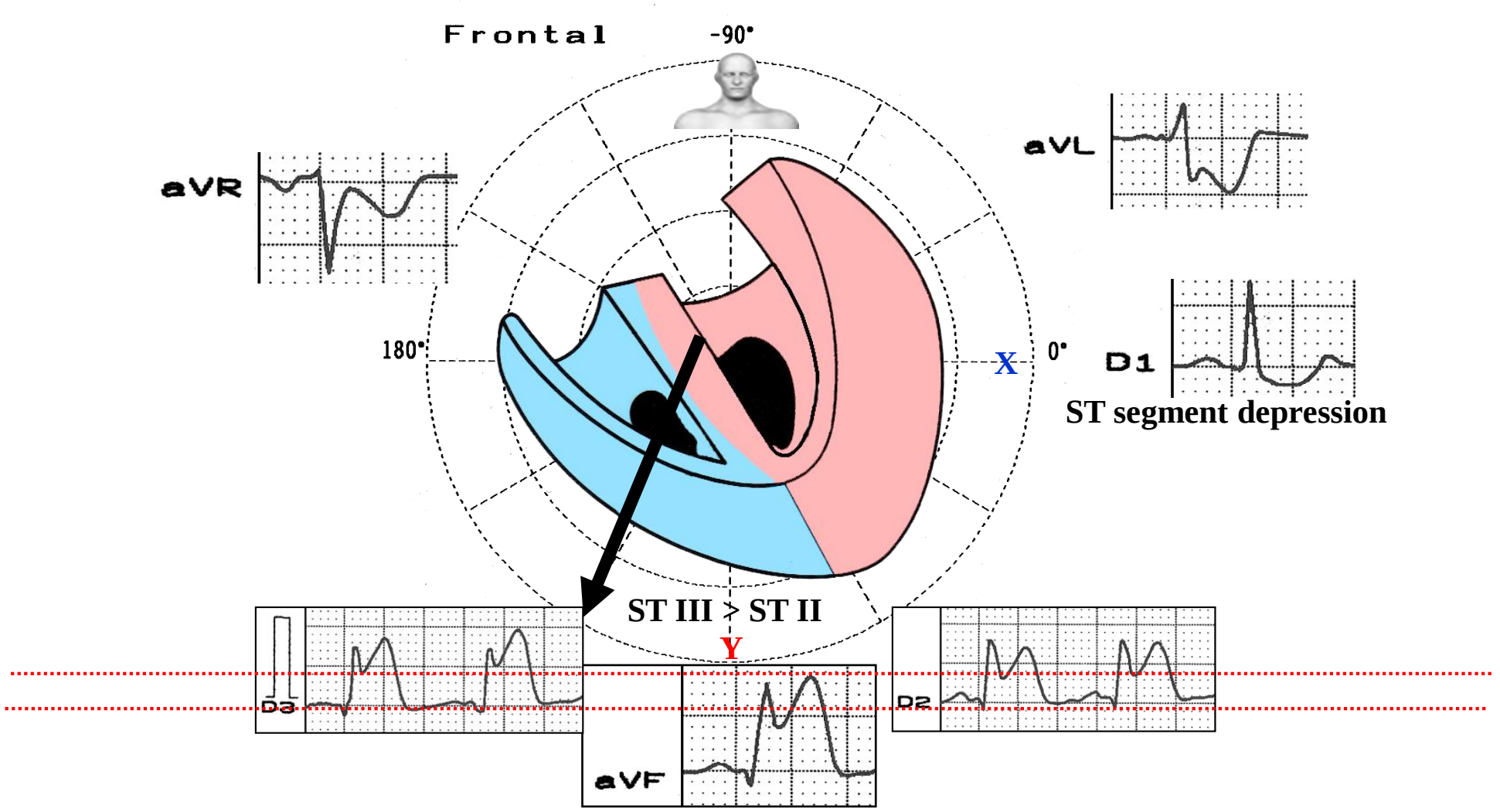
Third degree AV block consequence of AMI by obstruction of RCA. QRS complexes are narrow indicating suprahisian block.

Middle Portion Occlusion Right Coronary Artery (RCA)

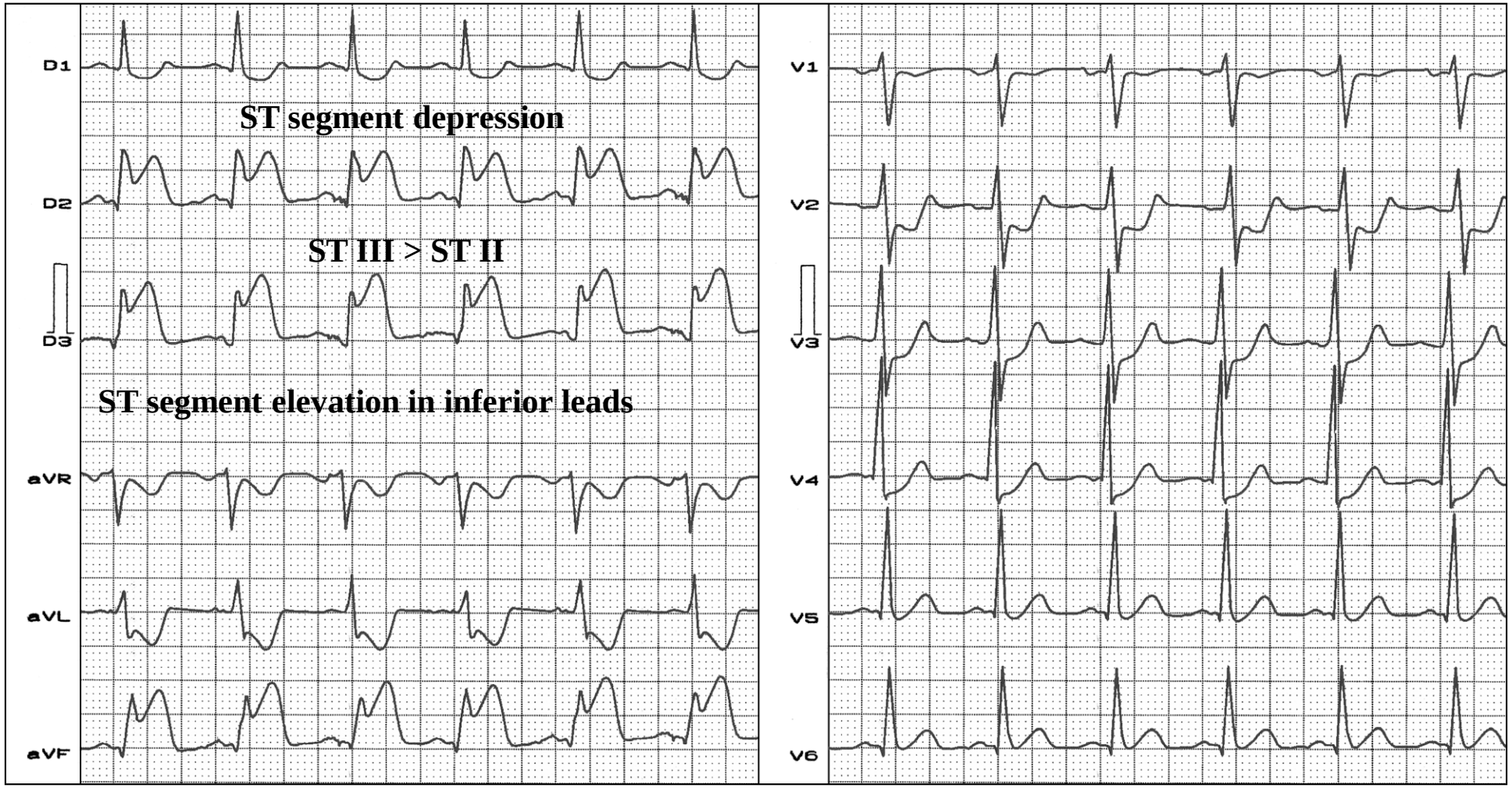




Cineangiography of the previous patient. The red arrow points out the total obstruction in the middle portion of the RCA.
The accessory V_4R lead has a isoelectric ST segment, because the RCA obstruction is located distal related to RV artery (without RV Infarction).

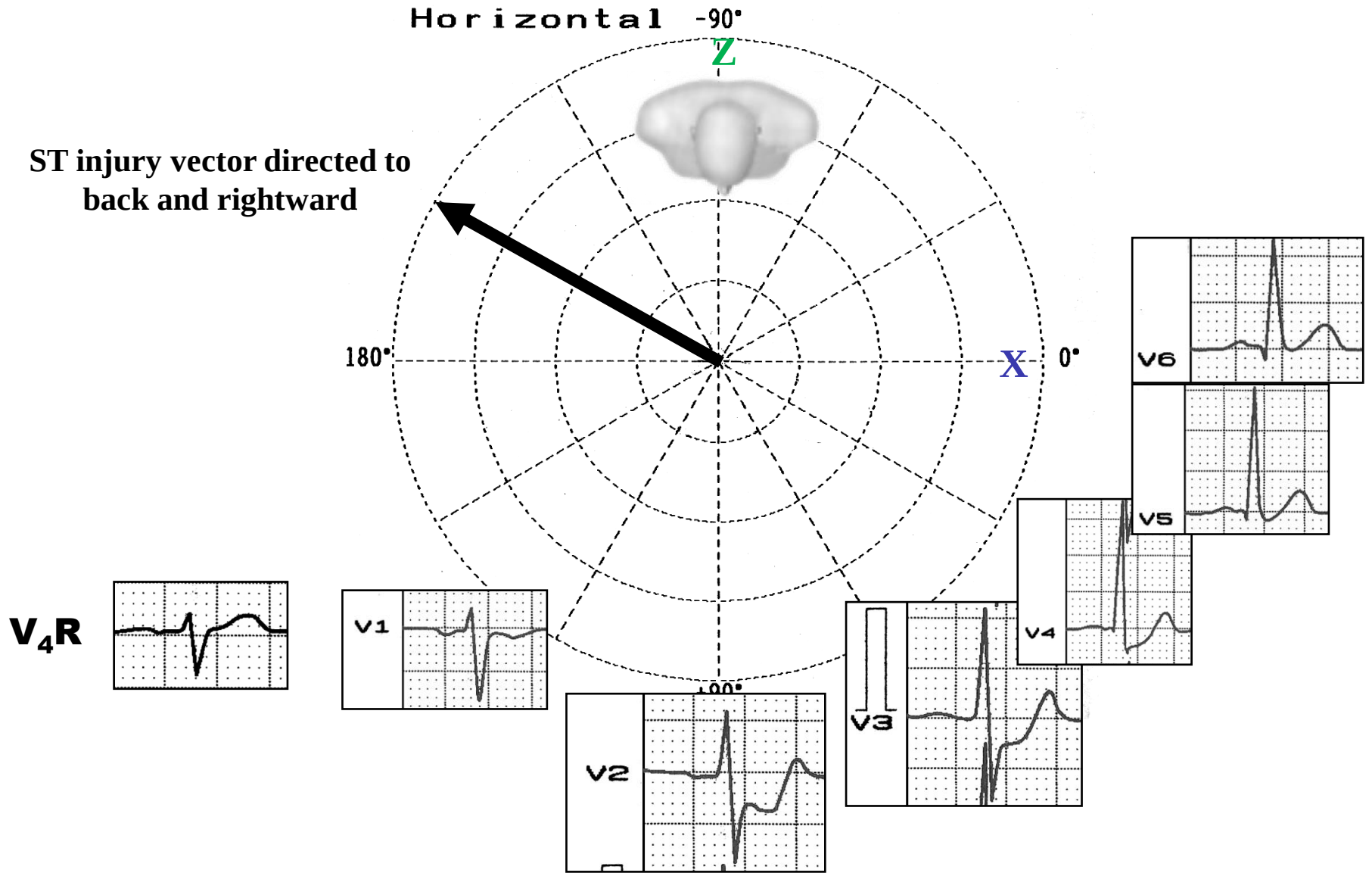


ST segment elevation in inferior leads. III>II because the ST deviation vector pointed to III

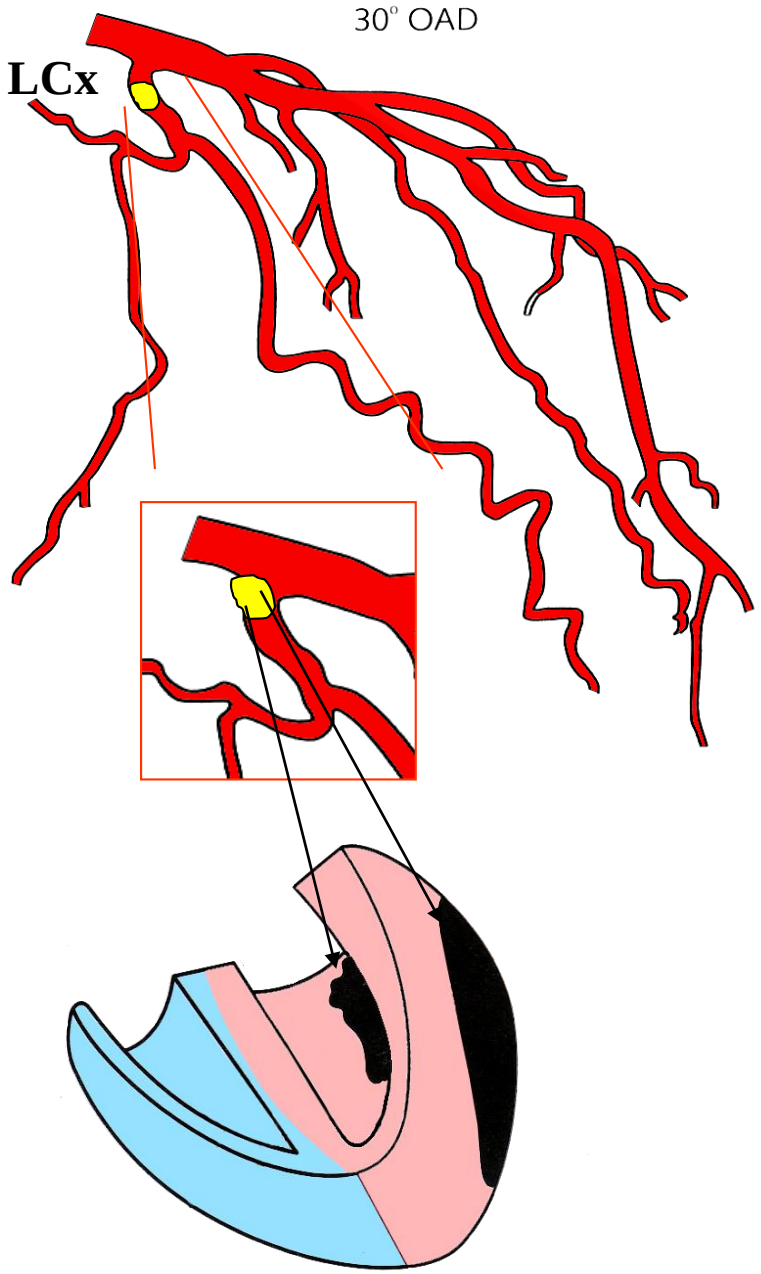

D1
D2
D3
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
ST segment depression
ST III > ST II
ST segment elevation in inferior leads

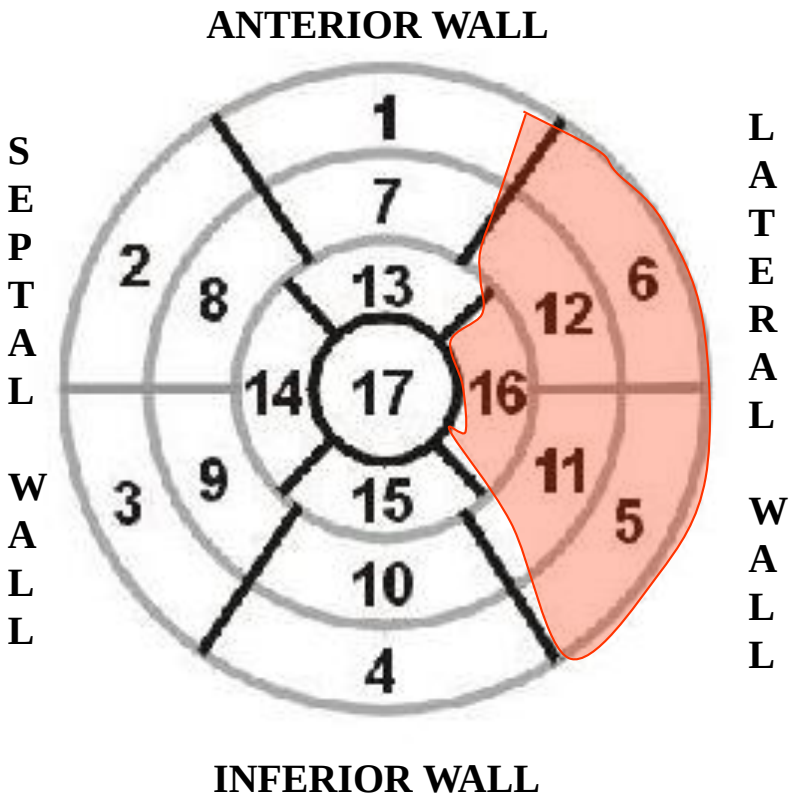
V_4R

ST injury vector directed to back and rightward

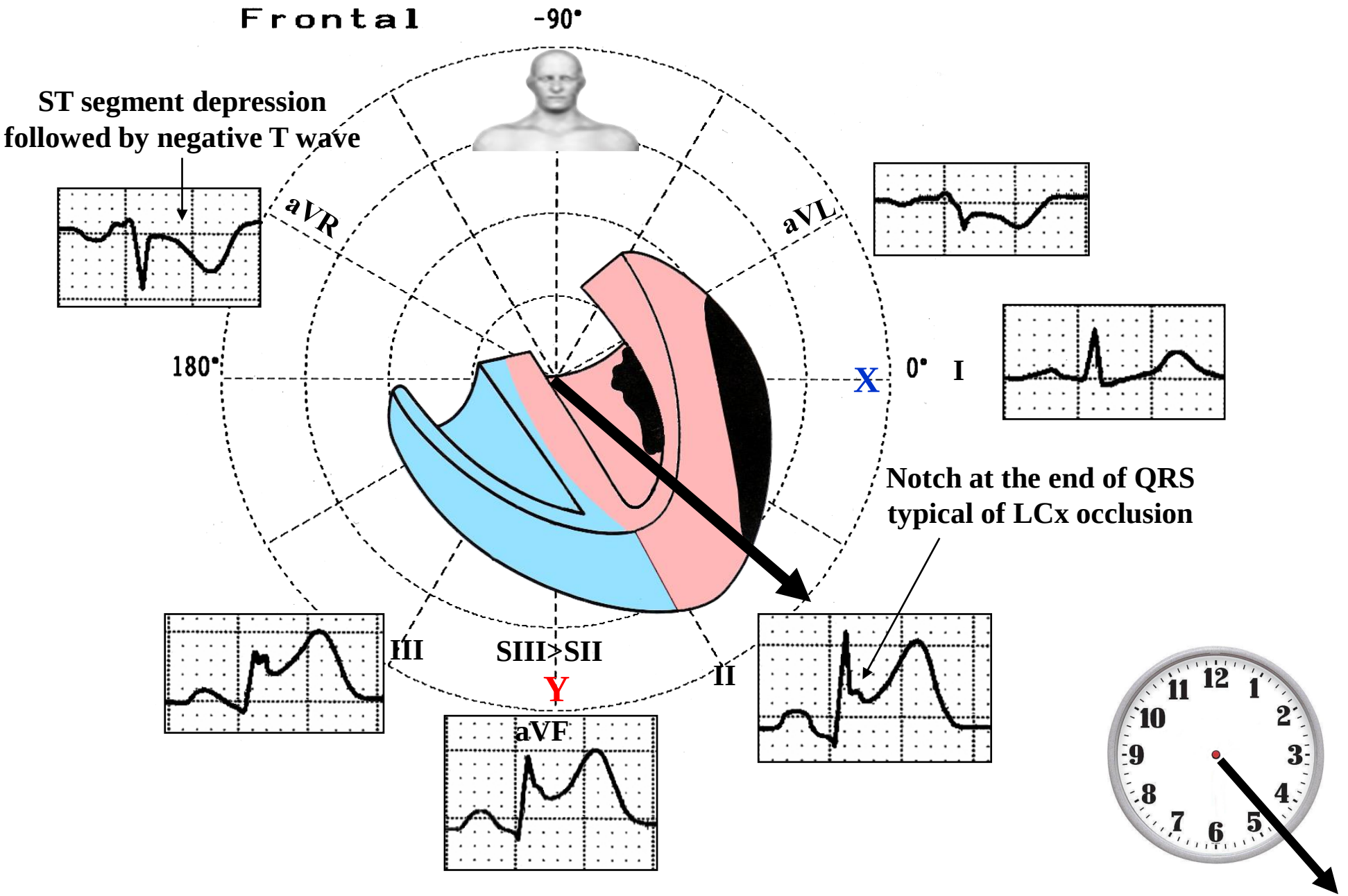


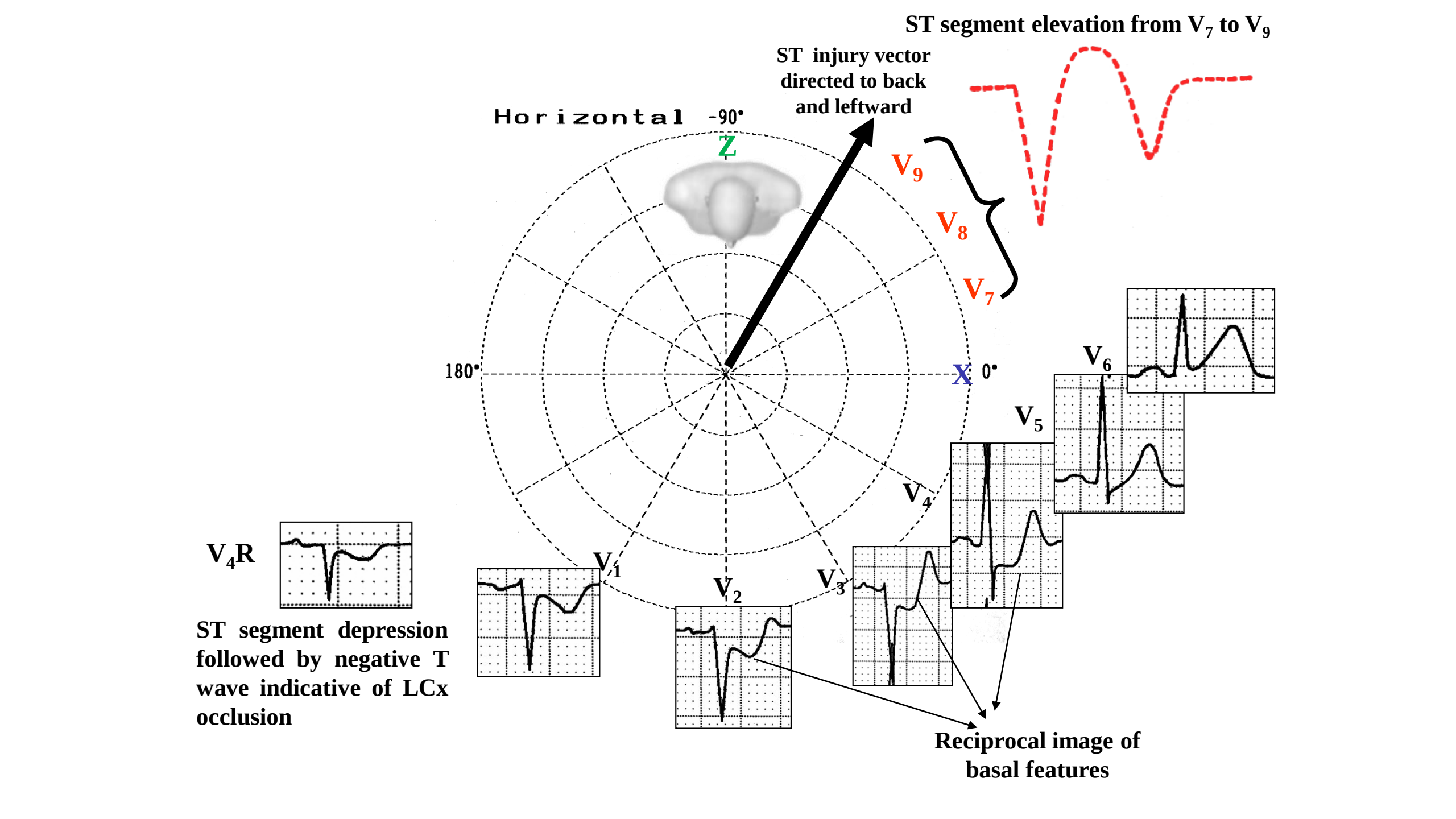
Occlusion of Left Circunflex Artery (LCx)

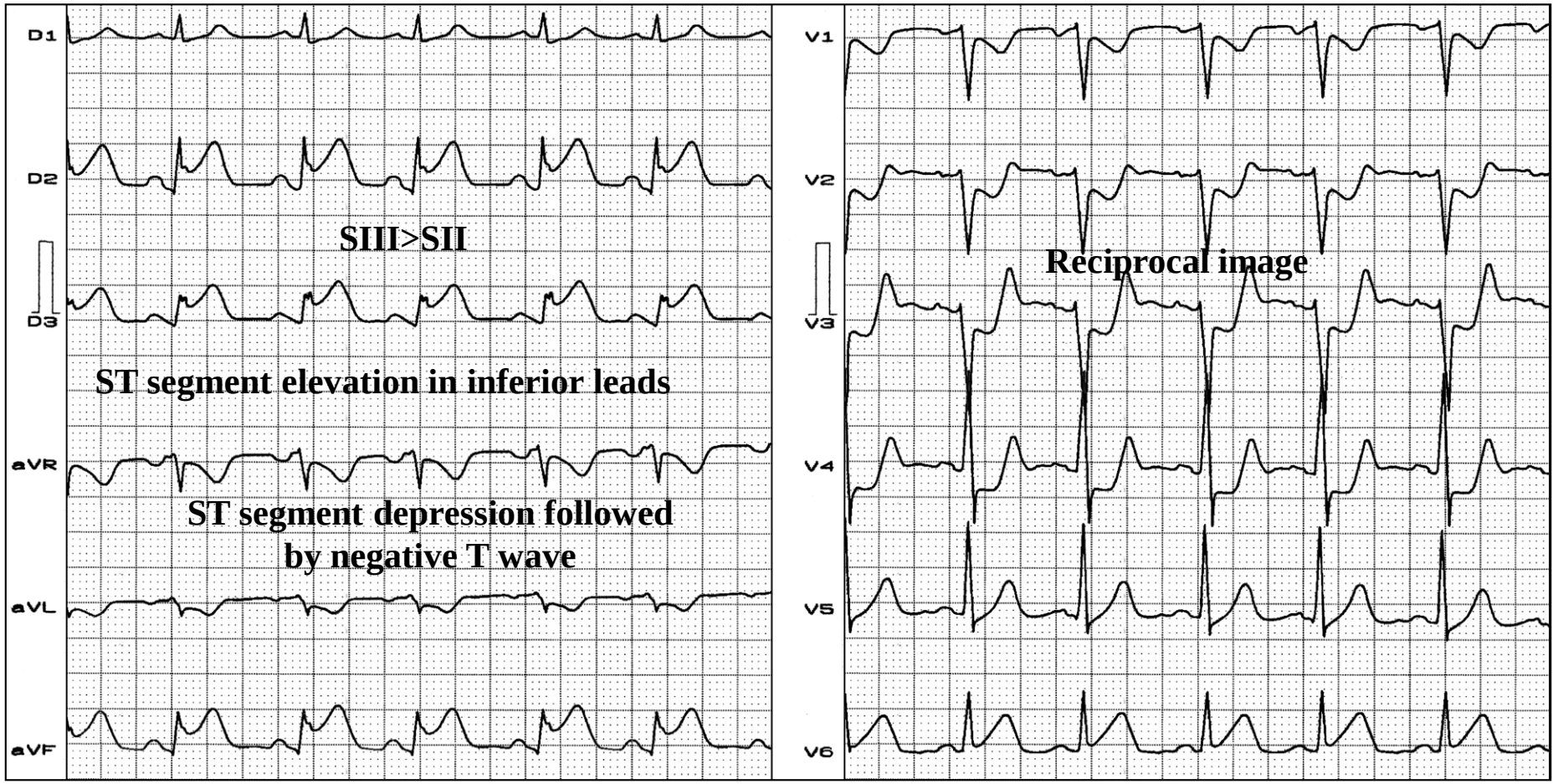




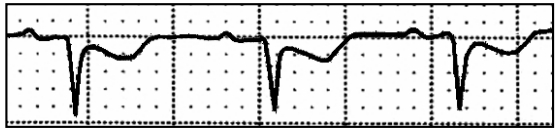
Occlusion of Left Circunflex Artery (LCx)




ST segment elevation from V7 to V9
ST injury vector directed to back and leftward
Horizontal -90°
Z
V9
V8
V7
180°
X
0°
V6
V5
V4
V3
V2
V1
V4R
ST segment depression followed by negative T wave indicative of LCx occlusion
Reciprocal image of basal features

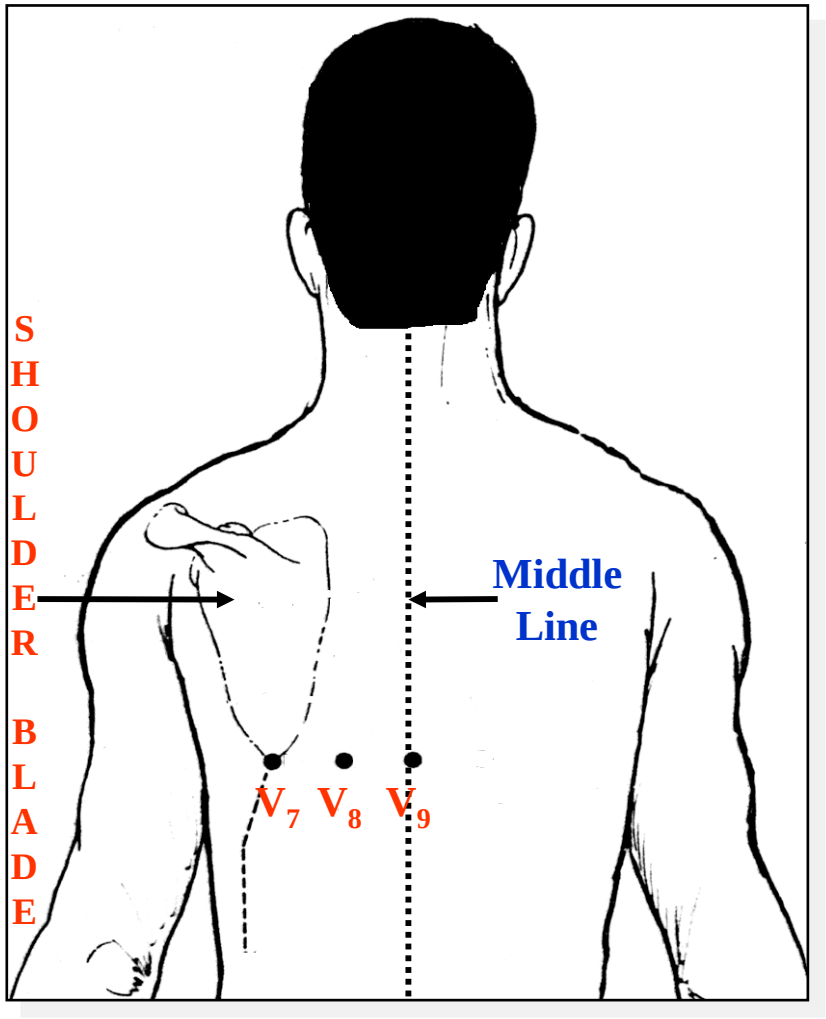


V_4R



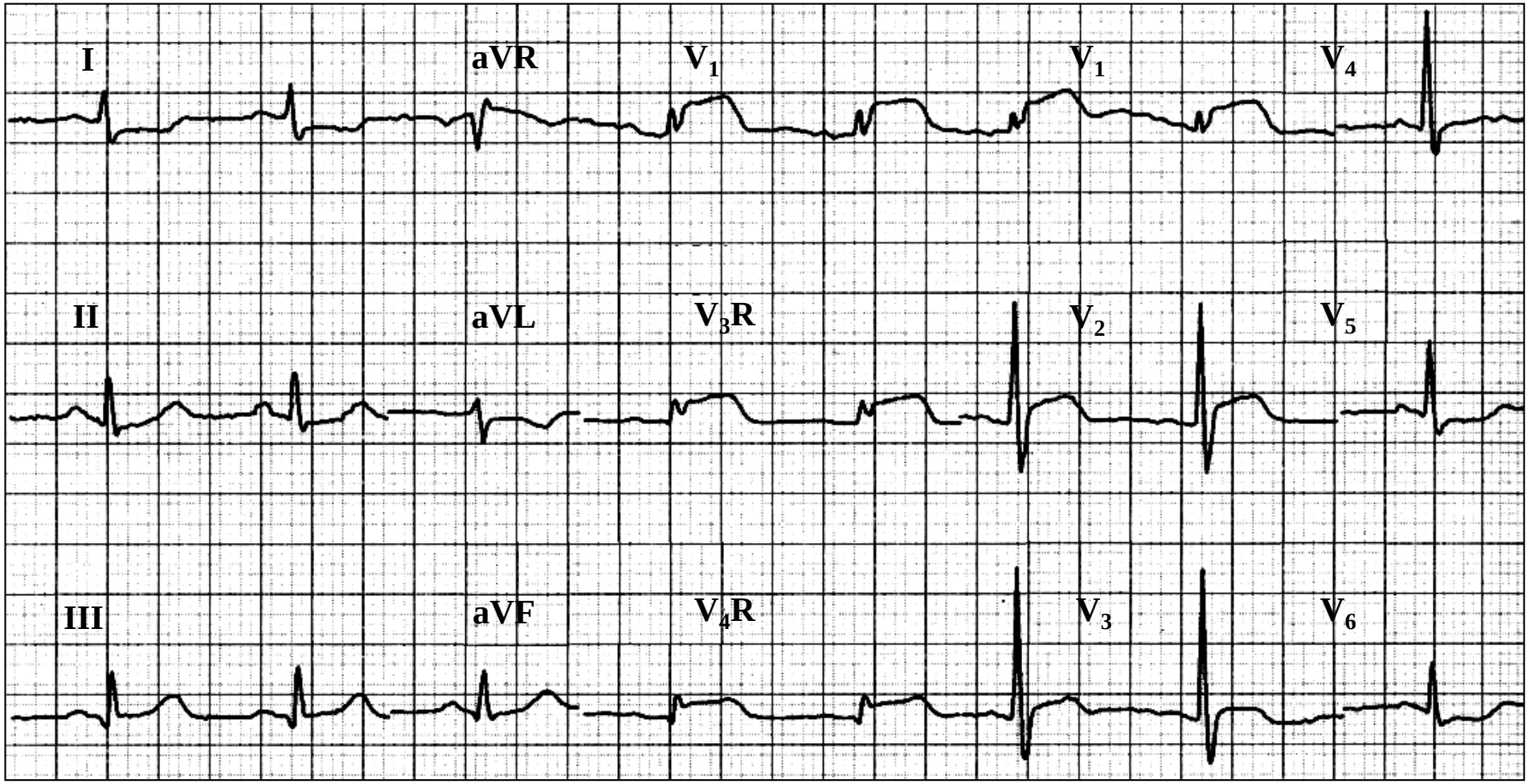
ST segment depression in V_4R followed by negative T wave

Accessory dorsal leads



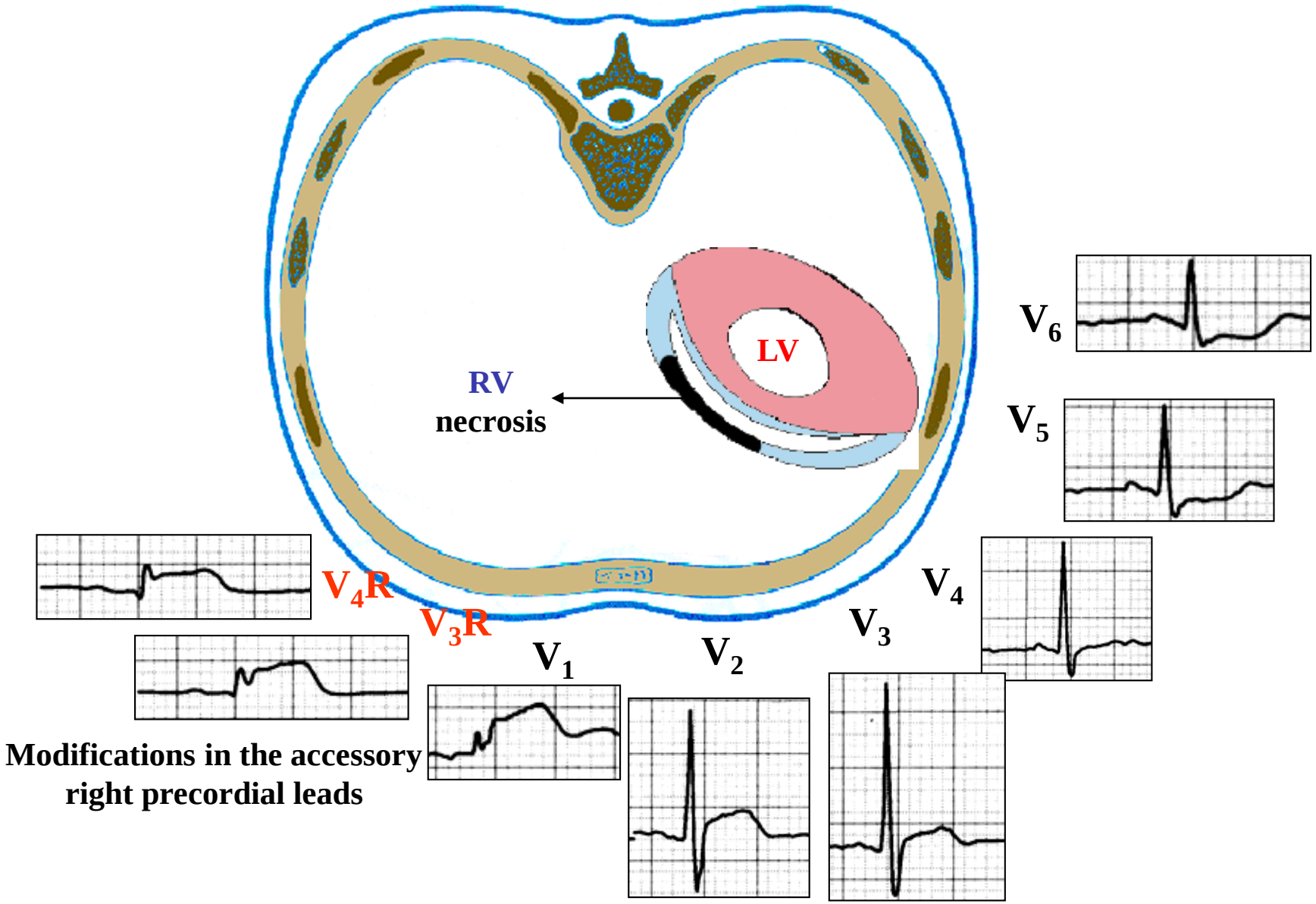
The accessory dorsal leads are located between the left shoulder blade and the spine V_7, V_8 and V_9 leads.

Isolated Right Ventricular Myocardial Infarction

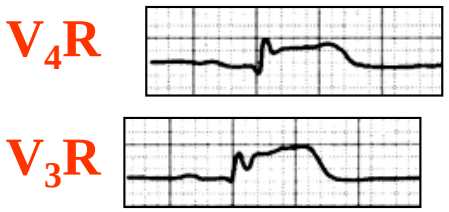


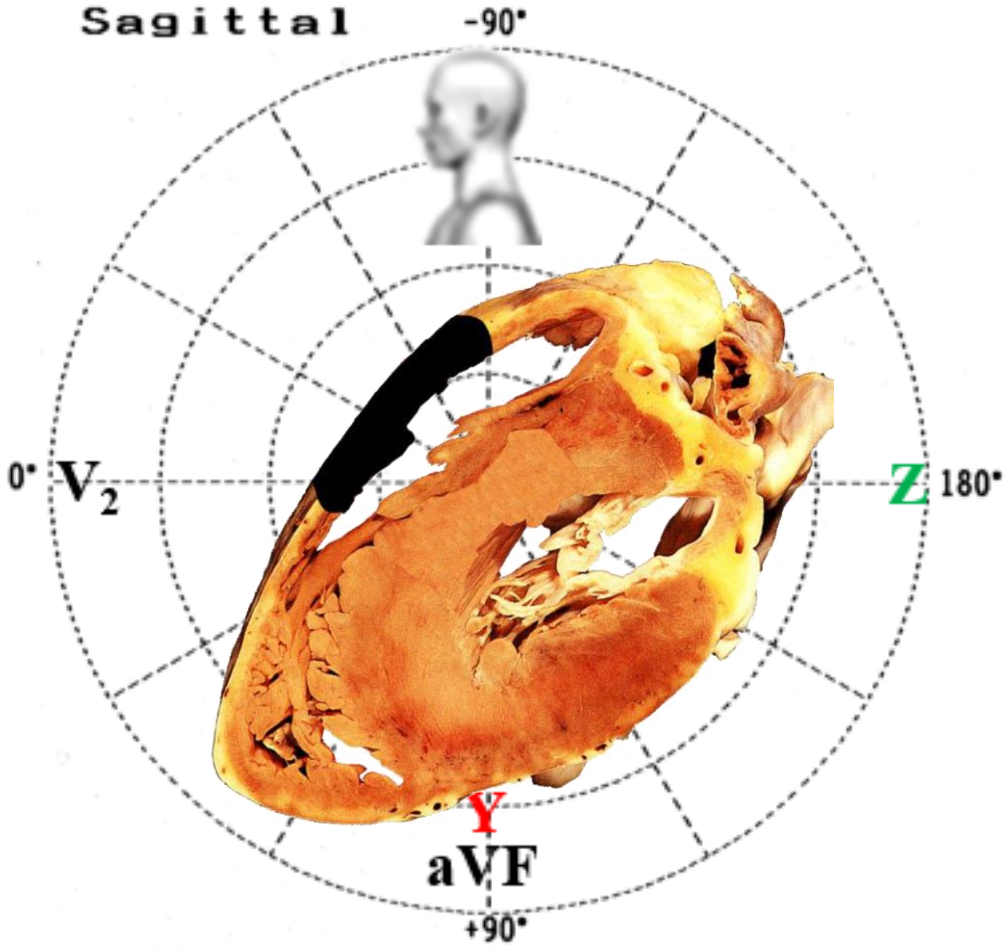
Isolated right ventricular MI without LV involvement, l injury current recorded in V_1,V_3R and V_4R.

Isolated Right Ventricular Myocardial Infarction

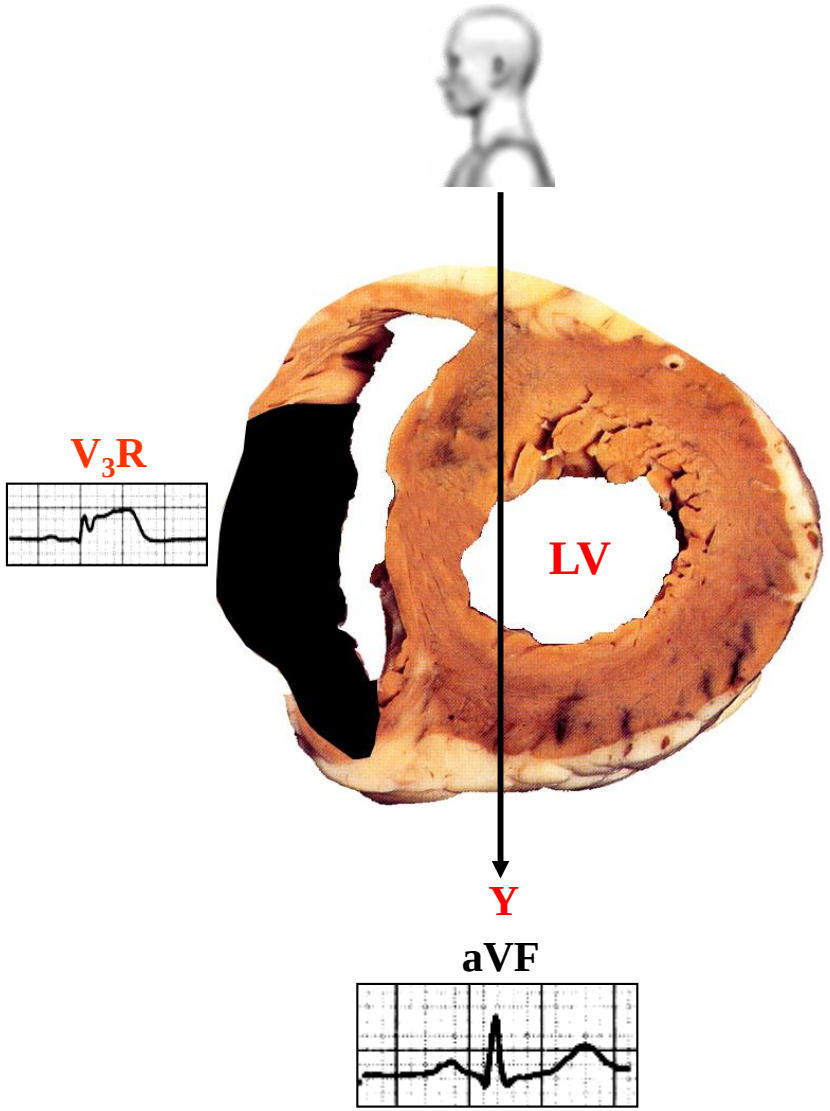


Isolated Right Ventricular Myocardial Infarction Left Sagittal View

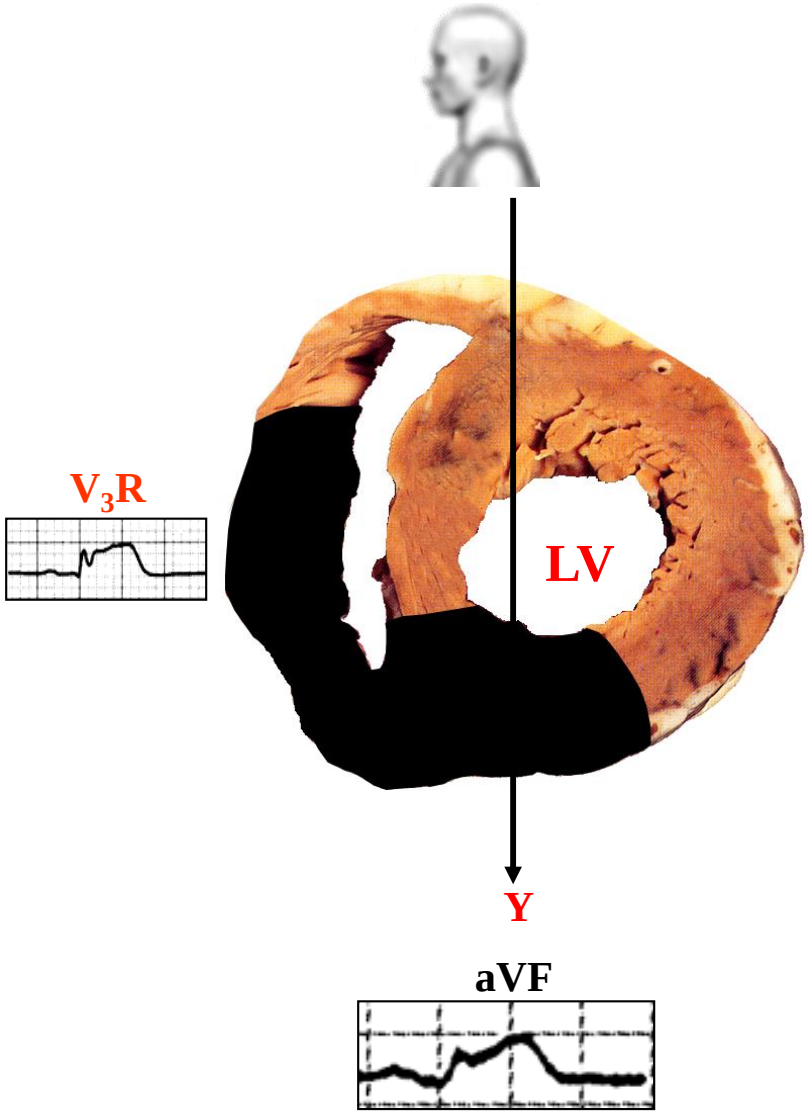




Isolated RV myocardial infarction (exceptional) view in the short axis



RV infarction associated to inferior myocardial infarction view in the short axis



It may cause ST segment elevation in V_1-V_4 : Differential diagnosis with anteroseptal MI

Limitations of the ST injury vector and the location of myocardial ischemia

Specificity: high
Predictive accuracy: high
Sensitivity: quite low

Clinical situations where the deviation of the ST segment is limited

1. Presence of a previous infarction
2. Preexisting abnormalities of the ST segment
3. Left Bundle Brach Block/Right Bundle Branch Block
4. Ventricular Preexcitation
5. Multivessel disease
6. Abnormal site of origin of a coronary artery
7. Dominance or underdevelopment of the coronary arteries.

There is a strong agreement between the direction of the ST injury vector and the location of myocardial ischemia. The ST injury vector may be the key to higher diagnostic accuracy for inferobasal transmural ischemia and may help distinguishing between RCA and LCX occlusions in the acute phase (**Andersen 2010**).

Muchas Gracias!!

Muito Obrigado!!

Thank you very much!!