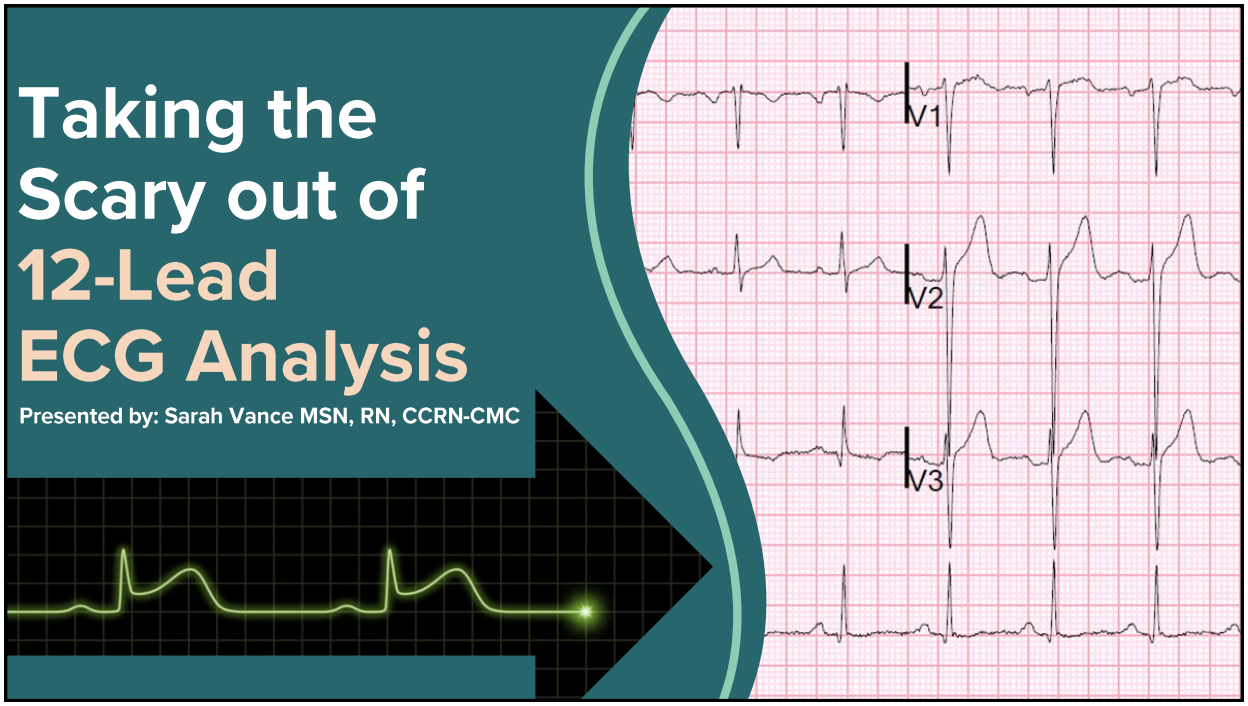
Taking the Scary out of 12-Lead ECG Analysis

Presented by: Sarah Vance MSN, RN, CCRN-CMC



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Objectives

Recognize	Understand	Apply
Identify perfusion territories and expected ECG or clinical findings associated with specific infarct locations.	Explain a systematic method for interpreting 12-lead ECGs.	Interpret 12-lead ECG findings to distinguish ischemia, injury, and infarction patterns.

Have some fun, learn some stuff, and impact patient care

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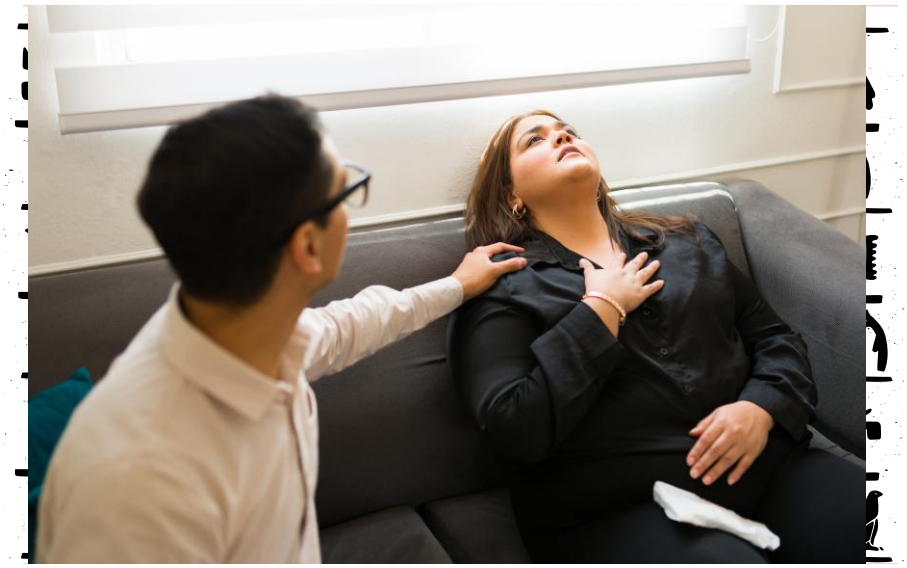
12-Lead ECG Analysis



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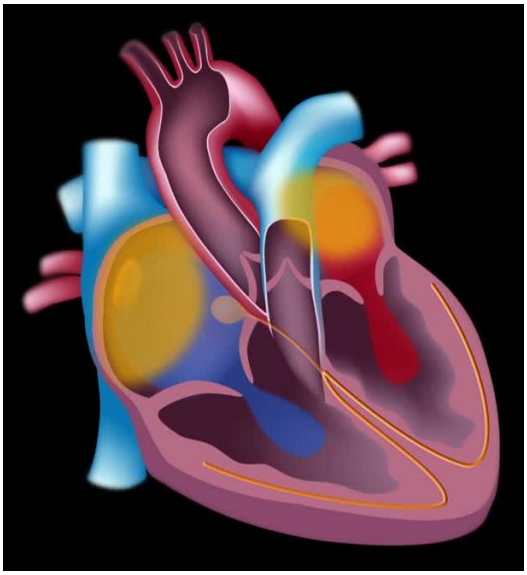
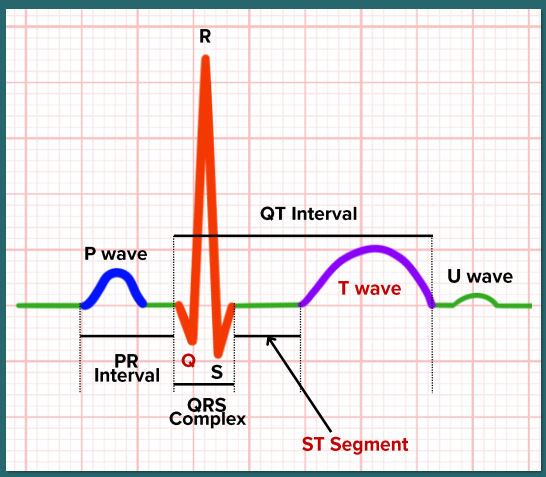
The Cardiac Cycle with ECG Tracing





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Coronary Artery Perfusion

Right Ventricle

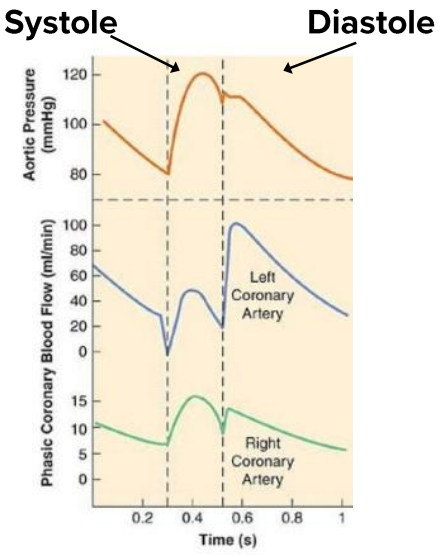
Equally perfused during diastole and systole

- Less affected by tachycardia
- Right coronary artery

Left Ventricle

Mostly perfused during diastole

- Sensitive to tachycardia
- Left main
  - Left ascending artery
  - Left circumflex artery



Barash's *Clinical Anesthesia*

Image: Yartsev 2020

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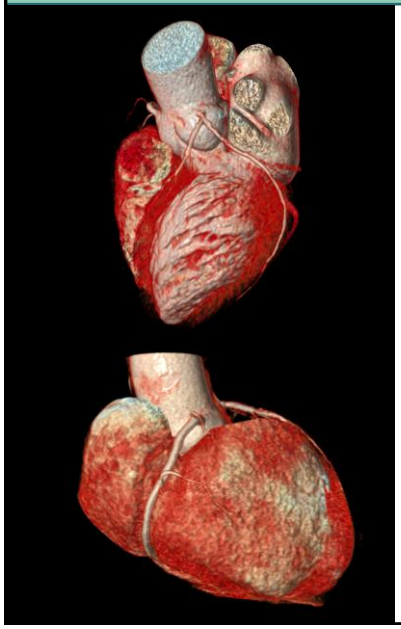
Coronary Artery Perfusion



- Tachycardia will affect coronary perfusion by decreasing diastolic time - ↑ risk of ischemia if underlying coronary artery disease!
- High level of oxygen extraction compared to other organs in the body
- LV CPP = Aortic diastolic pressure (ADP) - LVEDP

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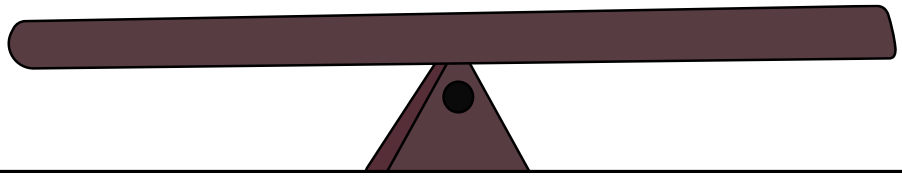
Factors Affecting Myocardial O_2 Supply & Demand

Imbalances between supply & demand cause ischemia. Prolonged imbalance leads to infarction.

O_2 Supply	
Hemoglobin	↓Hbg = ↓ supply
Arterial oxygenation	↓ SaO_2 / SpO_2 = ↓ supply
Diastolic filling	↓ Diastolic time = ↓ supply
Coronary arteries	Poor patency = ↓ supply
Cardiac output	↓CO = ↓ supply

O_2 Demand	
Heart Rate	↑ HR = ↑ demand
Preload	↑ Preload = ↑ demand
Afterload	↑ Afterload = ↑ demand
Contractility	↑ Contractility = ↑ demand



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Coronary Artery Anatomy Review

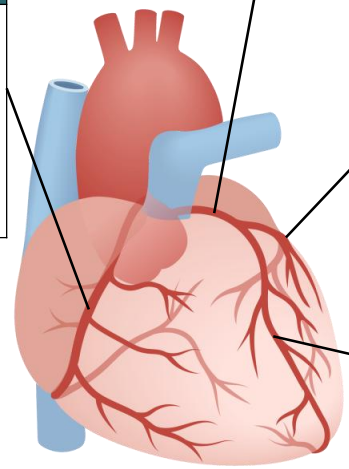
Right Coronary Artery

- Right ventricle
- Inferior wall
- Right atrium
- SA node (~60%)
- AV node (~90%)
- Posterior septum*

PDA*

- Posterior Heart
- RCA (~ 85%)
- LCx (~ 8%)
- Dual (~ 7%)

Left Main



Circumflex Artery (LXc)

- Left atrium
- SA node (~40%)
- Posterior LV
- Posterior septum*

Left Anterior Descending Artery

- Front of left ventricle and septum
- Apex of the heart (bottom of LV)
- Bundle of His
- Bundle Branches
- Papillary Muscle

Wu et al., 2024
DataBase Center for Life Science (DBCLS), CC BY 4.0, via Wikimedia Commons

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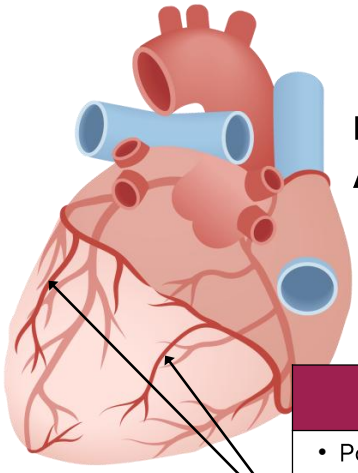
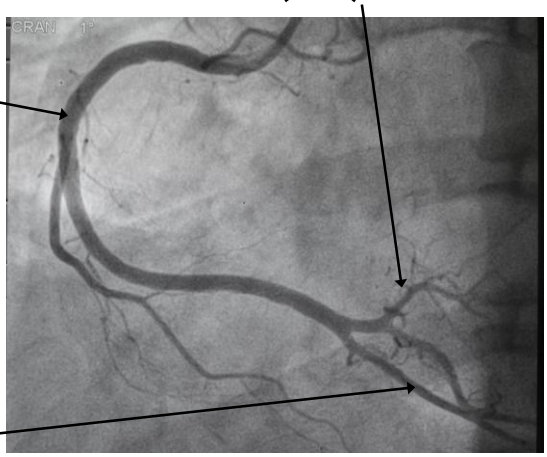
Cardiac Dominance



Right Coronary Artery (RCA)

Right Posterior Lateral Branch (RPL)



PDA*

- Posterior Heart
- RCA (~ 85%)
- LCx (~ 8%)
- Dual (~ 7%)

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Types of Myocardial Infarction per the Universal Definition of MI

Type 1	• **Spontaneous MI caused by atherothrombosis. Usually related to plaque disruption.**
Type 2	• **Imbalance between supply & demand unrelated to acute coronary atherothrombosis**
Type 3	• **Cardiac death + evidence of ischemia, but biomarkers were not obtained**
Type 4	• **PCI-related: stent thrombosis, stent restenosis, procedural complications ≤ 48 hrs**
Type 5	• **Peri-CABG complications detected ≤ 48 hours post-CABG**

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Acute Coronary Syndrome

Unstable angina	Non-ST Elevation Acute Coronary Syndrome (NSTE-ACS)	ST Elevation Myocardial Infarction (STEMI)
• No sustained ST elevation. • May have ST depression or T wave inversion. • Negative cardiac biomarkers • Warning sign for myocardial infarction		

Modifiable risk factors		Non-modifiable risk factors
• Smoking	• ETOH intake	• Age
• Dyslipidemia	• ↑ BMI	• Gender
• Hypertension	• Diet	• Familial history
• Diabetes	• Physical activity	• Race

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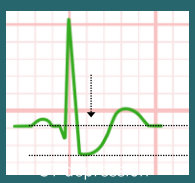
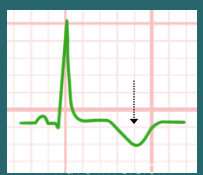
NSTEMI vs. STEMI

Positive (+) cardiac biomarkers

Partially occlusive thrombus

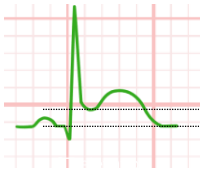
- ST depression in ≥ 2 contiguous leads and/or
- T wave flattening/inversion
- The absence of ECG changes does not exclude NSTEMI!





Completely occlusive thrombus

- ST elevation ≥ 2 contiguous leads in all leads other than V_{2-3}
- For leads V_{2-3}
  - ≥ 2 mm for males ≥ 40 years
  - ≥ 2.5 for males ≤ 2.5 mm
  - ≥ 1.5 mm in females
- New LBBB with ischemic symptoms → treat as STEMI



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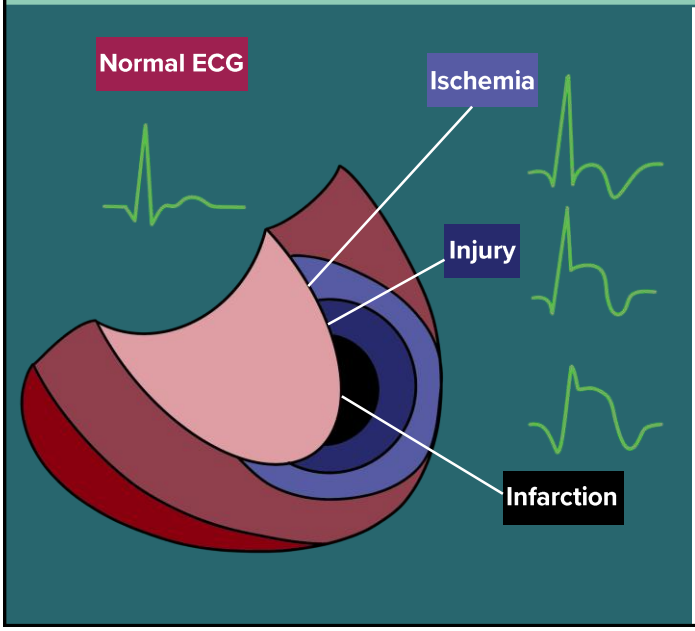
Indicators of Ischemia, Injury, Infarction



- **Indicative:** Inverted T-waves
- **Reciprocal:** Tall T-waves

- **Indicative:** ST elevation
- **Reciprocal:** ST depression

- **Indicative:** Pathological Q-waves
- **Reciprocal:** Tall R-waves

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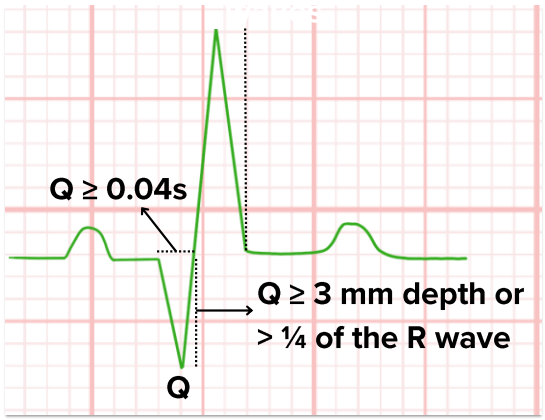
ECG Progression of a STEMI

Hyperacute	
Minutes - Hours	• ST-segment elevation • Tombstone T-waves • T-wave inversion

Acute	
Hours - Days	• ST-segment elevation • T-wave inversion • Pathological Q-waves

Recent	
Weeks - Months	• T-wave inversion • Pathological Q-wave

Old	
Several Months	• Pathological Q-wave



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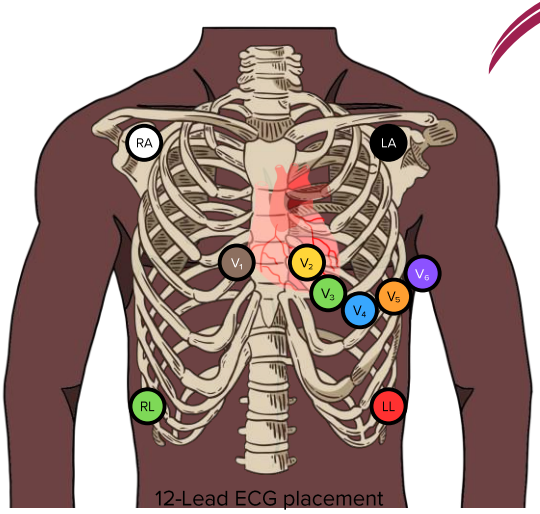
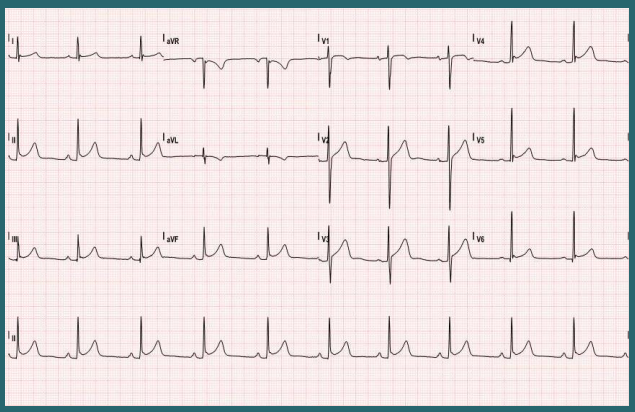
12-Lead ECG Analysis



12-Lead ECG placement



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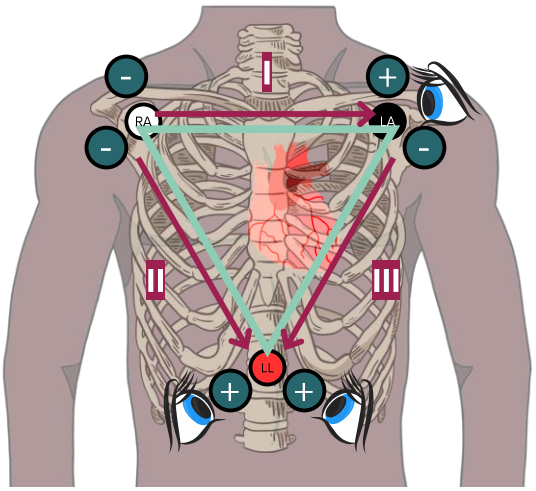
Limb Leads

RL → Ground Lead/reference point



- Bipolar leads
- Vertical plane
- Normal vector is downward → left
- ECG records from the POSITIVE lead

Standard Leads			
Lead	**Positive electrode**	**Negative electrode**	**View**
I	LA	RA	Lateral
II	LL	RA	Inferior
III	LL	LA	Inferior

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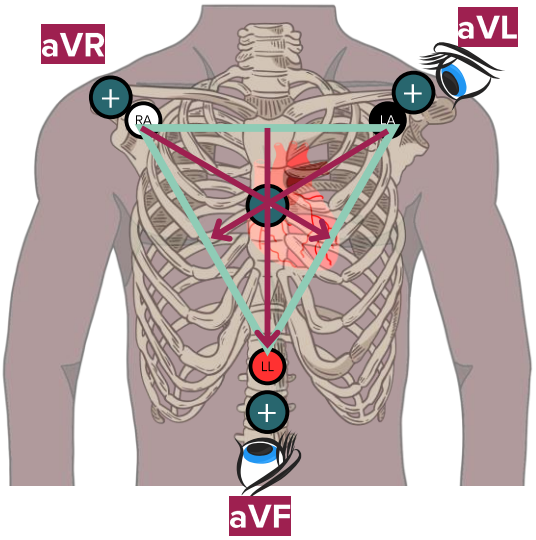
Augmented Leads

RL → Ground Lead/reference point



- Unipolar leads
- Vertical plane
- Average between +/- leads
- Normal vector is downward → left

Augmented Leads		
Lead	**Positive electrode**	**View**
aVR	RA	None
aVL	LA	Lateral / From the **LEFT**
aVF	LL	Inferior / From the **FOOT**

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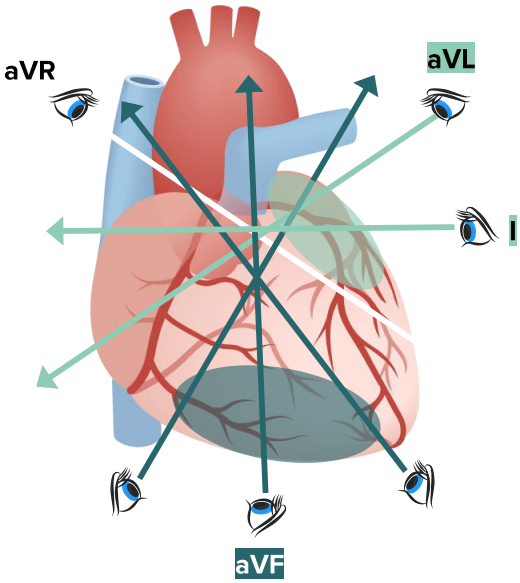
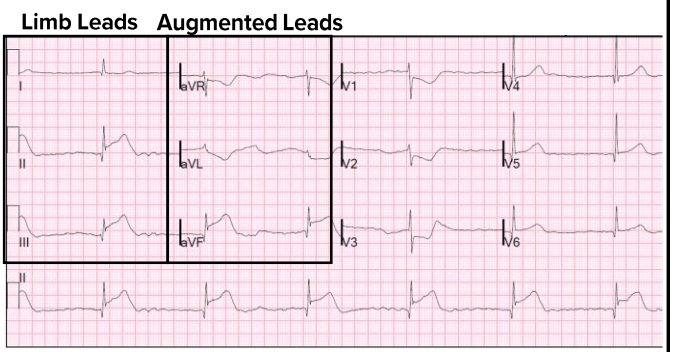
Vertical Plane Leads





Do you see any changes in this 12 - Lead ECG?

- aVF → FOOT/InFerior side of the heart
  - "Two Right Feet" = Lead II, aVF, RCA
- aVL → LEFT/LATERAL side of the heart
  - "I Look Left for Some Circumflex" = Lead I, aVL, LCx

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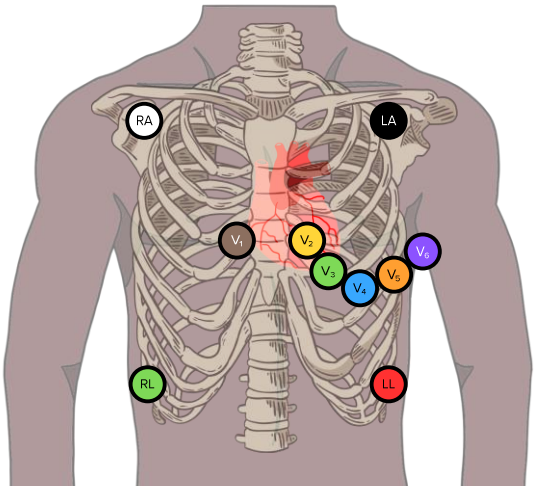
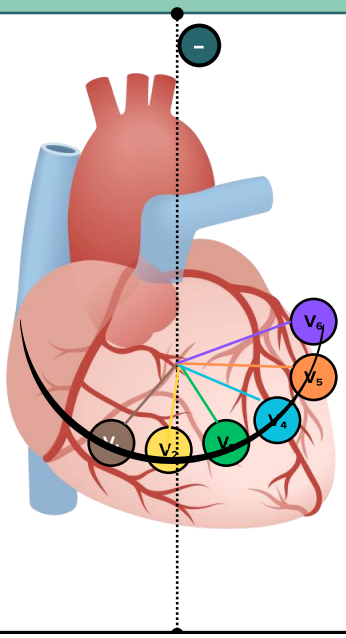
Precordial Leads





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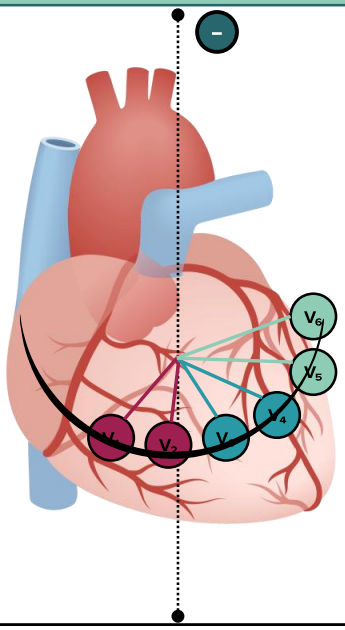
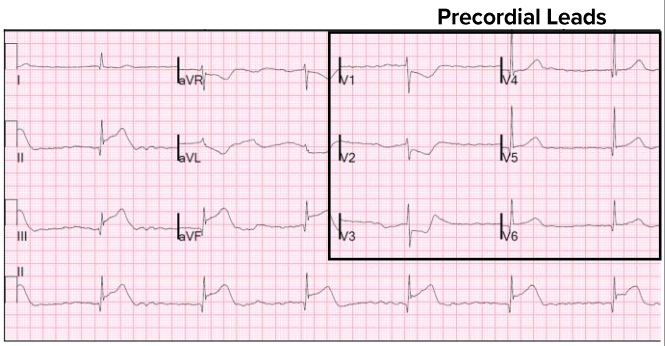
Horizontal Plane Leads





Do you see any changes in this 12 - Lead ECG?

- **Anteroseptal (DOOR) →**
  - **"LADs at doors One through Four" = leads V_1 - V_4**

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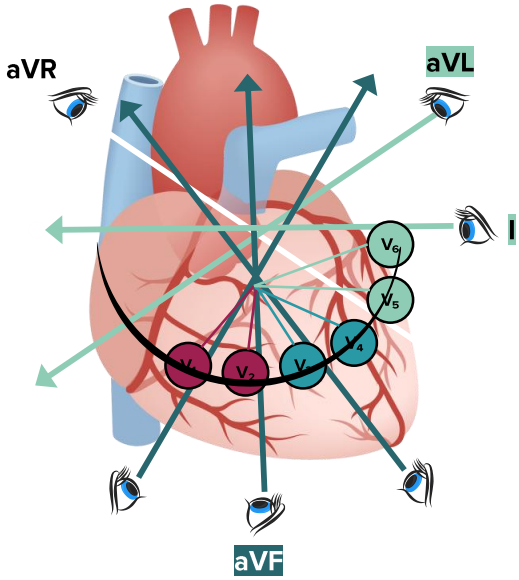
Reciprocal Changes



Electrical changes in leads opposite or complementary to the primary area of cardiac injury or ischemia, which manifest as ST-segment depression.

Reciprocal Changes		
Location	**Indicative Leads**	**Reciprocal Leads**
Anteroseptal	V_{1-4}	II, III, aVF
Inferior	II, III, aVF	I, aVL (sensitive to inferior MI)
Lateral	I, aVL (high lateral) V_5 - V_6 (low lateral)	III, aVF(when ST elevation in leads I & aVL)

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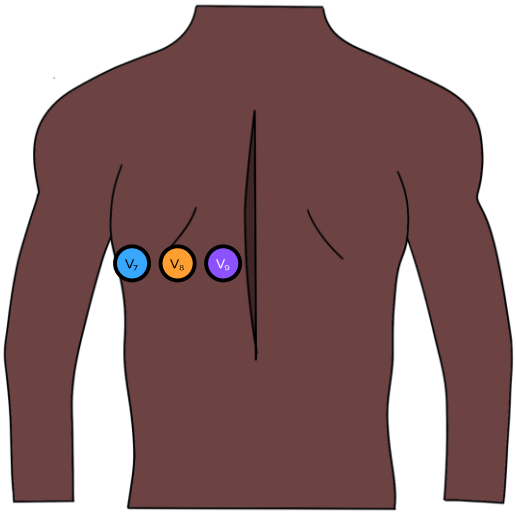
Posterior Wall MI



How would you know if it is a posterior wall MI?

Reciprocal Changes		
Location	**Indicative Leads**	**Reciprocal Leads**
Anteroseptal	V_{1-4}	II, III, aVF
Inferior	II, III, aVF	I, aVL (sensitive to inferior MI)
Lateral	I, aVL (high lateral) V_5 - V_6 (low lateral)	III, aVF(when ST elevation in leads I & aVL)
Posterior	ST **depression** in V_1 - V_3 V_7 - V_9 (posterior leads)	Tall R waves in leads V_1 - V_3

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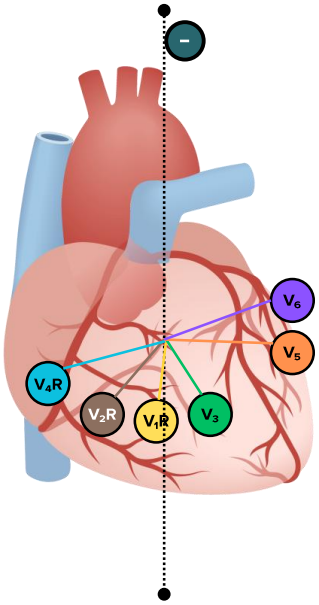
Right Ventricular MI



How would you know if it is right ventriuclar infarct??

Reciprocal Changes		
Location	**Indicative Leads**	**Reciprocal Leads**
Inferior	II, III, aVF	I, aVL (sensitive to inferior MI)
RVMI	V_1 & V_2R - V_6R (right-sided leads) **V_4R sensitive/specific to RVMI**	

- V_4R: Moving V_4 electrode to the 5th right ICS + MCL
  - > 88% sensitivity, >78% specificity, and >83% predictive accuracy[1]

1) Shams P, Parks LJ. Right Ventricular Myocardial Infarction. [Updated 2026 Feb 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK431048/

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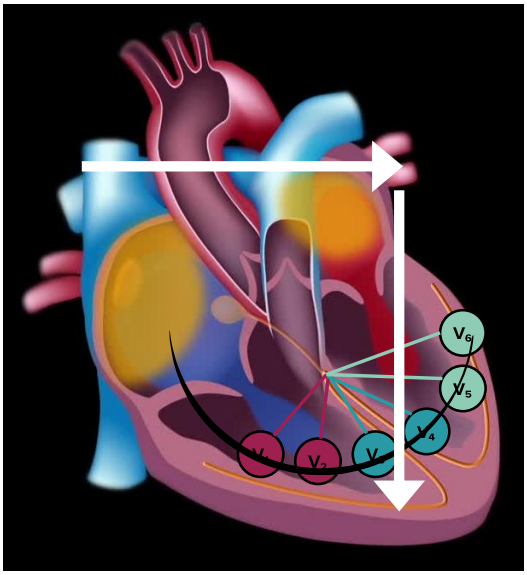
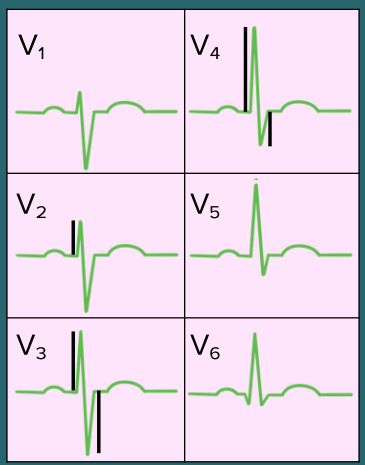
R-Wave Progression



Normal transition between V_{3-4}



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R-Wave Progression

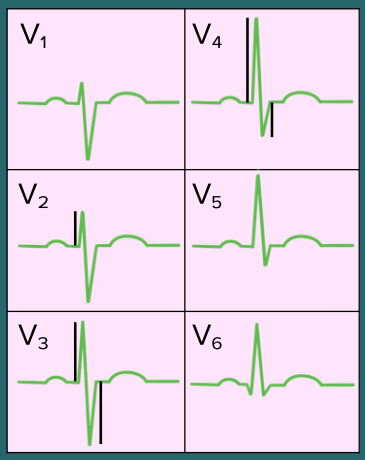
Poor R-Wave Progression

- Normal variation
- Anteroseptal wall MI
- Old anteroseptal Infarction
- Incorrect lead placement (V_1 & V_3)
- Left ventricular hypertrophy
- Conduction delay

Early R-Wave Progression

- Posterior MI
- Right ventricular hypertrophy
- Normal variant

Normal transition between V_{3-4}



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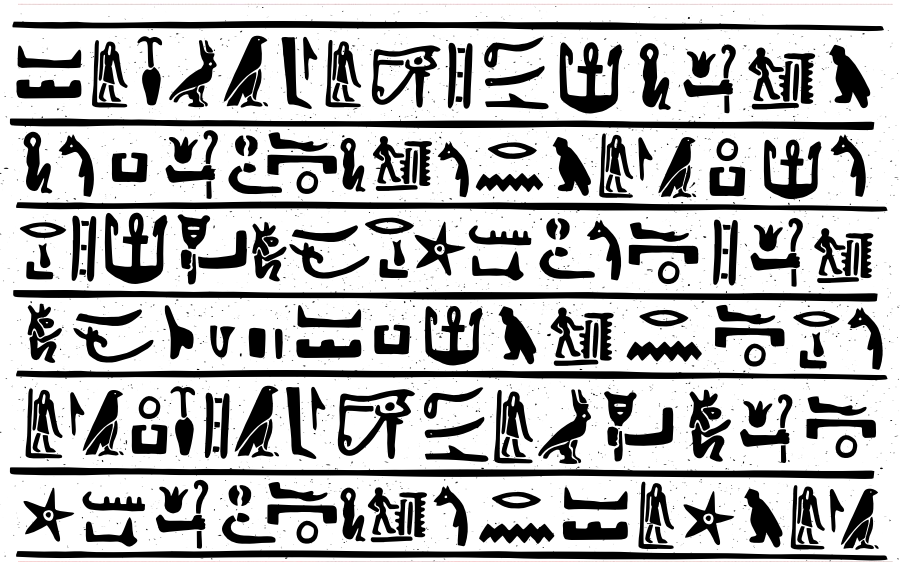
12-Lead ECG Analysis



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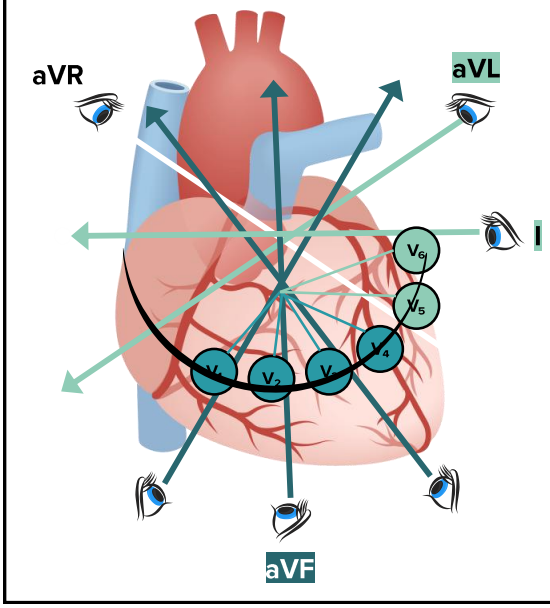
12-Lead ECG Analysis Steps



- Assess the patient and stay calm.
- Ensure electrodes are attached appropriately.
- General overview: Rate, rhythm, regularity, R wave progression, anything major?
- Look at lead groups: inferior, anterior, lateral, posterior.
- Evaluate reciprocal changes.
- Right-sided or posterior ECG needed?

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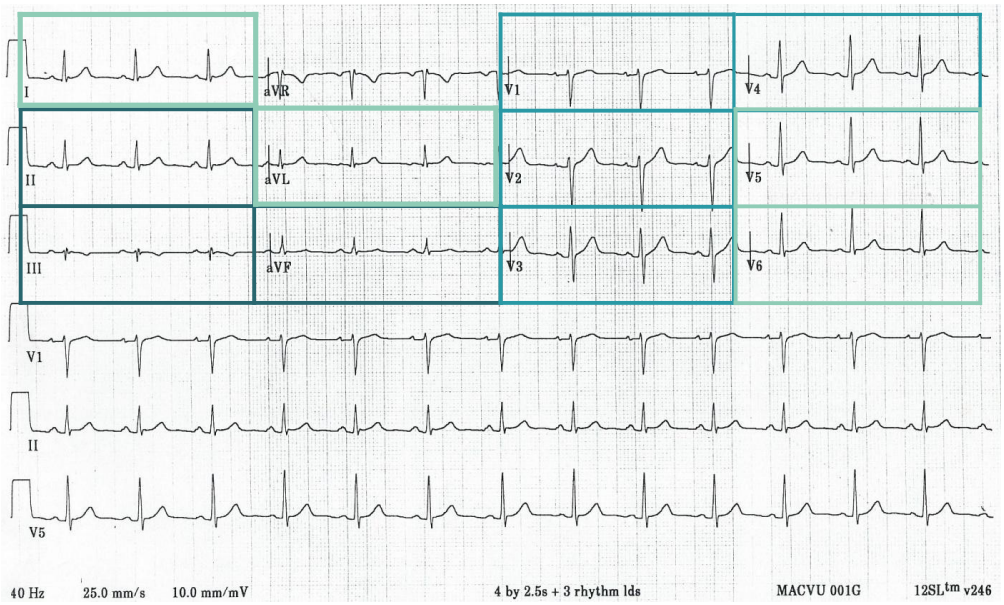
The Normal 12-Lead ECG



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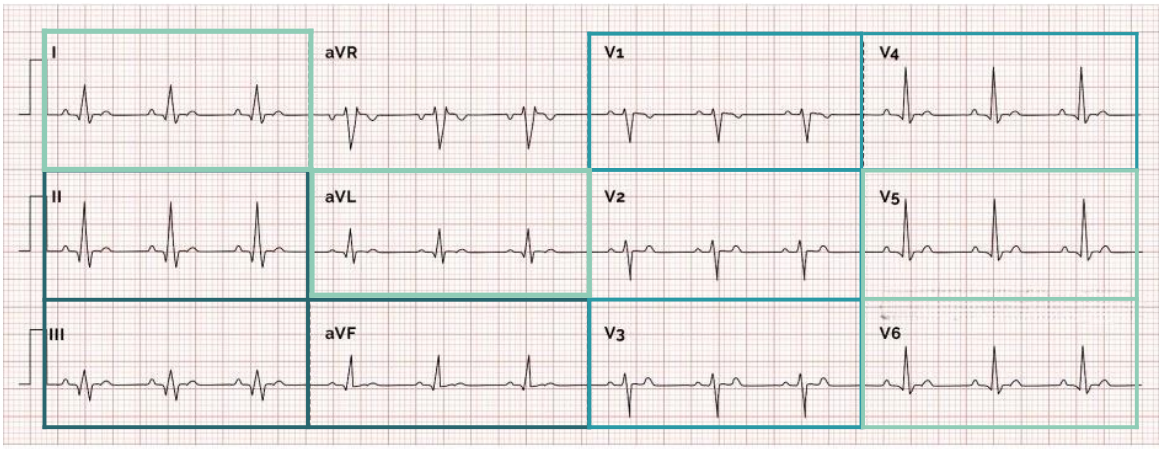
The Normal 12-Lead ECG



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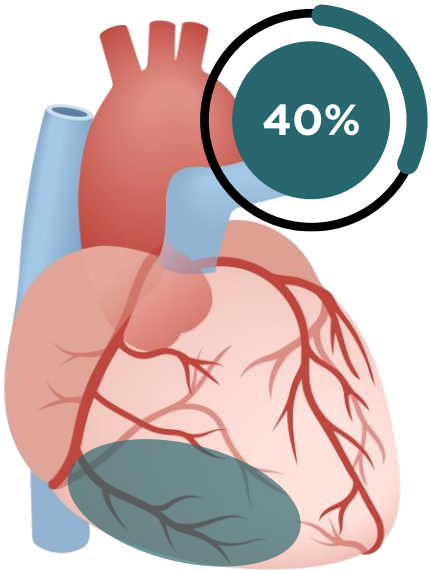
Inferior Wall MI



Which coronary artery(ies) can be the culprit?

- RCA in most
- LCx at times (left heart dominant)

Which will be the 12-Lead ECG changes?

- STE: II, III, aVF
- RC: I, aVL

Look Out For:

- Risk of RV infarction!
- Risk of 2° Type I or 3° AV block → may need emergent pacing
- NV, bradycardia, diaphoresis
- Papillary muscle rupture → within < 14 days

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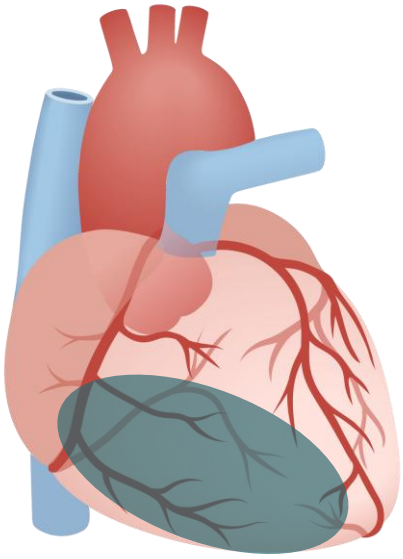
Right Ventricular Infarction



Which coronary artery(ies) can be the culprit?

- Usually proximal RCA

Which will be the 12-Lead ECG changes?

- STΔs:
  - V_1 & V_2R - V_6R (right-sided leads)
  - V_4R sensitive/specific to RVMI
  - ST elevation in V1 and ST depression in V2
  - ST elevation in III > I

Look Out For:

- Uncommon for ONLY RVMI
  - Typically associated with inferior wall MI
- Brady/tachyarrythmias

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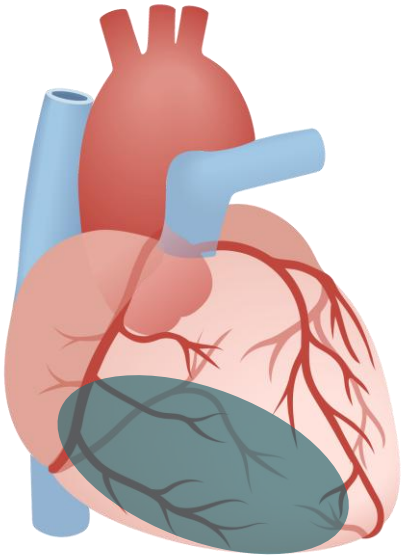
Right Ventricular Infarction



Clinical Findings:

- Hypotension
- +JVD
- Tachycardia
- Peripheral edema
- Clear lungs
- ↑ RAP/CVP
- Right sided S_3
- Tricuspid regurgitation

Management:

- Preload optimization!
  - SMALL fluid challenges & reassess
  - Caution with morphine, nitrates, and diuretics
- Vasopressors and/or positive inotropes for support → afterload sensitive!
- Mechanical circulatory support → LV involved?

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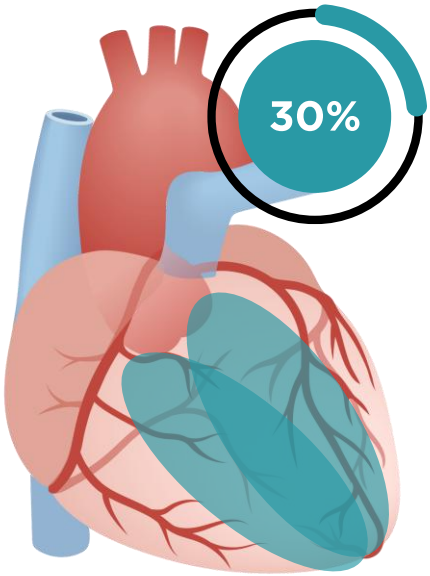
Anteroseptal Wall MI



Which coronary artery(ies) can be the culprit?

- LAD or Left Main (Widowmaker!)

Which will be the 12-Lead ECG changes?

- STE: V_{1-2} (septal) V_{3-4} (anterior)
- RC: II, III, aVF
- Possible loss of R wave progression

Look Out For:

- Risk for LV failure → cardiogenic shock!
  - Left-sided heart failure +/- MCS
- 2° Type II or 3° AV block → may need emergent pacing
- Arrythmias, bundle branch block
- Papillary muscle or septal rupture

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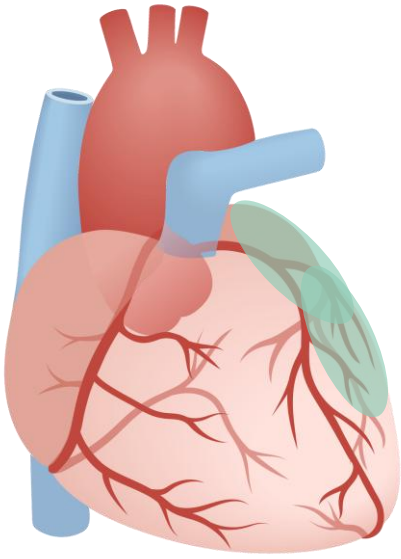
Lateral Wall MI



Which coronary artery(ies) can be the culprit?

- Left circumflex
- Proximal LAD
- Left main (Widowmaker!!)

Which will be the 12-Lead ECG changes?

- STE: I, aVL (high lateral) V_5 - V_6 (low lateral)
- RC: III, aVF (when ST elevation in leads I & aVL)

Look Out For:

- Usually associated with other MIs:
  - Inferior → RCA
  - Anterior/Septal → High-grade LAD/LM
- Heart blocks

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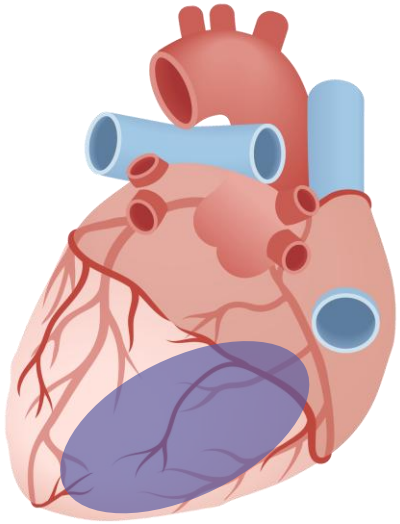
Posterior Wall MI



Which coronary artery(ies) can be the culprit?

- Posterior descending artery (PDA)
  - Left circumflex and/or
  - Right coronary artery (RCA)

Which will be the 12-Lead ECG changes?

- STΔs:
  - ST depression in V_1 - V_3
  - V_7 - V_9 (posterior leads)

Look Out For:

- Usually associated with other MIs
  - Inferior wall MI
  - Lateral wall MI

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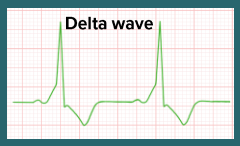
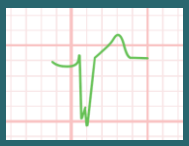
STEMI Mimics

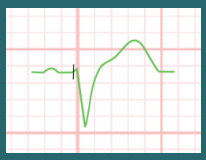
E	• Electrolytes: K^+, Ca^{2+}
L	• Left/right bundle branch block
E	• Electrical (WPW, VPaced, Brugada)
V	• Ventricular hypertrophy
A	• Ventricular aneurysm, aortic dissection
T	• Takotsubo / traumatic brain injury
I	• Inflammation (myo/pericarditis)
O	• Osborn (J) wave
N	• Non-ischemic vasospasm



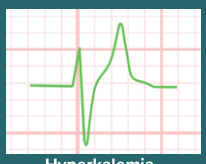
Wolff-Parkinson-White (WPW) Syndrome


Left bundle branch block


Spodicks's sign in pericarditis


Ventricular pacing

Brugada syndrome


Hyperkalemia

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Reminder

~~PRACTICE~~

~~MAKES~~

~~PERFECT~~

REPETITION

MAKES

PROGRESS

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Resources

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