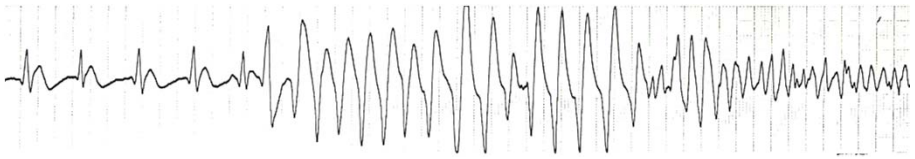
ECG Diagnosis of Acute Coronary Syndrome
STEMI, Confounders, & Mimickers



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We will discuss…..

- ECG diagnosis of ACS
- ECG findings of STEMI
  - ACS findings
  - Regional issues
  - Diagnostic tools
- Confounders
- Mimickers
- Limitations
- Cases

Ischemic Heart Disease

The Good Old Days

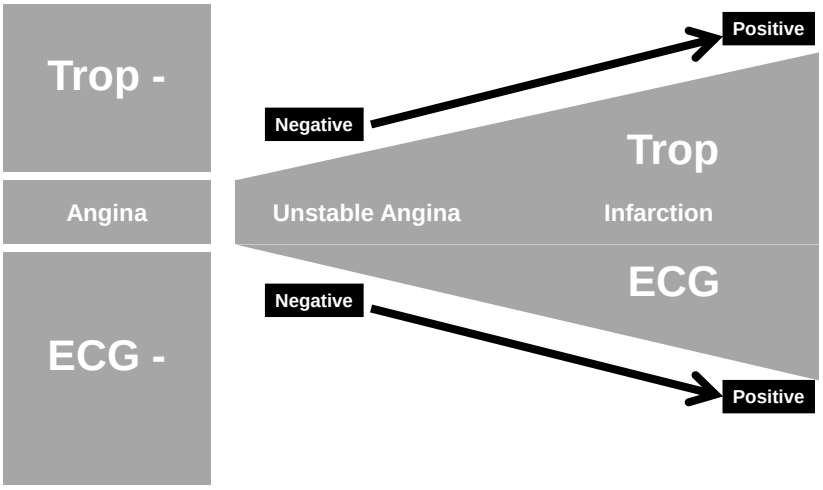
When the world was "black & white".....

CPK -	CPK -	CPK +
Angina	USAP	Infarction
ECG -	ECG + / -	ECG +

Ischemic Heart Disease

Today

Shades of grey.....



Prehospital Diagnosis of STEMI via the ECG

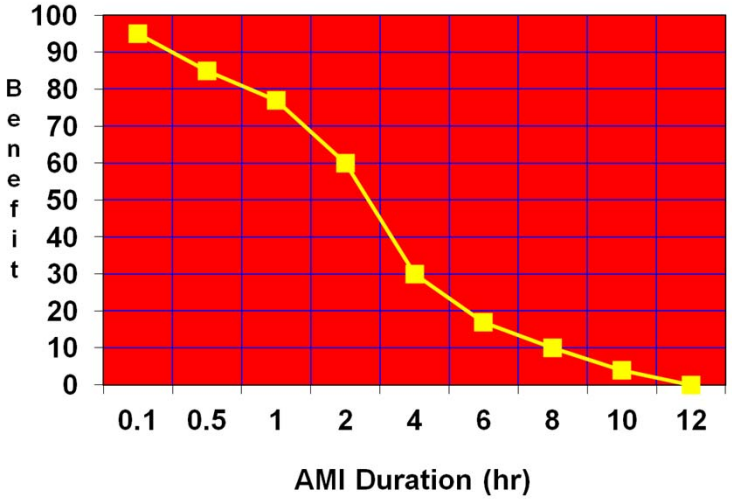
"…greatly reduces time to hospital-based reperfusion Rx…and should be used."

Investigation (Lead Author)	ECG Interpretation	Time to Hospital Reperfusion* (Study Patients) [minutes]	Time to Hospital Reperfusion* (Control Patients) [minutes]	Time Difference [minutes]
Kereiakes 1992	Hospital	30	50	20
Foster	EMS	22	51	29
Karagounis	Hospital	48	68	20
Kereiakes 1990	Hospital	36	63	27
Millar-Craig	EMS	37	97	60
Canto	Hospital	30	40	10
Aufderheide	Hospital	46	65	19

Average Time Savings = 27 minutes

Time to Therapy in STEMI

"Re-establishing Coronary Flow"



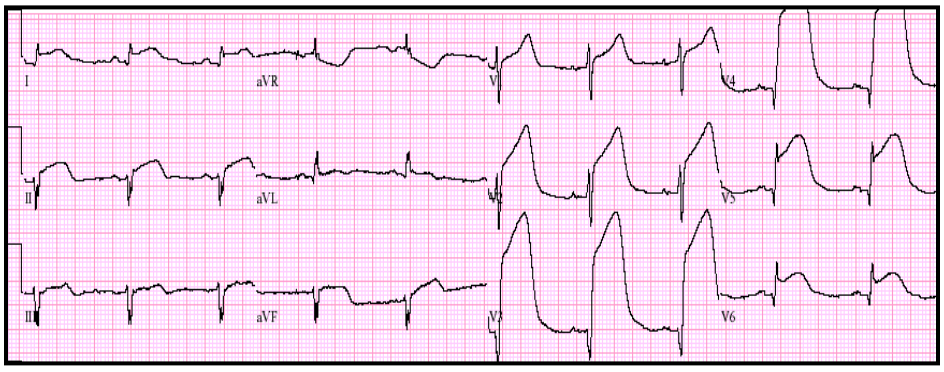
Uses of the ECG in Patients with Suspected ACS

- Uses
  - Establish the diagnosis
  - Select appropriate therapy
  - Predict risk of CV complications & mortality
  - Choose appropriate in-house disposition
  - Evaluate other causes of chest discomfort
- Caveats
  - Imperfect tool
  - Ultimate plan should not rely solely on ECG

ECG Diagnosis of ACS

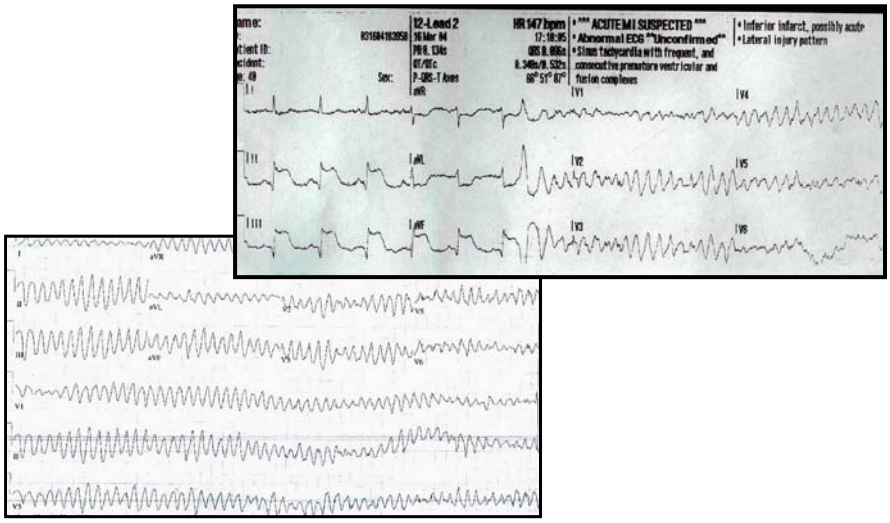
Risk Stratification in Suspected ACS

- The primary initials tools
  - History – guides early evaluation
  - Examination – less helpful, only complications
  - ECG – primary diagnostic study
  - Biomarkers – useful in select situations
- Impact of alternative diagnoses
- "Process" of evaluation – R/O MI process



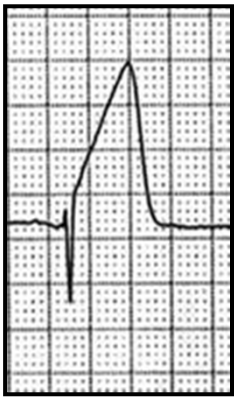
Sometimes it is not subtle …

….or just plain obvious!



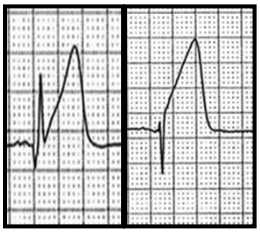
ECG Findings of STEMI

The Prominent T Wave

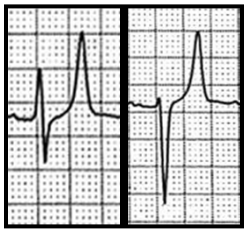


Prominent T Wave

- Also known as **"hyperacute" T wave**
- Earliest ECG sign of STEMI
  - 5 - 30 min after onset
  - Transient feature / often not seen
  - Reasonable ECG indication for urgent reperfusion
- Differential diagnosis is broad
  - STEMI vs. hyperkalemia

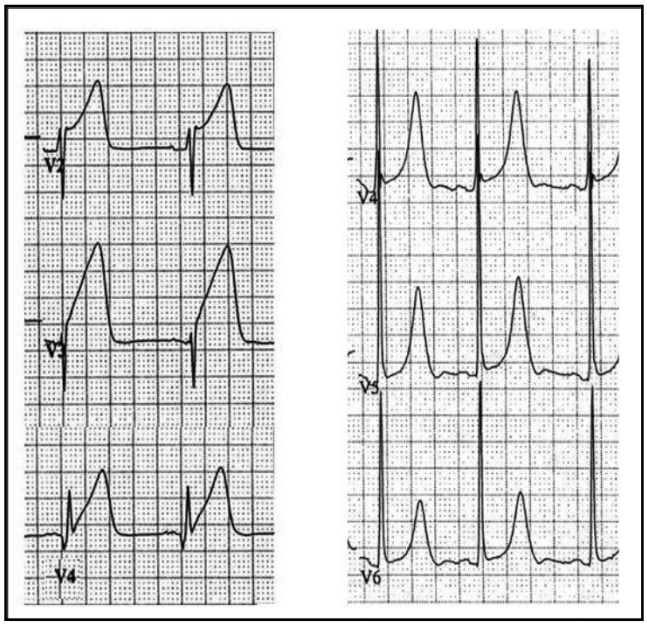


STEMI

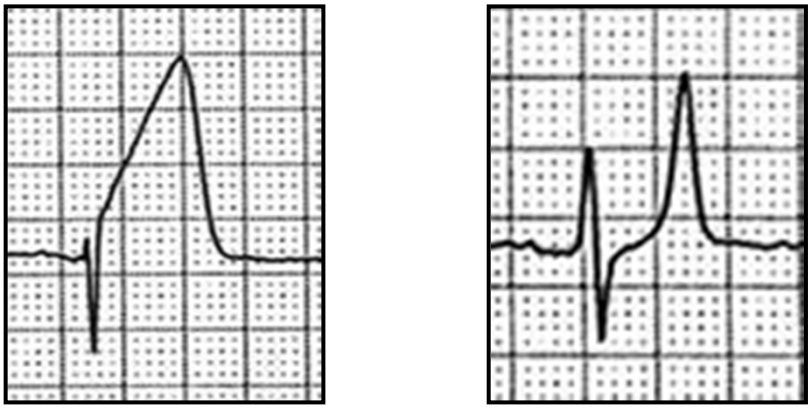


Hyperkalemia

STEMI Hyperkalemia



STEMI Hyperkalemia

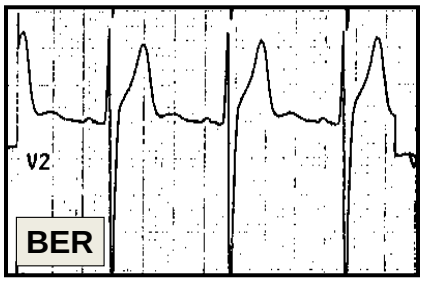


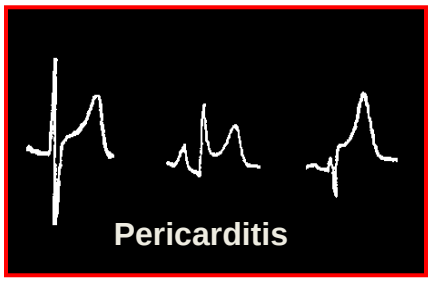
Width

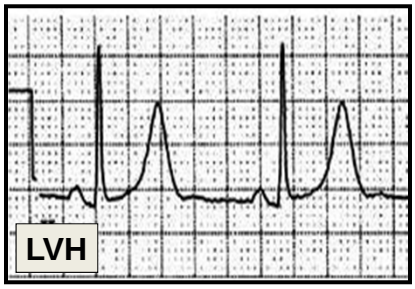
Broad vs Narrow

Symmetry

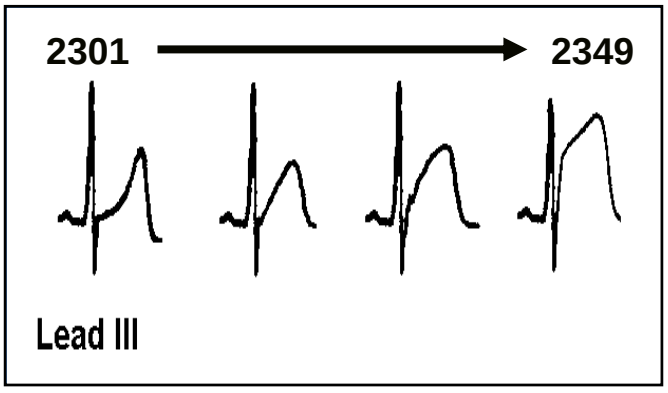
Asymmetric vs Symmetric







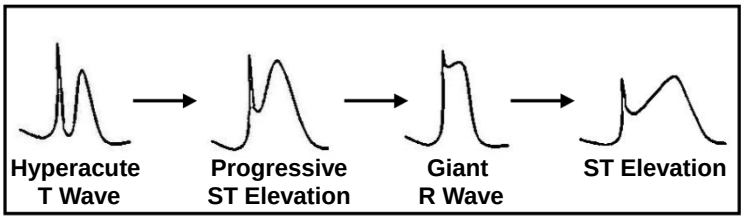
Evolution of STEMI
Hyperacute T Wave



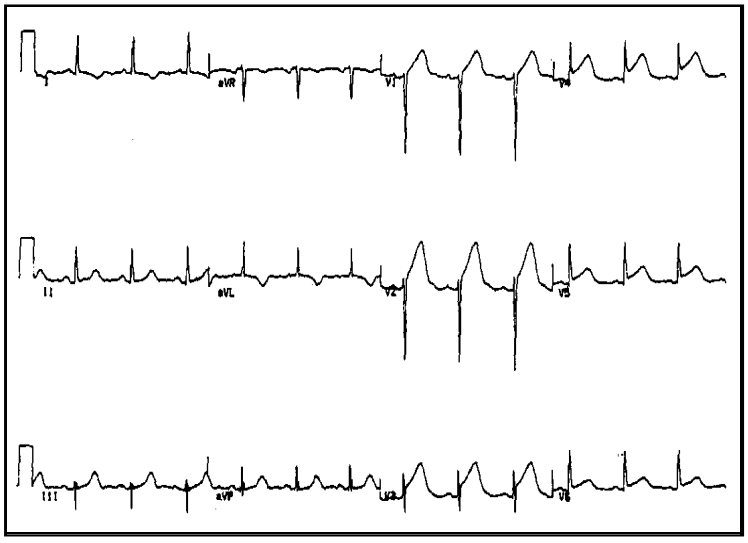
Evolution of STEMI

Hyperacute T Wave Transition to STEMI

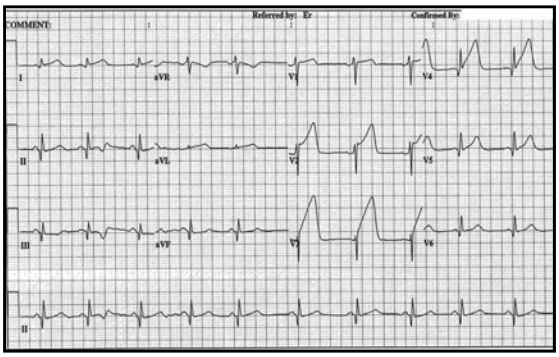
1523 → **1549**



Prominent T Wave in Early STEMI



56 year-old male with chest pain for 20 minutes.
Exam—alert, pale, diaphoretic, BP 105/70, lungs clear.
Based upon this ECG, would you:
A. Administer ASA and nitro
B. Administer ASA and metoprolol IV
C. Administer ASA and activate STEMI ALERT
D. Stop at McDonalds for a BigMac (without cheese, of course)



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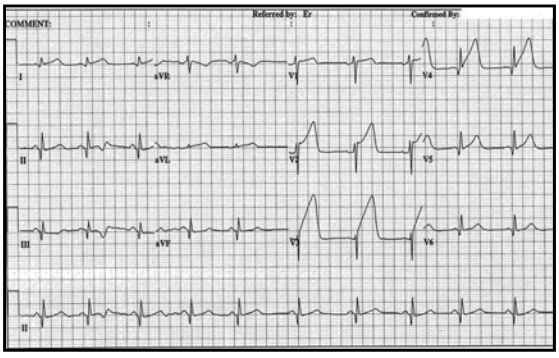
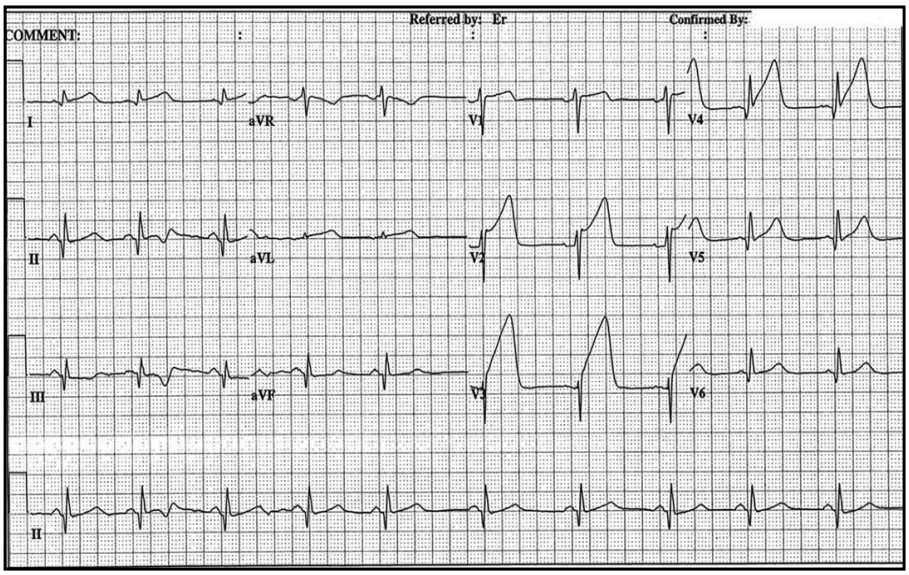
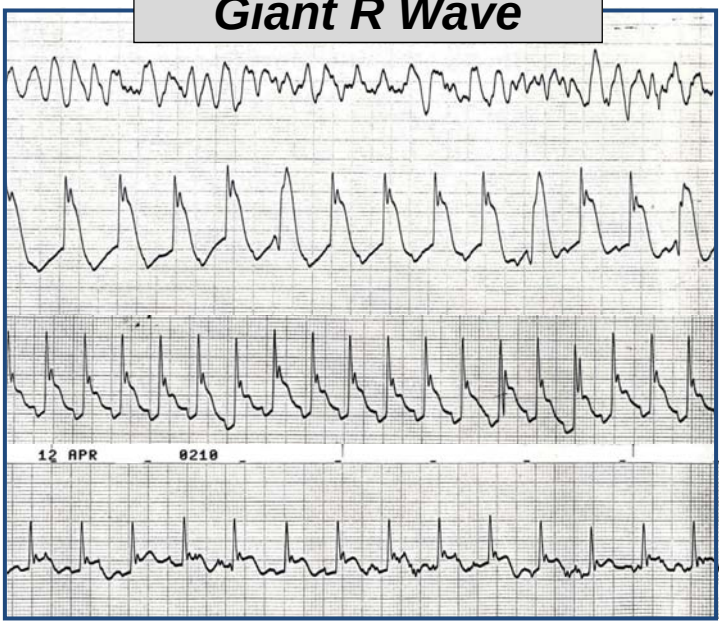


Prominent T Wave in Early STEMI



Evolution of STEMI
Giant R Wave



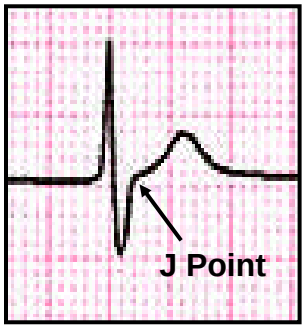
ST Segment Elevation

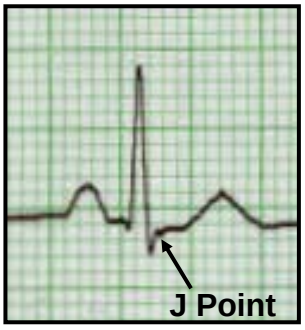
ST Segment Elevation

- Current of injury -- STEMI
- A "demanding" ECG finding
  - Identifies a potential time-sensitive lesion
  - Requires urgent therapeutic decisions
- Caution – not all ST elevation is STEMI

ST Segment

- Initiation @ J point
  - J point = juncture of QRS complex with ST segment
- Termination @ T wave
- Normal = isoelectric +/- 1 mm





ACEP Clinical Policy

CARDIOLOGY/CLINICAL POLICY

Clinical Policy: Indications for Reperfusion Therapy in Emergency Department Patients with Suspected Acute Myocardial Infarction

From the American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on Reperfusion Therapy in Emergency Department Patients with Suspected Acute Myocardial Infarction:
Francis M. Fesmire, MD (Subcommittee Chair)
William J. Brady, MD
Sigrid Hahn, MD
Wyatt W. Decker, MD
Deborah B. Diercks, MD
Chris A. Ghaemmaghami, MD
Devorah Nazarian, MD
Andy S. Jagoda, MD (Clinical Policies Committee Chair)

358 Annals *of* Emergency Medicine Volume 48, no. 4 : October 2006

AHA ACS Guidelines 2010

***Circulation* 2010;122:s787**

Part 10: Acute Coronary Syndromes: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Robert E. O'Connor, William Brady, Steven C. Brooks, Deborah Diercks, Jonathan Egan, Chris Ghaemmaghami, Venu Menon, Brian J. O'Neil, Andrew H. Travers and Demetris Yannopoulos

Circulation 2010;122;S787-S817
DOI: 10.1161/CIRCULATIONAHA.110.971028
Circulation is published by the American Heart Association. 7272 Greenville Avenue, Dallas, TX 72514

ST Segment Elevation

Anatomically oriented ST elevation

-- ≥ 1 mm in at least 2 leads
-- ≥ 2 mm in at least 2 precordial leads
-- lacking features of non-infarction syndrome

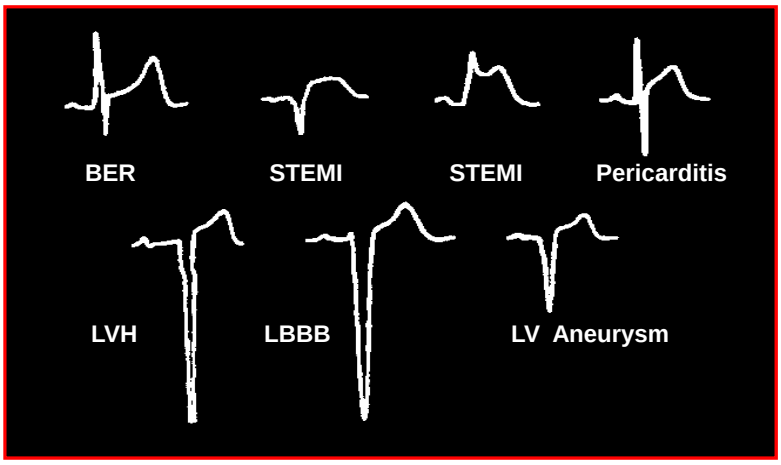
ST Segment Elevation

A key phrase.....

"*.....lacking features of non-infarction syndrome.*"

ACEP 2006 & AHA 2010 Guidelines

ST Segment Elevation
Electrocardiographic Differential Diagnosis



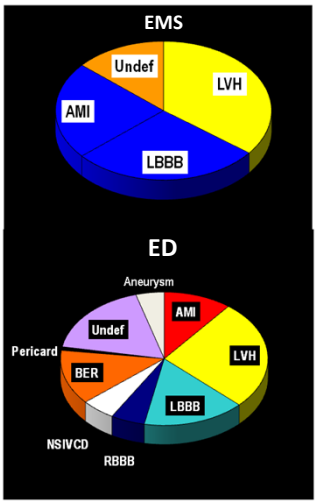
ST Segment Elevation

Electrocardiographic Cause of ST Elevation

Multiple causes of ST segment elevation

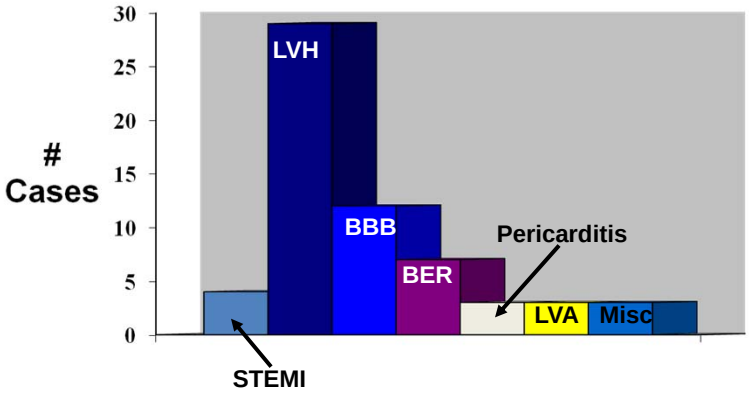
-- Adult patients
-- Chest pain (or equivalent)
-- ST elevation in 2 leads

....Similar criteria for fibrinolysis & PCI



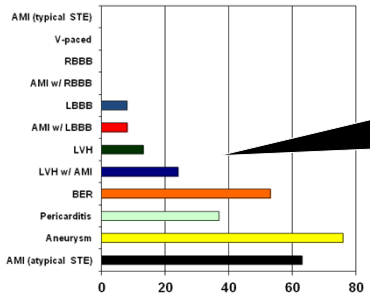
Electrocardiographic Patterns Responsible for Interpreter Disagreement

-- Determination of ST Segment Elevation --



Erling et al, Am J Emerg Med, 2003

ST Segment Elevation
Errors in Interpretation by EPs

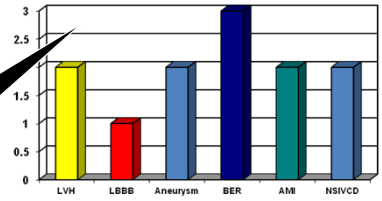


Brady et al, Acad Emerg Med 2001;8:349

Survey of Emergency Physicians
Adult Chest Pain Patients with ECG ST Segment Elevation

Error rate = 5.9%

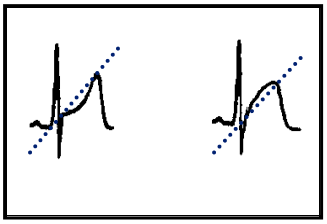
Rate of Incorrect ECG Diagnosis



Brady et al, Acad Emerg Med 2000;7:1256

Interpretative Aides with ST Segment Elevation
STEMI vs non-STEMI Causes of Elevation

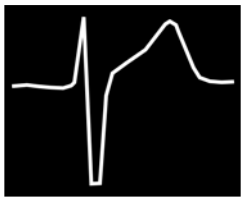
- **ST segment morphology**



- **Reciprocal ST segment depression**

- **Dynamic change of ST segments**

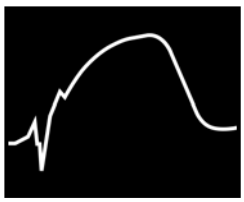
ST-Segment Abnormalities



Concave upward
(BER)

Concave upward
(pericarditis)

Oblique straightening
(AMI)

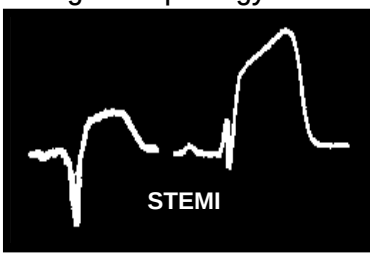


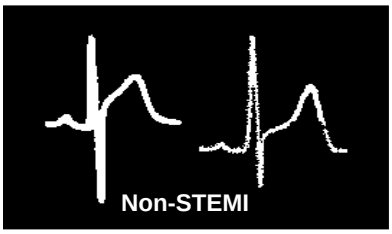
Convex upward
(AMI)

ST Segment Elevation

Morphology

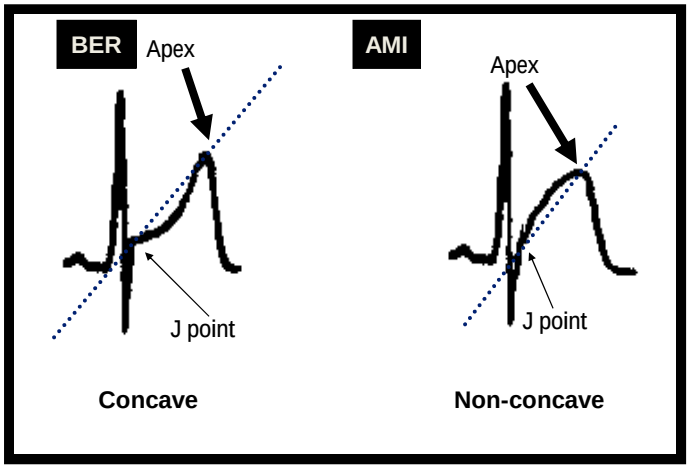
ST segment elevation in STEMI -- convex or obliquely straight morphology





ST segment elevation in non-infarction syndromes -- frequent concave morphology

Determination of ST Segment Morphology



Brady et al, Acad Emerg Med 2001;8:961

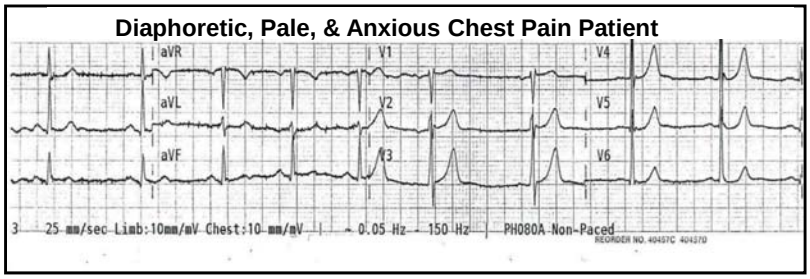
Reciprocal Change & Dynamic Nature of ST Segment Elevation

Reciprocal Change

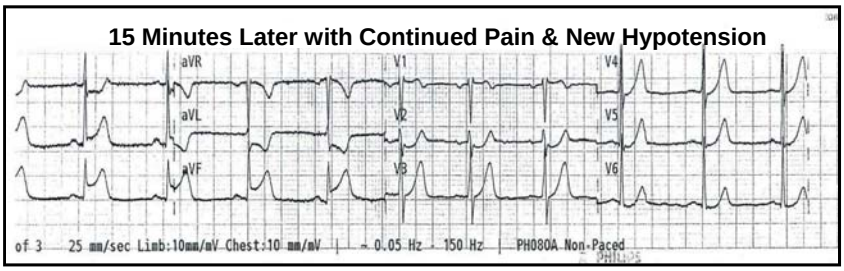
- **Definition: ST segment depression distant from ST segment elevation on same ECG**
- **Frequency of occurrence**
  - **75% inferior STEMI**
  - **30% anterior STEMI**
- **Uses**
  - **Increases diagnostic accuracy of ST elevation**
  - **Identifies higher risk STEMI presentations**

Serial ECGs

Diaphoretic, Pale, & Anxious Chest Pain Patient



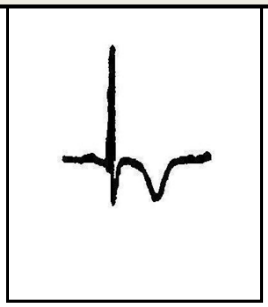
15 Minutes Later with Continued Pain & New Hypotension

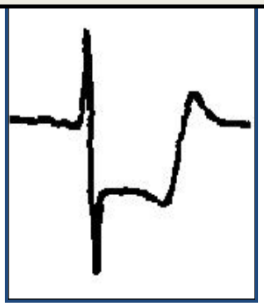


Reciprocal Change & Dynamic Nature of the ST Segment Elevation Discussion to Follow

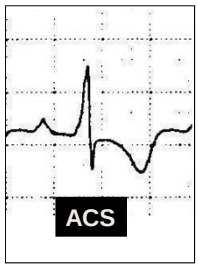
Other Electrocardiographic Abnormalities

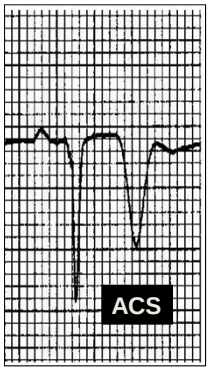
T Wave Inversion &
ST Segment Depression

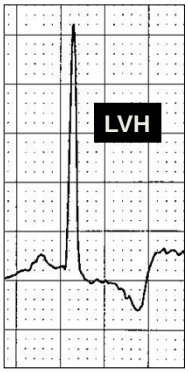


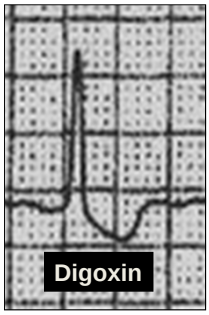


T Wave Inversions



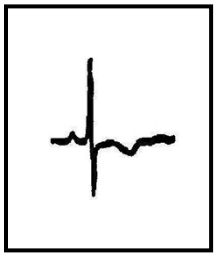


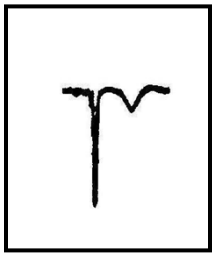


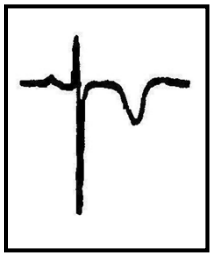


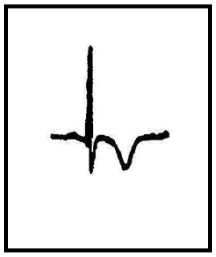
T Wave Inversions

Acute Coronary Syndrome





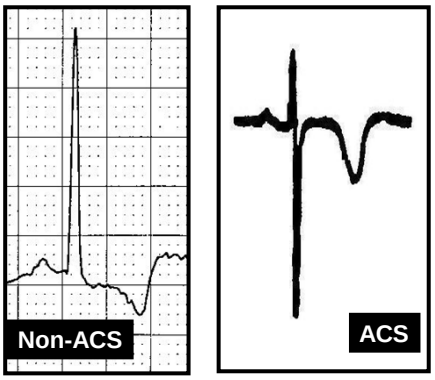




T Wave Inversions

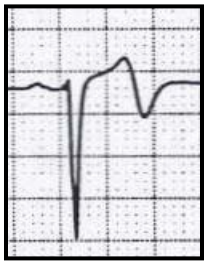
ACS vs. Non-ACS

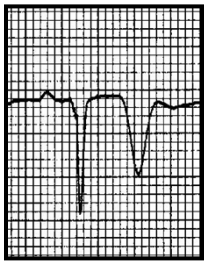
- **Non-ACS**
  - **Gradual down-sloping limb**
  - **Abrupt return to baseline**
  - **"Overshoot"**
  - **Fixed**
- **ACS**
  - **Symmetric**
  - **Dynamic**



Wellen's Syndrome

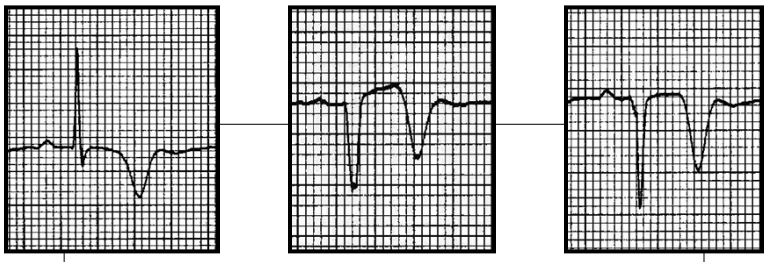
"The LAD Coronary T Wave Syndrome"



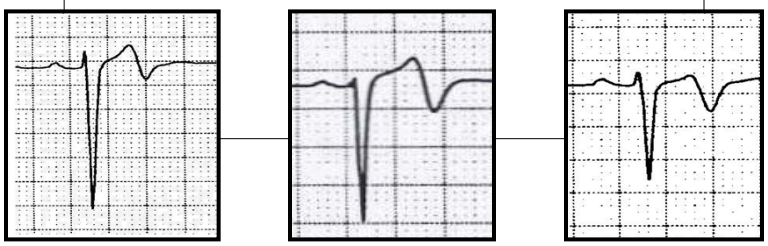


Wellen's Syndrome

- **Pattern of ECG changes associated with critical, proximal LAD stenosis**
- **Also referred to as "LAD coronary T wave syndrome" or "widow maker syndrome"**
- **Syndrome criteria: T waves changes plus…**
  - **-- History of chest pain**
  - **-- No serum marker changes**
  - **-- No Q waves, ST elevation, or loss of R wave**
- **Natural history -- anterior wall AMI within 30 days**

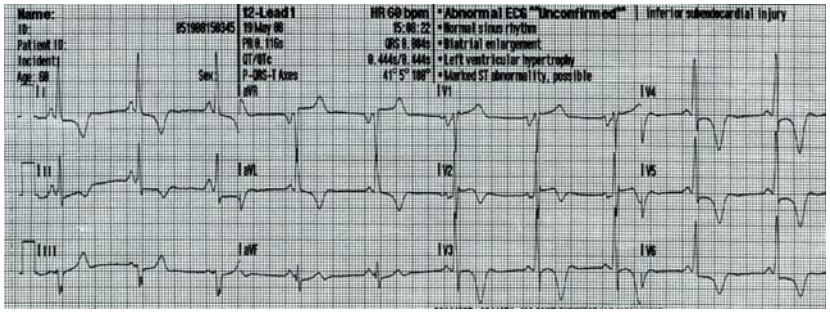


- **Two patterns have been described**
- **Deeply inverted T waves across the right / mid precordium (75%)**
- **Biphasic T waves in a similar distribution (25%)**



59 year-old female with recent chest pain who is now without complaint and has a normal exam. She wants to refuse any care. You decide that:

A. this is likely ok in that she is painfree and well appearing.
B. this is really a bad idea and do your best to explain the risks of nontreatment.
C. this is not the best plan but as long as she sees her doctor in the next week or so, that's ok.
D. I really do not reading ECGs so I am going to ignore this extremely high-risk pattern.



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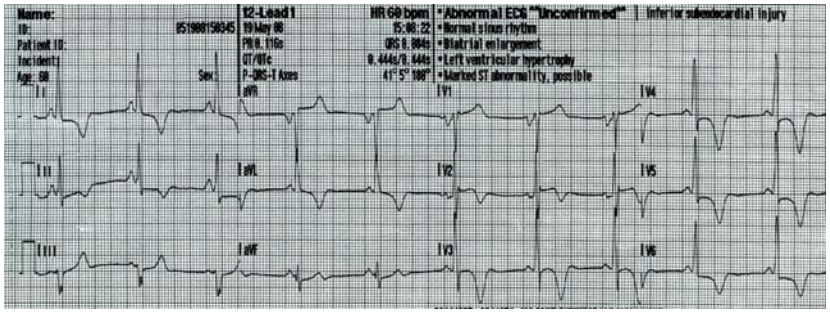
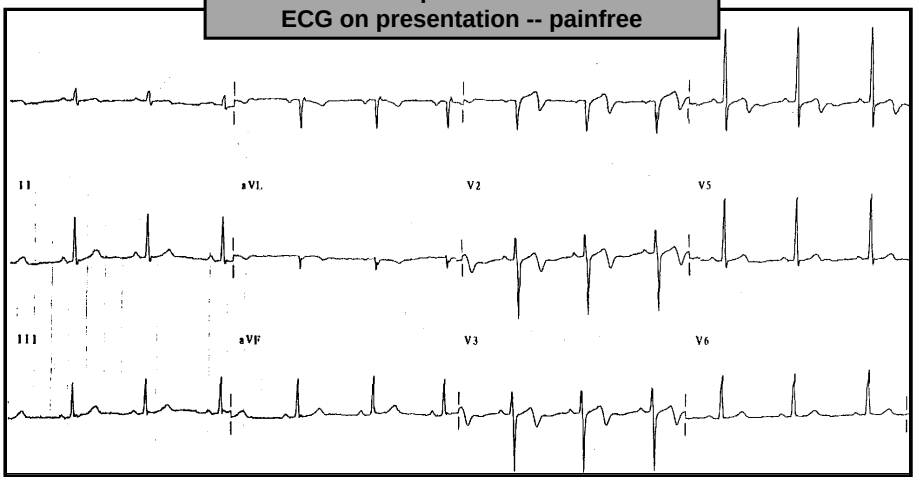


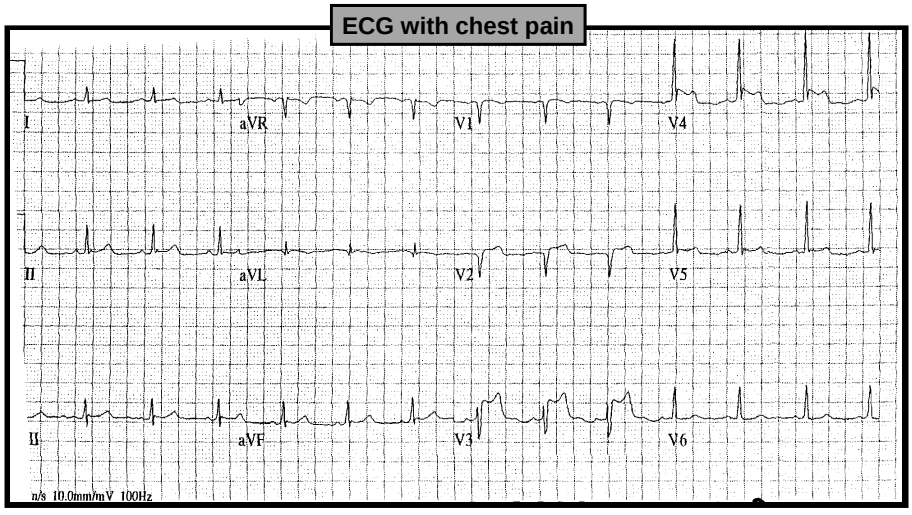
Wellen's Syndrome

Recent Complaint of Chest Pain
ECG on presentation -- painfree

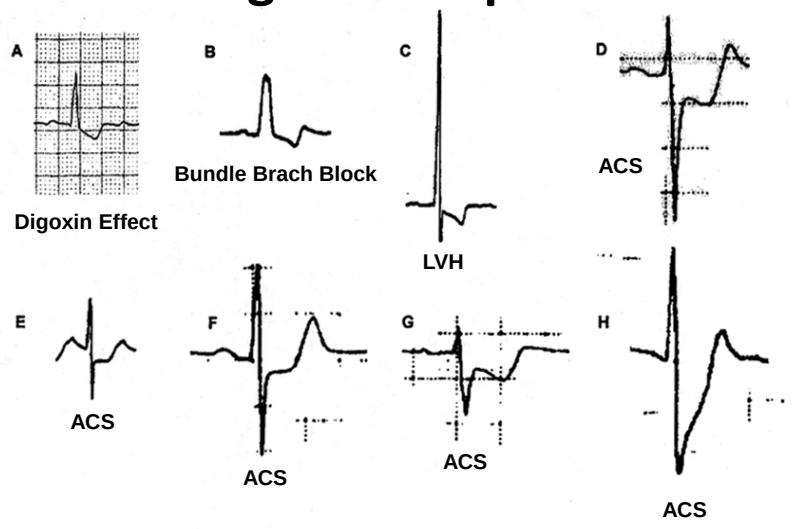


Wellen's Syndrome

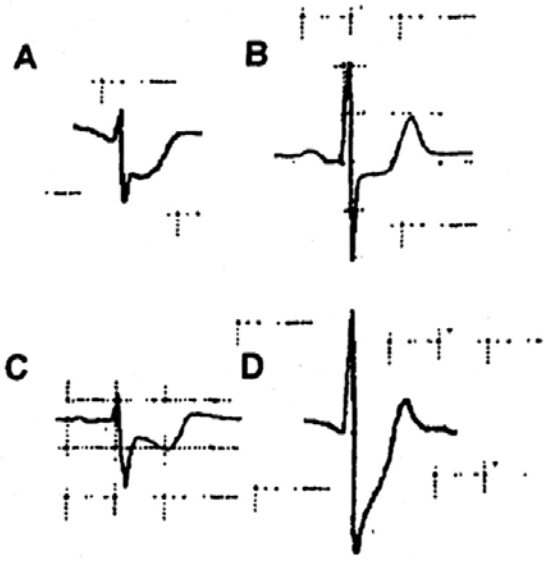
ECG with chest pain



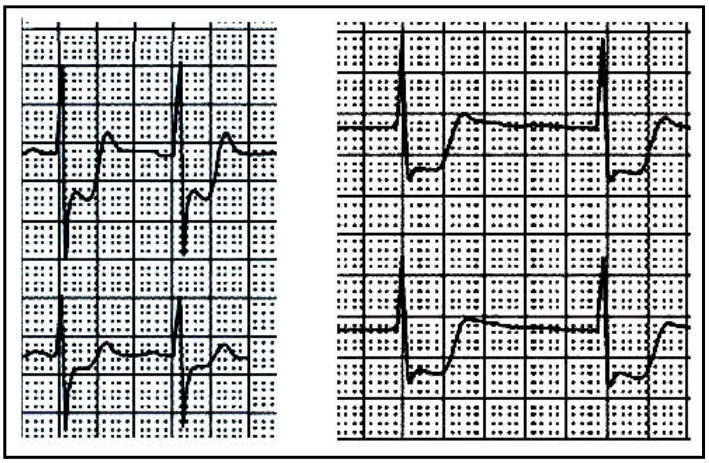
ST Segment Depression



ST Segment Depression -- ACS



ST Segment Depression

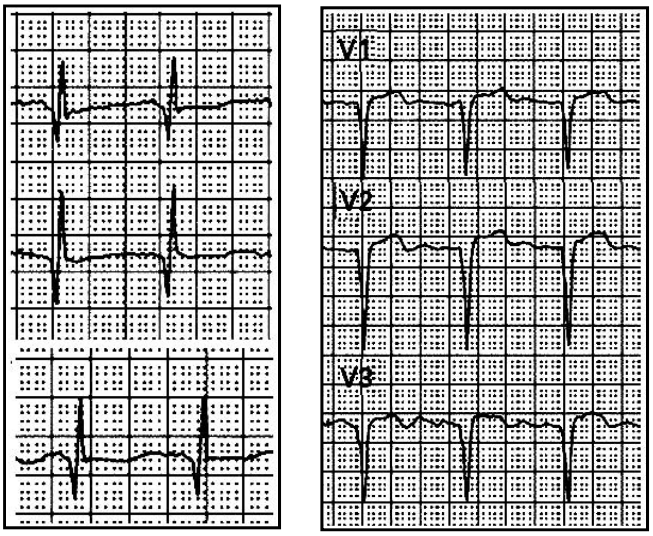


Q Wave

Q Waves

- **Most often a manifestation of myocardial necrosis**
  - **Usually fully developed within 9 – 12 hours post-MI**
  - **Can appears as early as 2 – 3 hours after onset**
  - **Do NOT use presence of Q wave to identify time course**
- **Indicates past MI – recognized or unrecognized**
  - **Sole finding in < 5% AMI presentations (ie, NSTEMI)**
  - **Frequent with other ECG abnormalities**
- **Reduces ECG's ability to detect ischemic extension into adjacent area(s)**

Q Wave

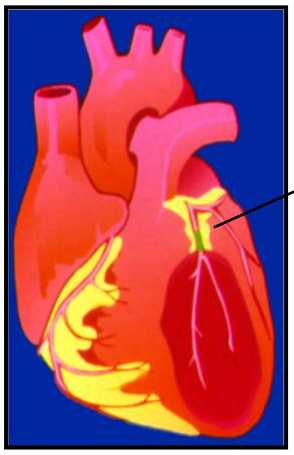


BREAK

Regional STEMI Issues

Localization of Myocardial Infarcts

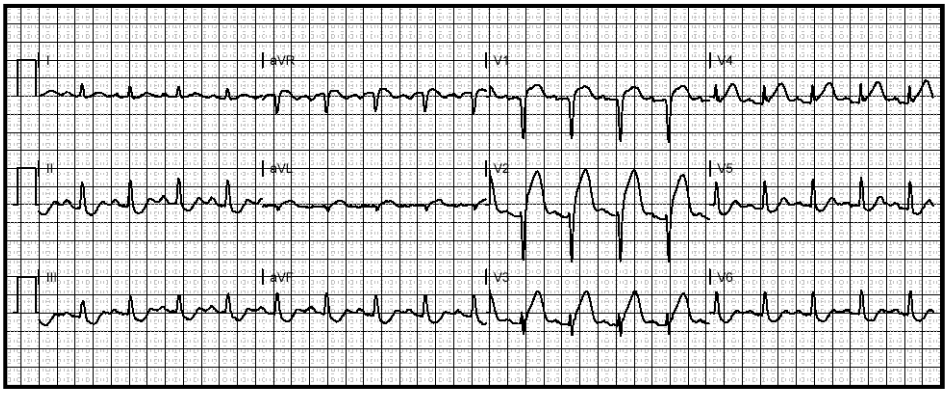
Anterior or Anteroseptal STEMI



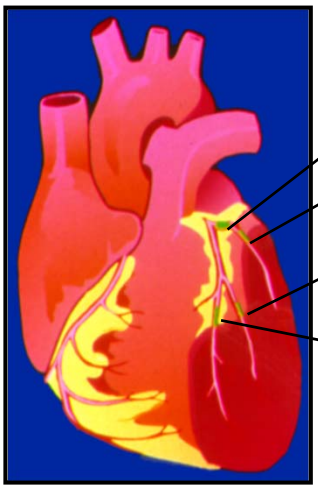
Occlusion of the proximal left anterior descending coronary artery

Anterior or Anteroseptal STEMI

Leads V_1-V_4



Anterolateral STEMI



Occlusion of the:

Left circumflex coronary artery

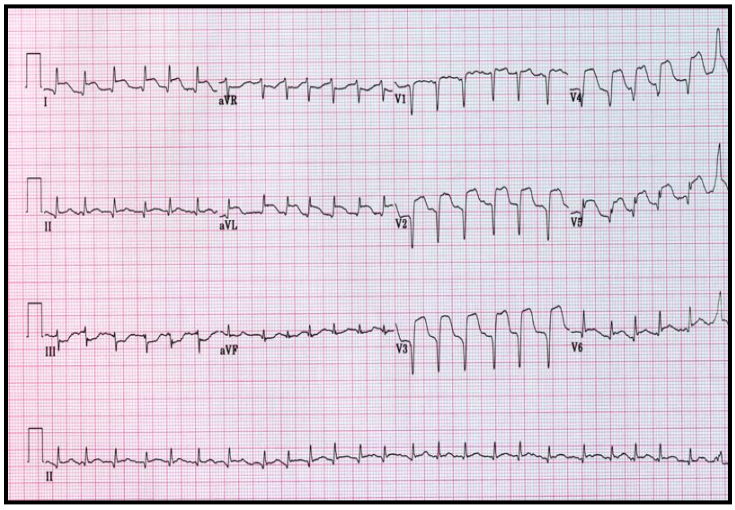
Marginal branch of left circumflex artery

Diagonal branch of left anterior descending artery

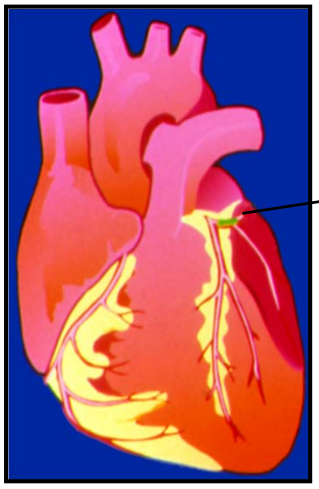
Left anterior descending artery

Anterolateral STEMI

Leads $V_1 - V_4$ & I, AVL, V_5, V_6



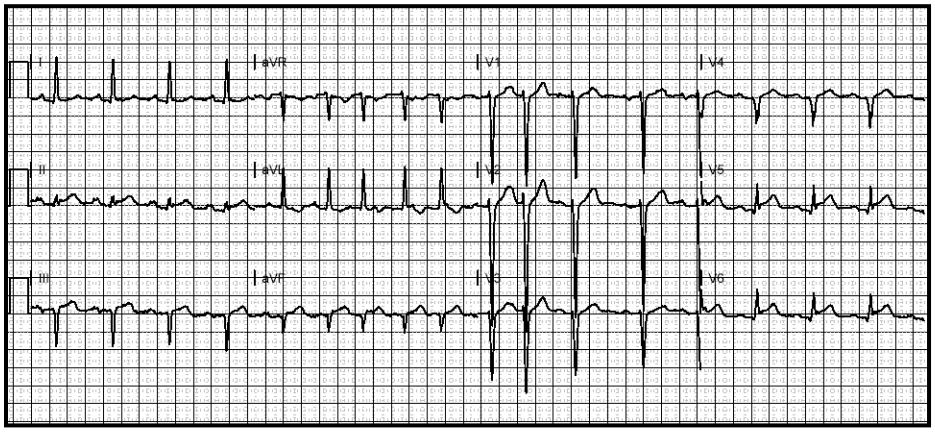
Lateral STEMI



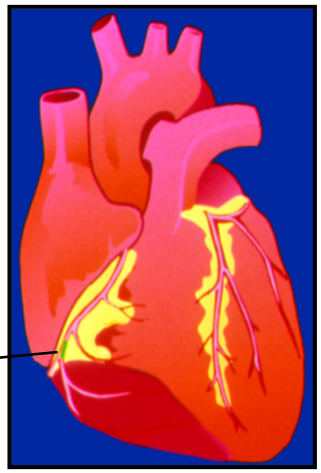
Occlusion of the left circumflex coronary artery

Lateral STEMI

Leads I & AVL



Inferior STEMI

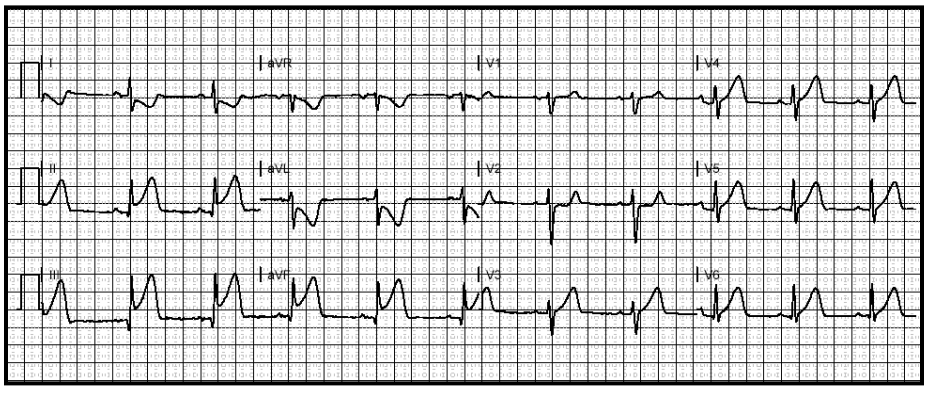


Occlusion of the

right coronary artery

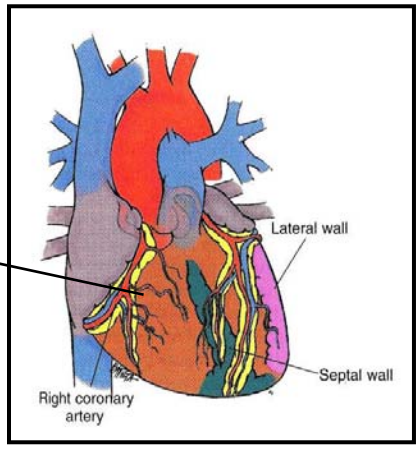
Inferior STEMI

Leads II, III, AVF



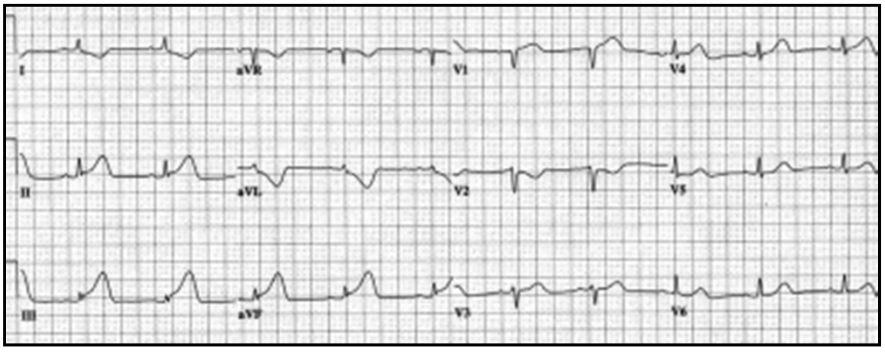
Right Ventricular Infarction

Occlusion of the RV Branch of RCA



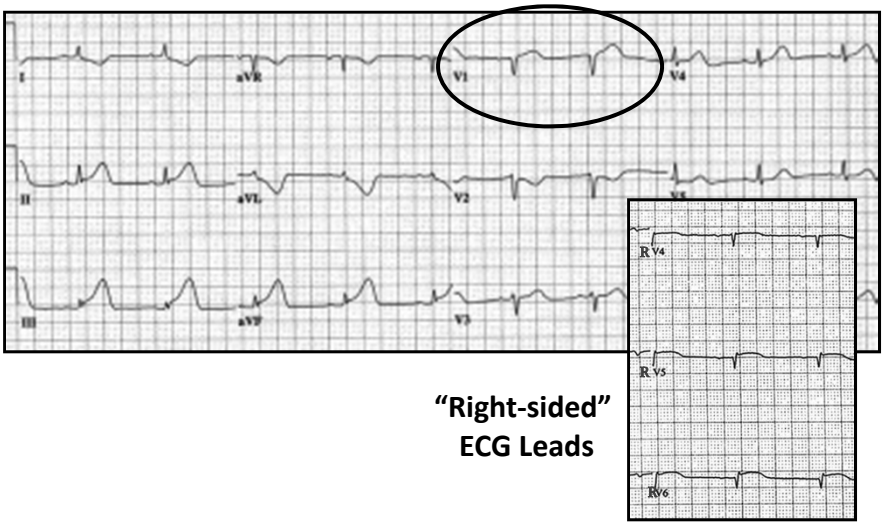
Inferior STEMI with RV Infarction

Leads II, III, AVF and……



Inferior STEMI with RV Infarction

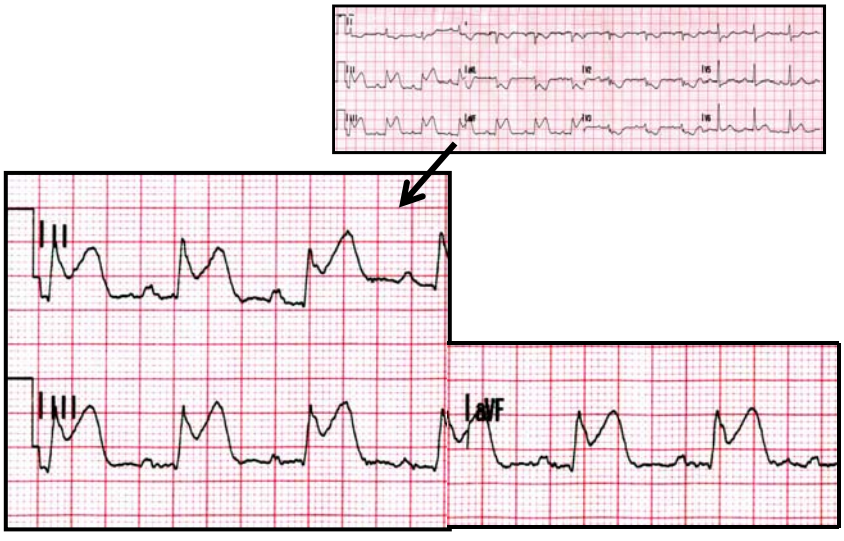
…..V1, RV leads



"Right-sided" ECG Leads

Inferior STEMI with RV Infarction

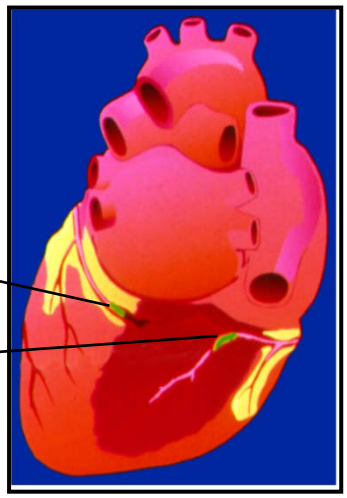
ST Elevation III > II or AVF



Posterior AMI

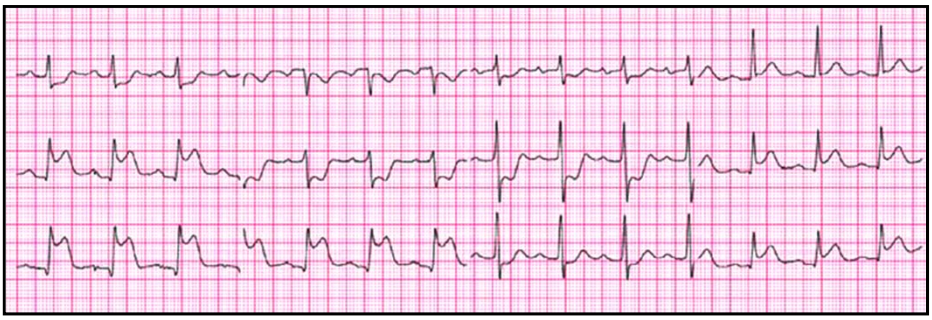
Occlusion of the distal circumflex artery

Occlusion of the posterior descending or distal right coronary arteries



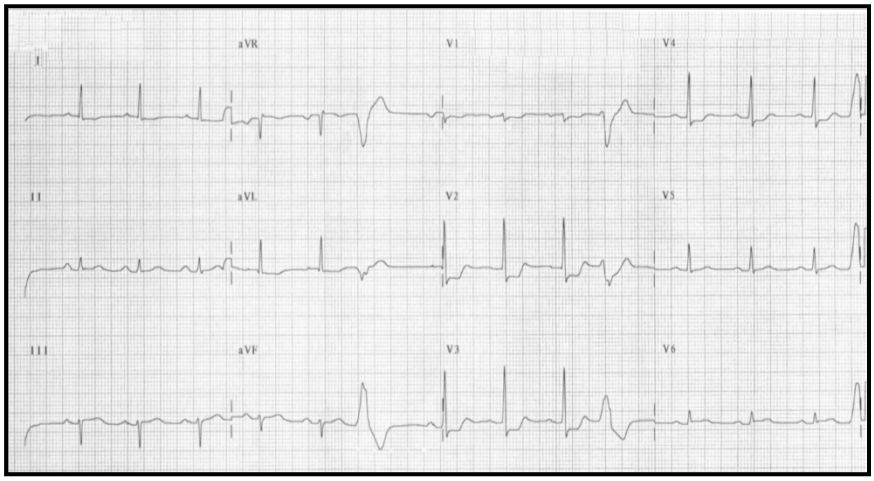
Posterior AMI with Inferior STEMI

ST Depression V1, V2, +/- V3 with ST Elevation II, III, AVF



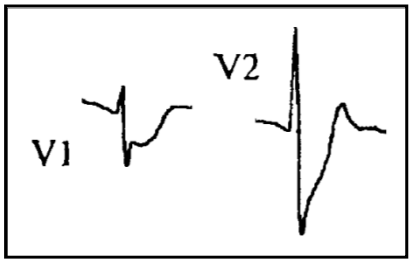
"Isolated" Posterior AMI

ST Depression in $V_1 - V_4$ and ....

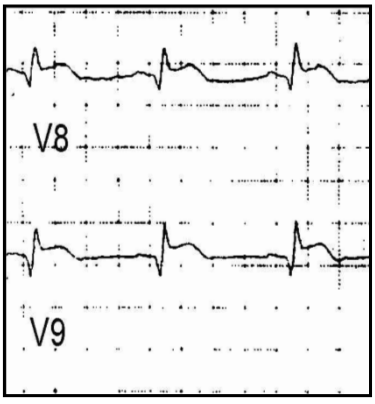


Posterior AMI

12-lead & Additional-lead Findings



12-lead ECG
Leads V1 & V2



Additional-lead ECG
Leads V8 & V9

ECG Diagnostic Tools & Interpretative Aids

Reciprocal ST Segment Depression

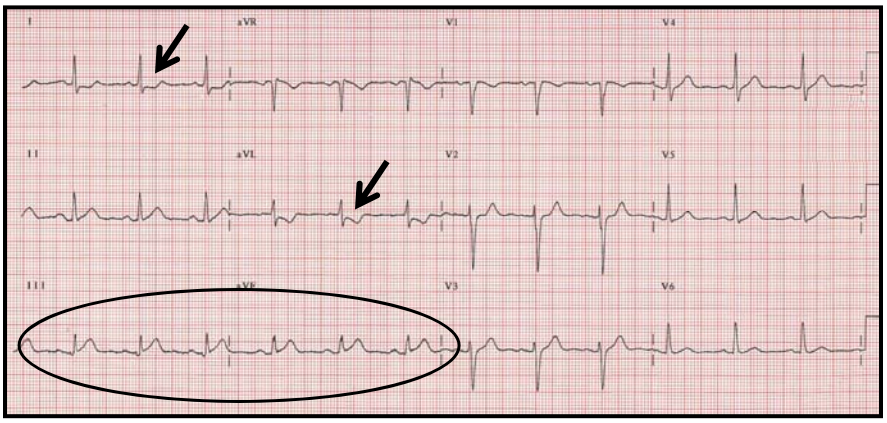
“Reciprocal Change”

Reciprocal Change

- Defined as ST segment depression distant from ST segment elevation
- Seen in 75% of inferior STEMI & 30% anterior STEMI
- Increases diagnostic accuracy of ST elevation -- PPV of 95% for STEMI
- Most useful – subtle ST segment elevation
- Also identifies higher risk STEMI presentations

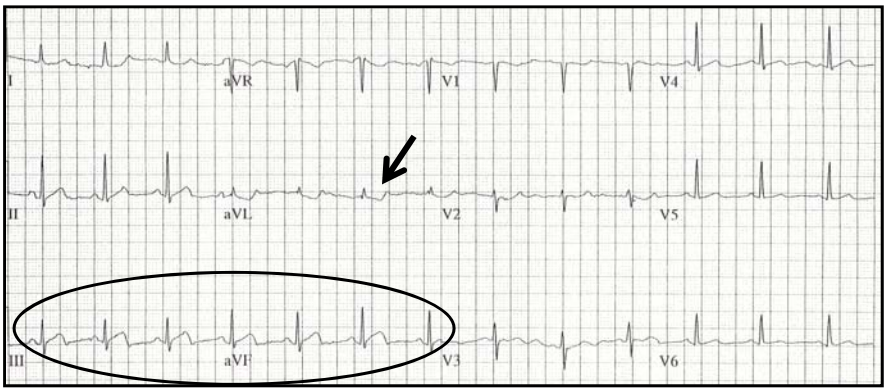
Subtle Acute Inferior Wall STEMI

Reciprocal ST segment Depression Leads I & aVl



Subtle Inferior Wall STEMI

with Reciprocal ST Segment Depression



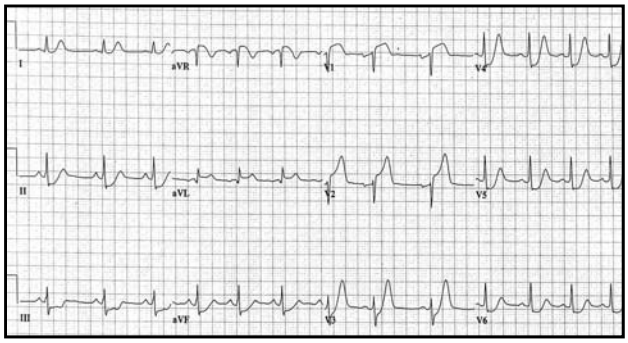
In this patient with obvious anterior STEMI, what does the widespread ST segment depression indicate:

A. Confirmation that this ECG demonstrates STEMI

B. Predicts a greater chance of adverse event

C. A and B are correct

D. Boy, there's is a lot of abnormality on this ECG.



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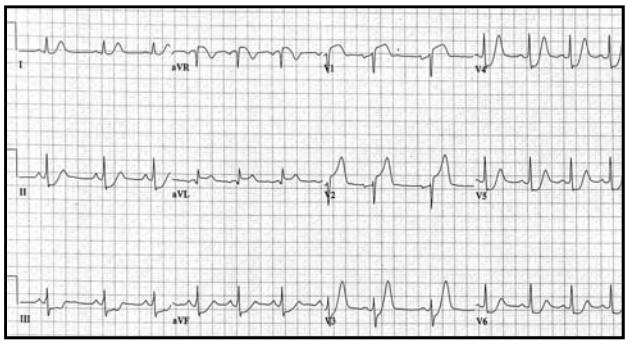
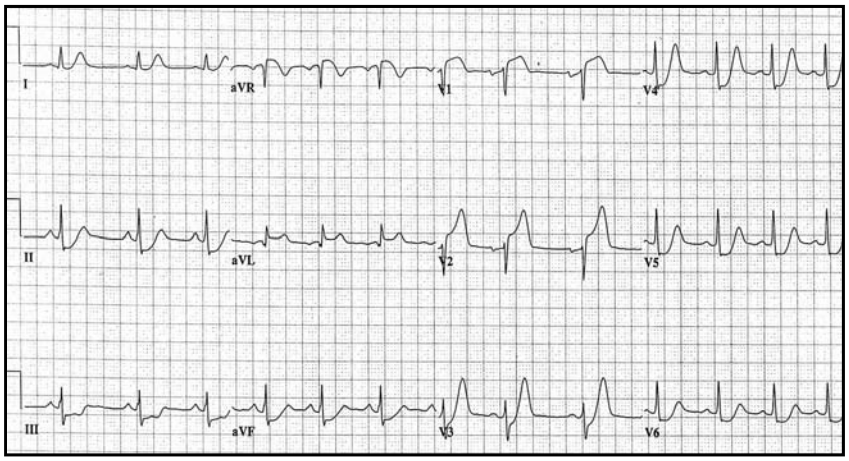


Obvious Anterior Wall STEMI

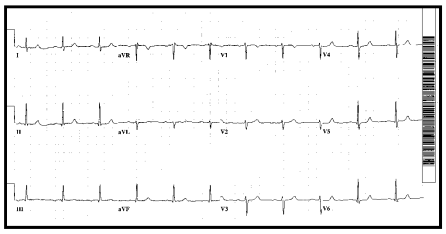
Diffuse Reciprocal ST segment Depression

High Risk ECG Presentation



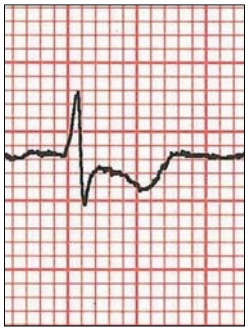
Early "Reciprocal" Change in Lead aVl

- The normal ECG -- lead aVl
  - Isoelectric ST segment
  - Upright T wave

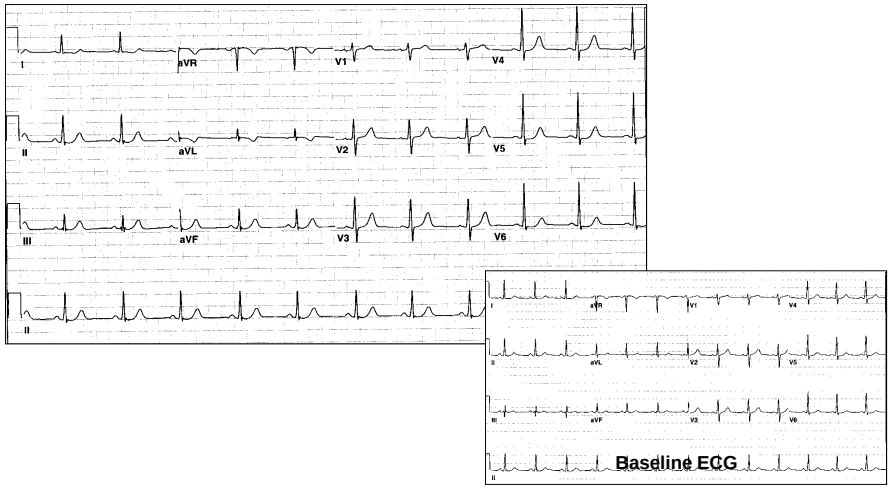


"Early" Reciprocal Change in Lead aVl

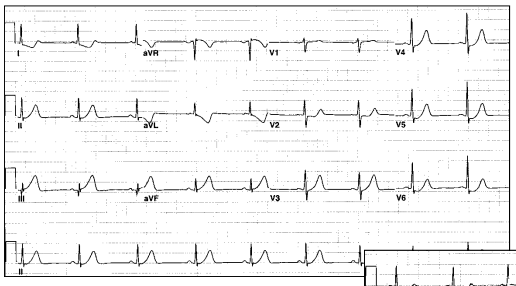
- Predictive of impending inferior wall STEMI



Early Reciprocal Changes in Lead aVl
Adult Female with Chest Pain & Diaphoresis

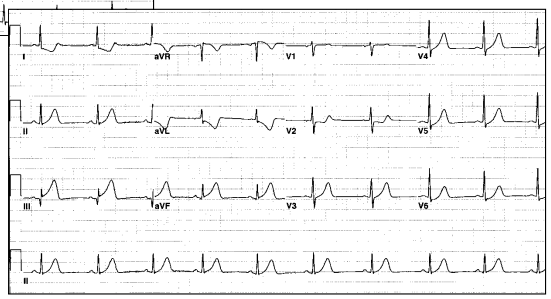


Early Reciprocal Changes in Lead aVl



Increasing Discomfort

Hypotension after Nitroglycerin



Inferior STEMI
PCI with RCA thrombus

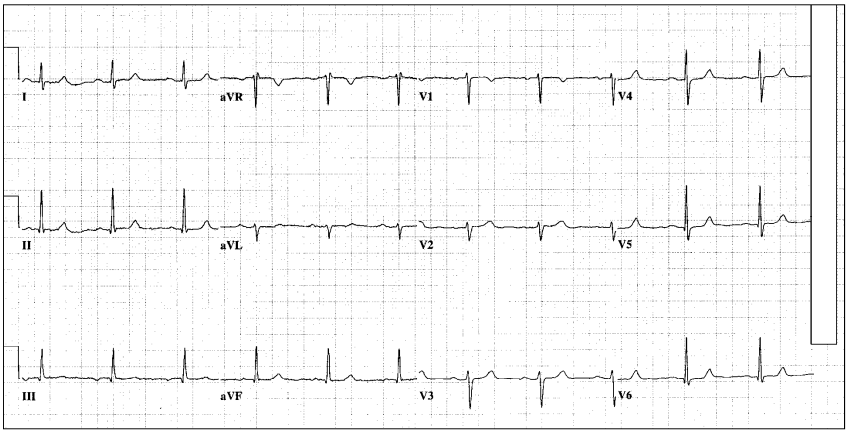
Loss of Precordial T-Wave Balance

"*Too Tall T Wave in Lead V1*" (*TT_{V1}*)

Normal ECG
Normal T Wave in Lead V1

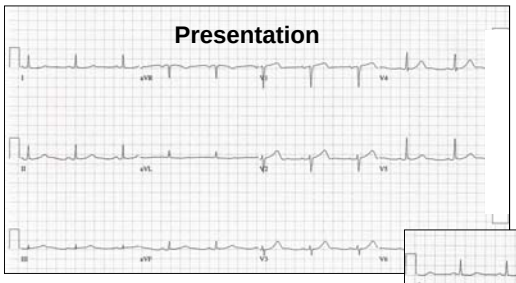
- **Normal T wave in lead V1 is INVERTED**
- **In <u>appropriate</u> patient, potential early warning of anterior ACS event**

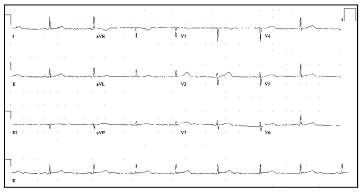
Normal ECG
Normal T Wave in Lead V1



TT_{V1}
49 year-old Male
Chest Pain

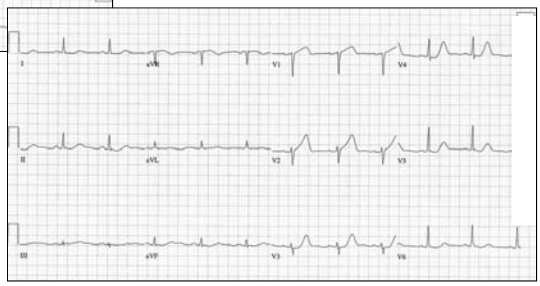
Presentation





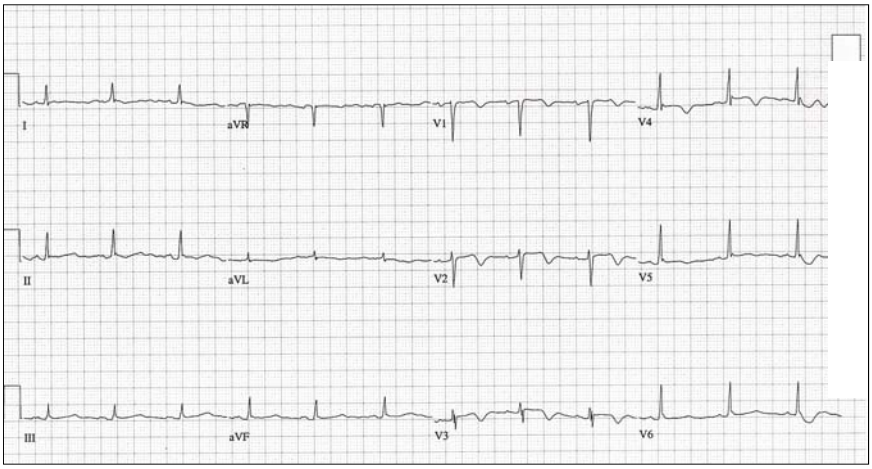
Baseline ECG

Increased Chest Pain
Hypotension & Pulmonary Edema



TT_{V1}

s/p PCI Proximal LAD Lesion
+ Troponin



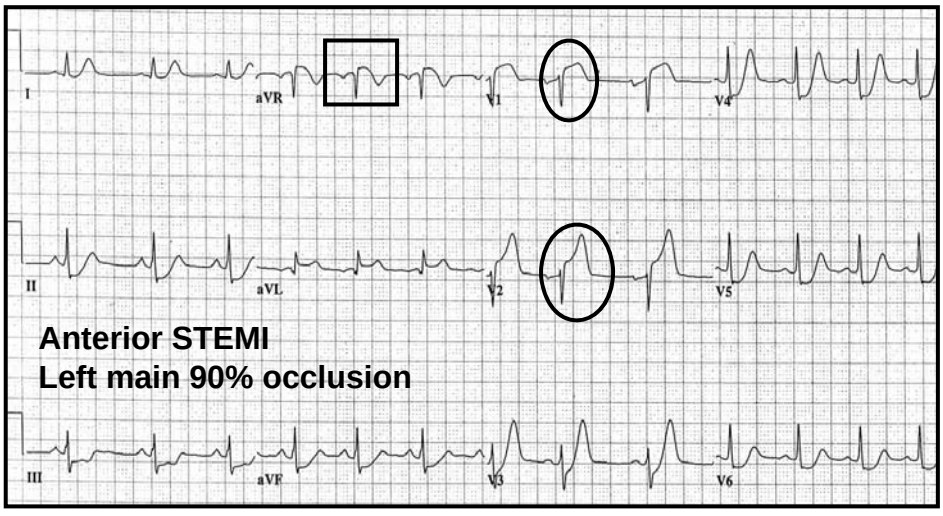
Left Main Coronary Obstruction

ST Segment Elevation in Lead aVR

Left Main Coronary Artery Obstruction

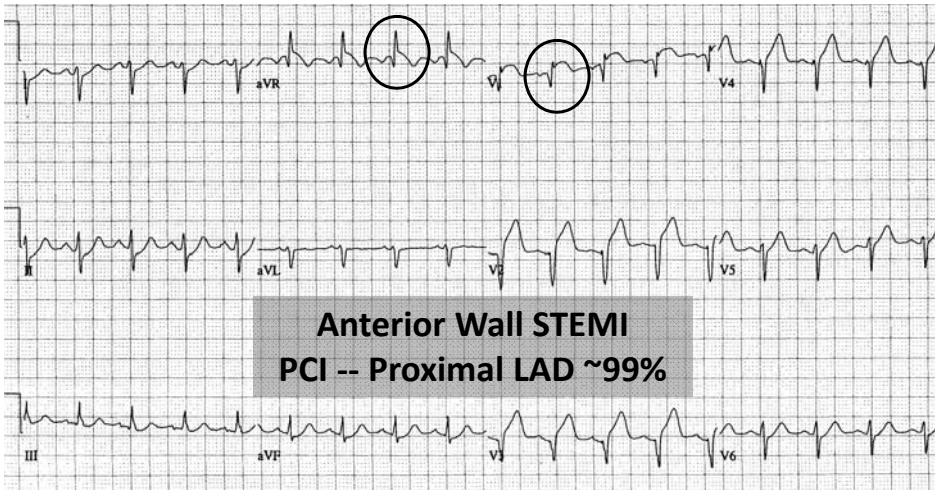
- Left main coronary artery (LMCA) stenosis -- 70% mortality
- Acute reperfusion therapy
  - Fibrinolysis does NOT improve outcome
  - PCI therapy decreases mortality to 40%
- Time to PCI = a major predictor of survival
- How to identify?
- ST segment elevation in lead aVr

58 year-old Female with Chest Pain



Anterior STEMI
Left main 90% occlusion

AMI with Proximal LAD Stenosis



Additional-lead ECGs

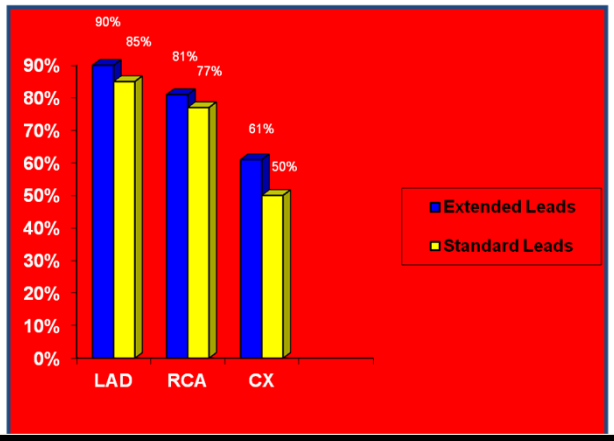
Additional-lead ECGs

- Why?
- Do we really know what we're missing?
  - Posterior
  - Right ventricular
  - More?????
- 15, 18, 24 leads…….
- Body Mapping

Additional-lead ECGs

- ED chest pain patients *(Brady et al AJEM 2000)*
  - Increased description of injury
  - No alteration in therapy or disposition
  - No false negative ST segment elevation
- ED chest pain patients to be admitted to CCU *(Zalenski et al Ann EM 1993)*
  - Increased rate of diagnosis of AMI
  - Increased sensitivity of AMI DX by 12%

Additional-lead ECGs



The diagnosis of AMI by standard leads I, II, III, aVR, aVL, aVF, & V_1 to V_6 with & without extended leads.

Additional-lead ECGs

!! Caution !!

- Literature-base is sparse
- Less clinical experience
- Tolerate lower magnitude ST segment elevation
- Other electrocardiographic findings not defined

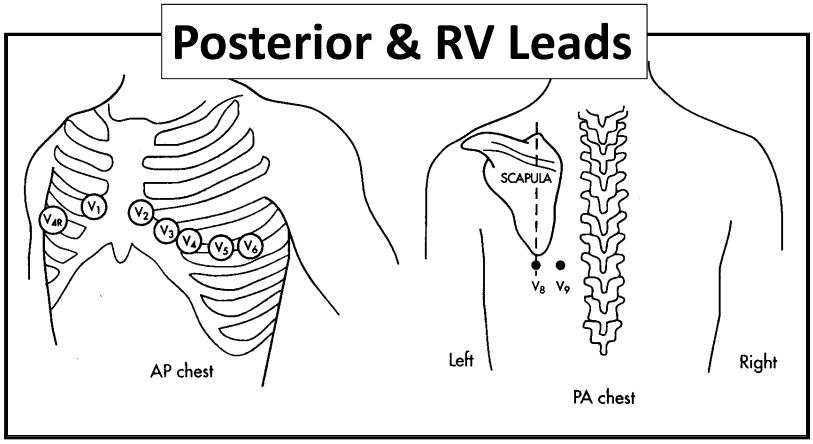
Additional-lead ECGs Indications

- Anterior (leads V_1, V_2, V_3) ST segment depression
- ST segment elevation AMIs
  - All inferior wall AMIs
  - All lateral wall AMIs
- Evidence of RV failure

Performing the 15-lead ECG

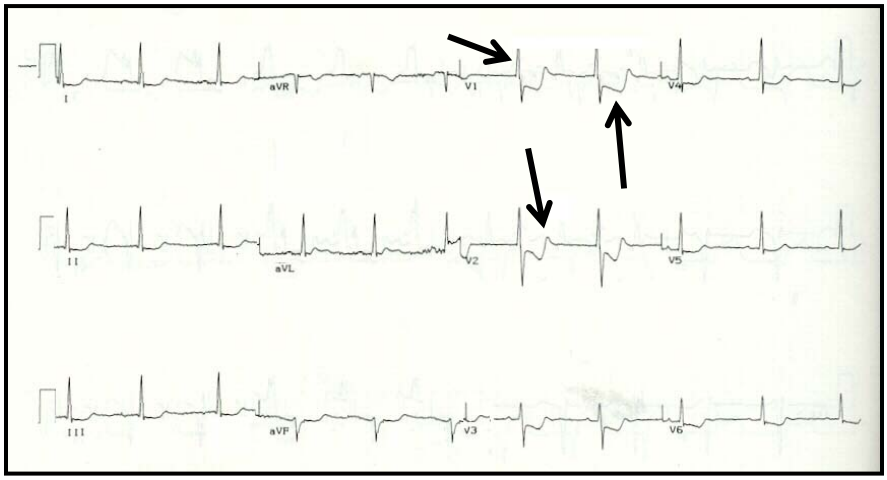
- 15-lead ECG machine / software or …..
- Use 12-lead ECG
  - Perform in standard fashion
  - Then remove V4, V5, & V6
    - Place V4 on right chest = lead RV4
    - Place V5 & V6 on left posterior thorax = leads V7 & V8
- 12 standard leads + 3 additional leads = The 15 lead ECG
- Label ECG appropriately

15-lead ECG



12 Standard Leads + V4R + V8 + V9 = 15-lead ECG

56 year-old Female
Chest pain with diaphoresis



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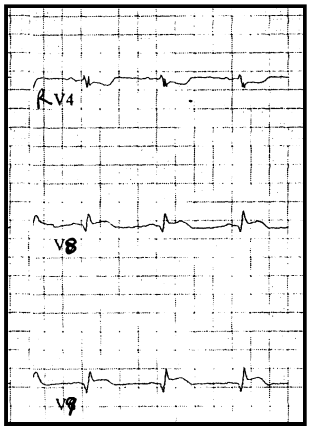


Posterior leads V8 & V9 -- acute posterior wall STEMI

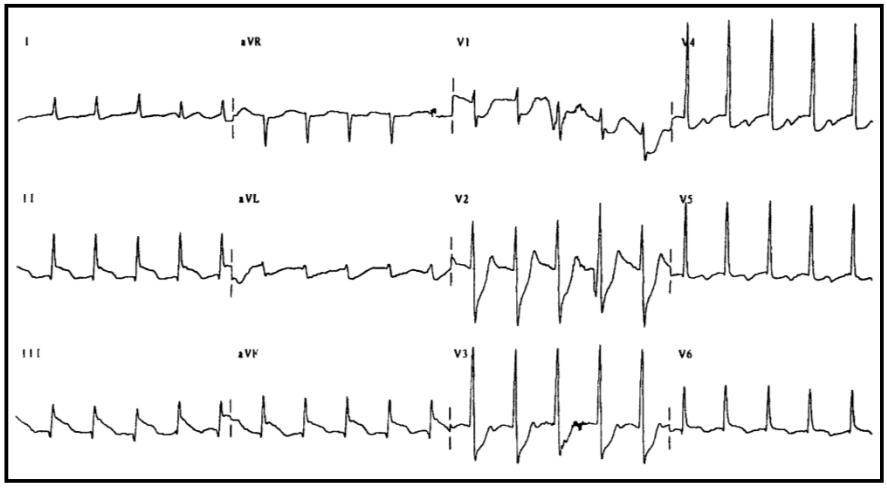
Echocardiogram – inferior & posterior wall hypokinesis

PCI -- circumflex obstruction with acute thrombus

Stent placed with adequate flow

Troponin +

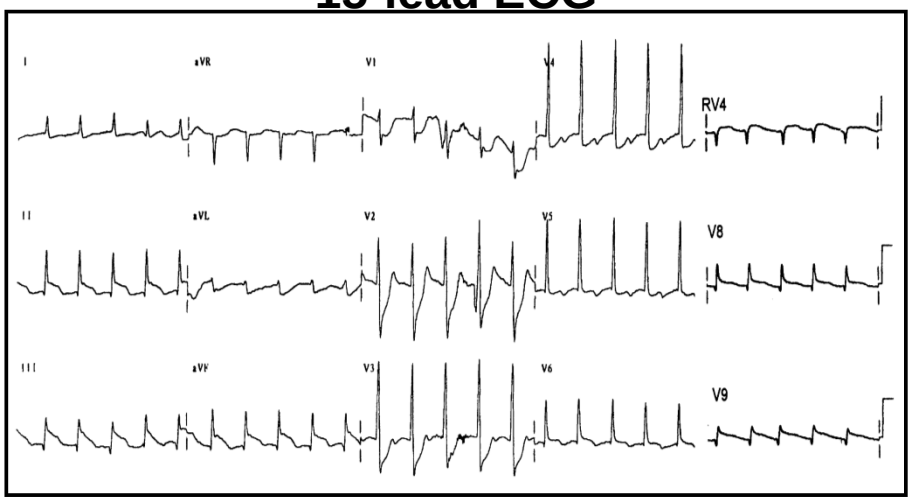
Inferoposterior AMI: 1 of 2
with Nitrate-related Hypotension



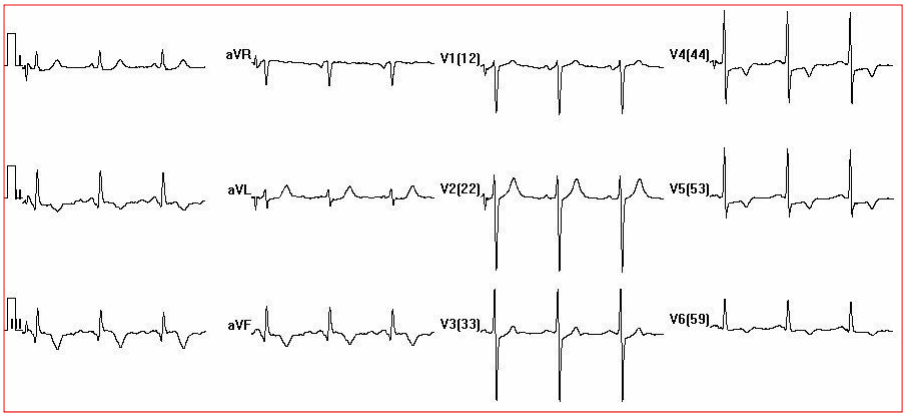
Inferoposterior AMI: 2 of 2

with RV Infarction

15-lead ECG

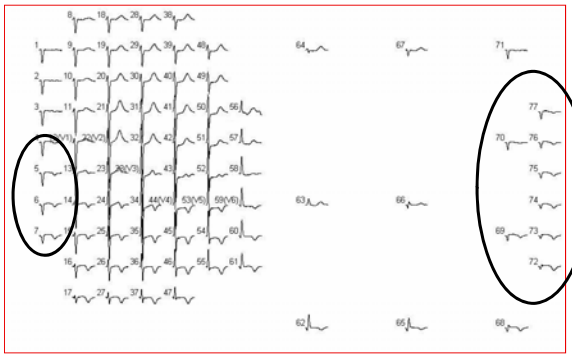


Chest Pain & Diaphoresis
+ Troponin

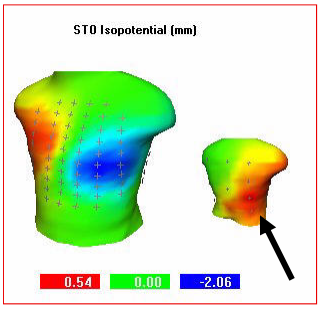


NSTEMI or ……?

The Ultimate in Additional-lead ECGs
Body Surface Mapping



80-lead ECG

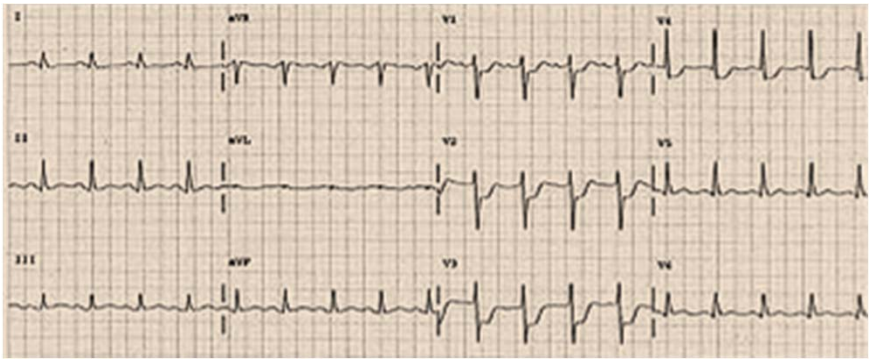


Posterior Wall & RV STEMI

ST0 Isopotential Body Map

In this patient with chest pain and ill appearance, the ECG indicates what ACS diagnosis:

A. likely an AMI.
B. likely unstable angina without AMI
C. non-specific abnormality that is concerning
D. A volatile stock market



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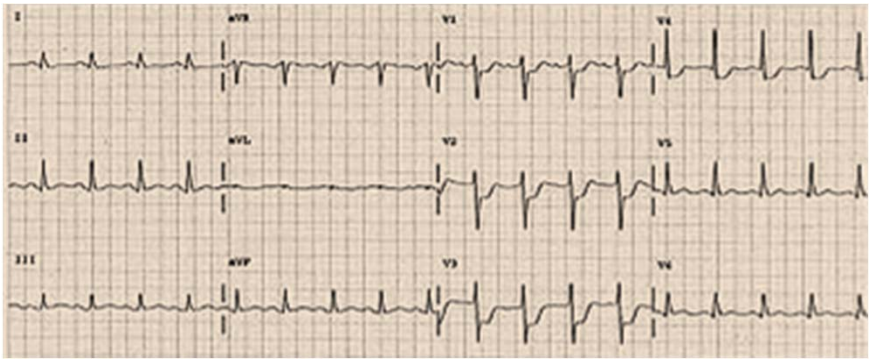
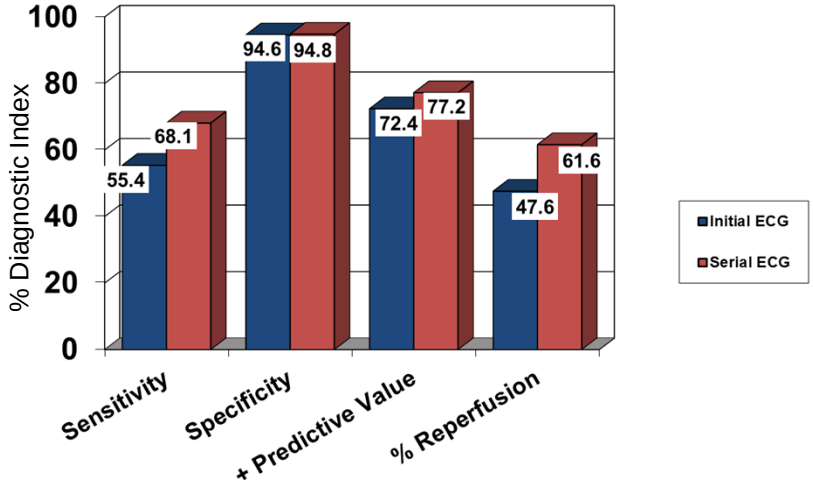


Serial ECGs & ST Segment Trend Monitoring

Serial ECGs

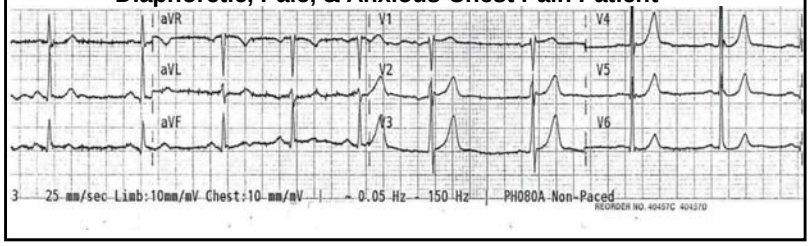
- ~ 50% of AMI patients -- nondiagnostic ECG on ED presentation
- Serial acquisition of ECG at frequent intervals may improve diagnostic accuracy
  - Evolution of ST segment elevation
  - Confounding & mimicking patterns

Initial vs. Serial ECG
ED Patients with Chest Pain

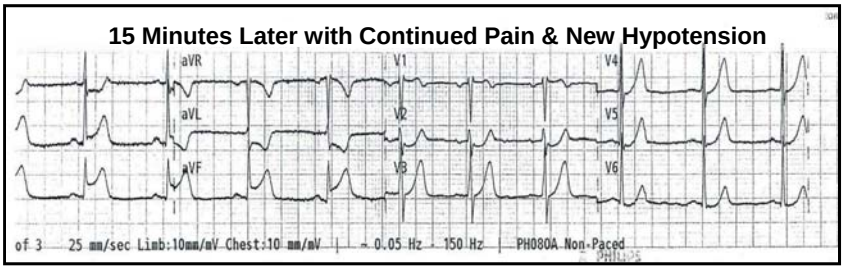


Serial ECGs

Diaphoretic, Pale, & Anxious Chest Pain Patient

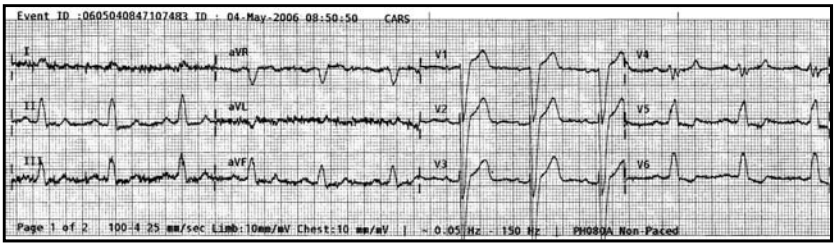


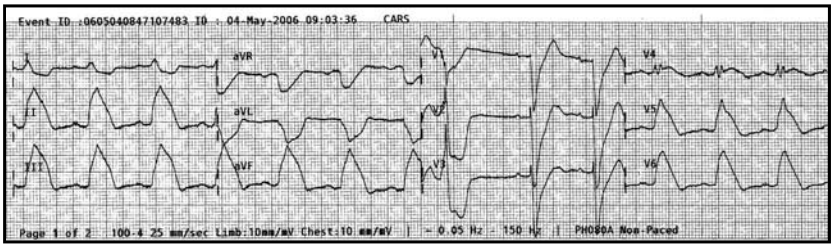
15 Minutes Later with Continued Pain & New Hypotension



Serial ECGs

Confounding Pattern with LBBB





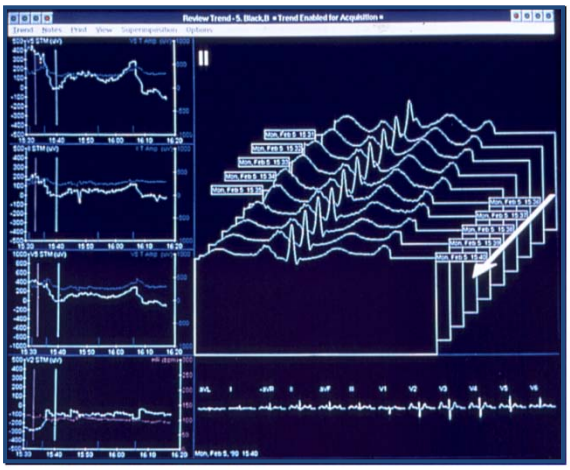
ST Segment Trend Monitoring

- **Serial 12-lead ECG tracings**
  - **Obtained every 20 seconds**
  - **Computer interpretation & comparison**
  - **Continuous ST segment trend monitoring**
- **Fesmire et al** ***(Ann EM 1998)***
  - **1000 ED chest pain patients**
  - **Additional 16.2% with ACI not noted initially**

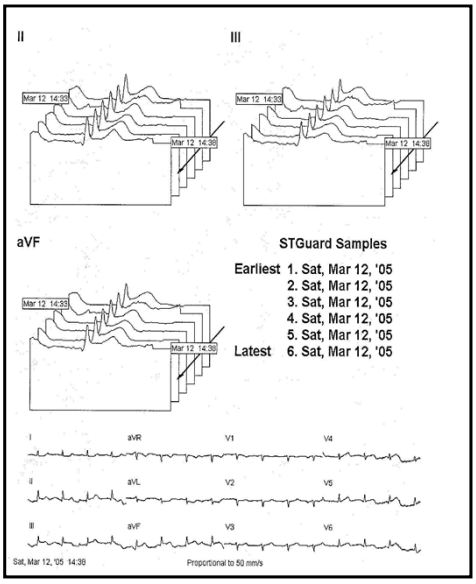
ST Segment Trend Monitoring

- **Fesmire** ***(AJEM 2000)***
  - **Impact on therapy**
  - **Grouped relative to risk**
  - **26 of 706 patients had therapy changed**
  - **14.6% of high-risk population**
  - **1.1% of low-risk population**
- **Fesmire** ***(Ann EM 1995)***
  - **LBBB chest pain patients**
  - **5 patients w/ AMI diagnosed via serial change**

Sequential Complexes and Graphs of ST-Segment Changes



Evolution of Inferior STEMI



BREAK

ECG Confounders

ECG Confounding Patterns

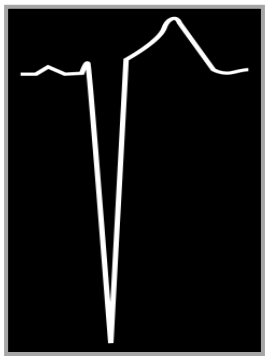
- **Confounding patterns**
  - Left bundle branch block
  - Ventricular paced pattern
  - Left ventricular hypertrophy (by voltage) with strain
- **Confounding** -- reduce the ECG's abililty to detect ACS-related change
- **Mimicking –** produce ST segment & T wave changes confused with ACS-related findings

Risk Stratification in Suspected ACS

- **The primary initials tools**
  - **History – guides early evaluation**
  - **Examination – less helpful, only complications**
  - ~~**ECG – primary diagnostic study**~~
  - **Biomarkers – useful in select situations**
- **The ECG is largely invalidated with confounding patterns**

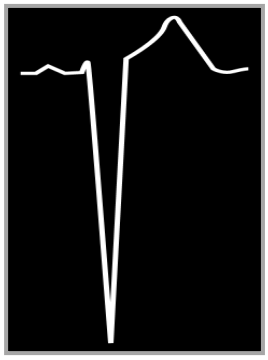
Left Bundle Branch Block

- LBBB reduces diagnostic power of ECG
- Changes mask ischemic change
  - or can be misinterpreted as injury/infarct
- Most frequently misinterpreted pseudoinfarct pattern in practice today, responsible for:
  - Delayed diagnosis & RX of AMI



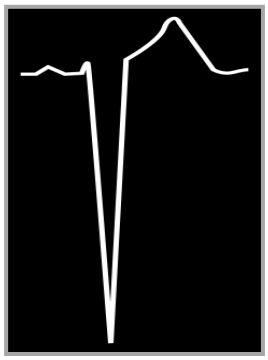
Left Bundle Branch Block

- Patients with LBBB pattern:
  - If new
    - Candidates for thrombolysis
    - At high risk for CHB, cardiogenic shock, & death
  - If old
    - Have significant, pre-existing LV dysfunction
    - High risk for death
- May benefit significantly from acute revascularization therapies
  - More so than "typical" AMI patients
- Yet are diagnosed early much less often

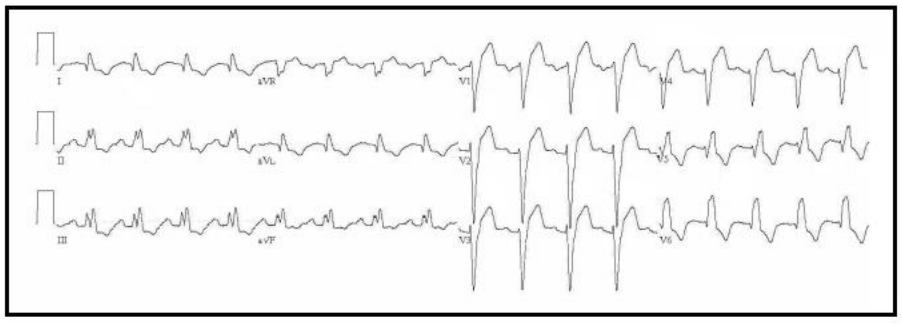


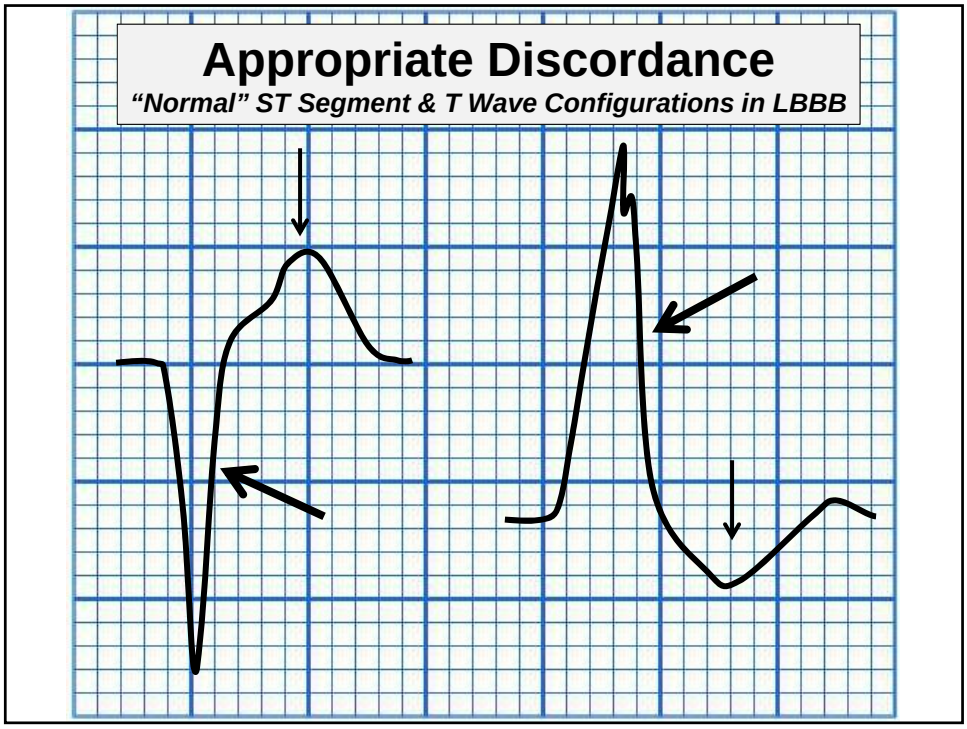
Left Bundle Branch Block

- **Characteristics**
  - **QRS complex > 0.12 sec**
  - **Mainly negative QS or rS complex in lead V_1**
  - **Monophasic R wave in leads V_6, I & aVl**
- **Secondary repolarization findings:**
  - **QS or rS complexes -- ST elevation**
  - **Large monophasic R wave -- ST depression**
- **Explained by the *Concept of Appropriate Discordance***
  - **-- ST segment / T wave complex is directed opposite from the major, terminal portion of the QRS complex**

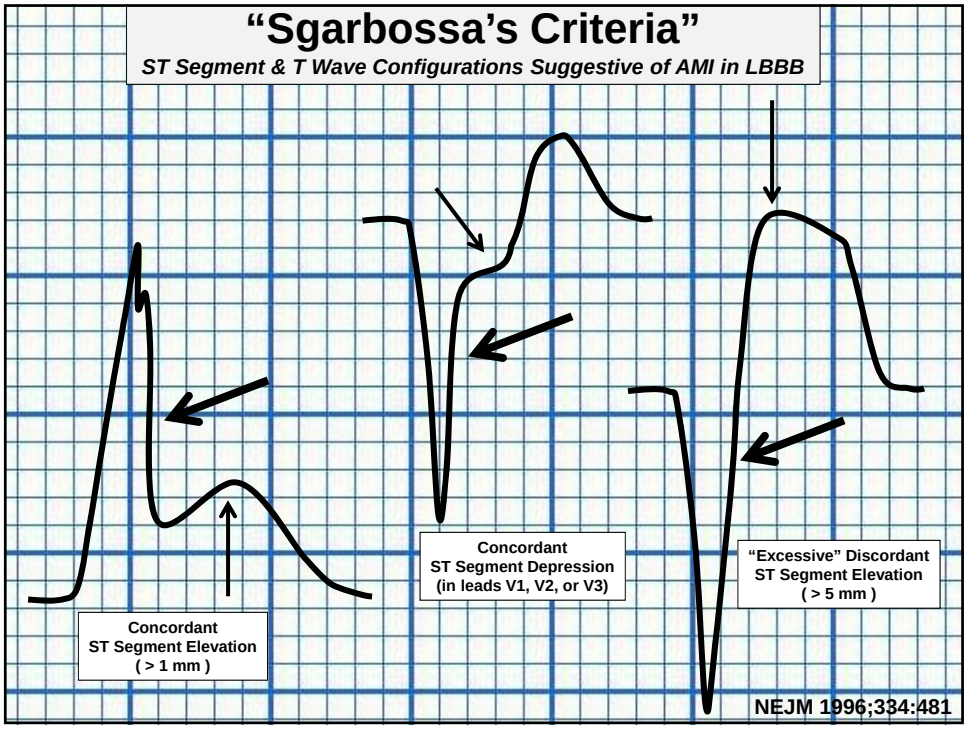


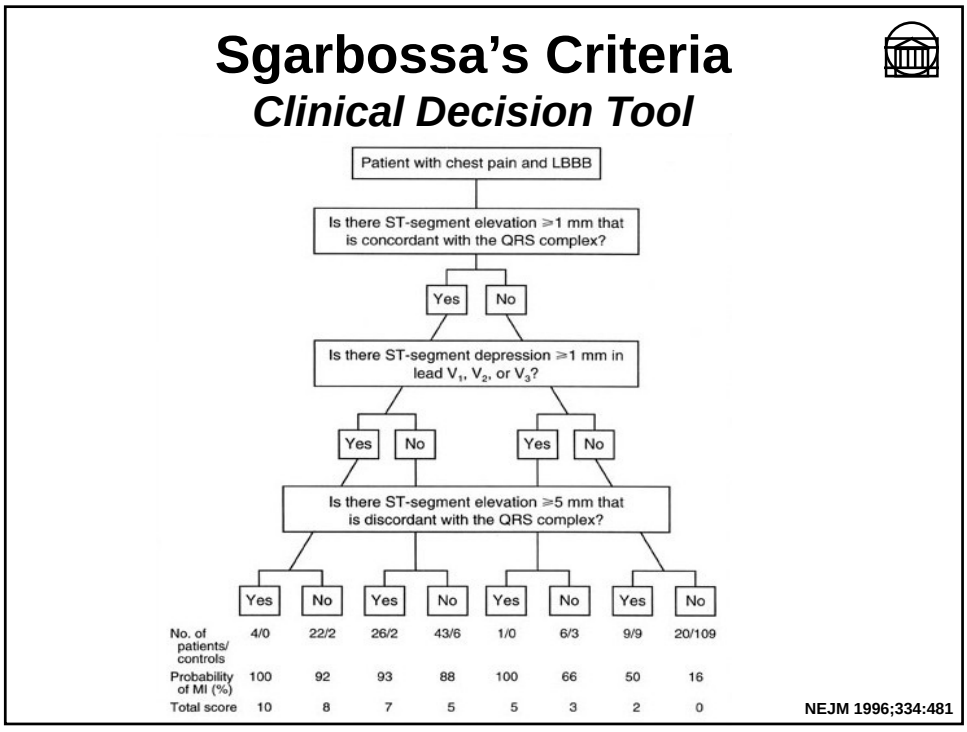
Left Bundle Branch Block Normal ST Segment & T Wave



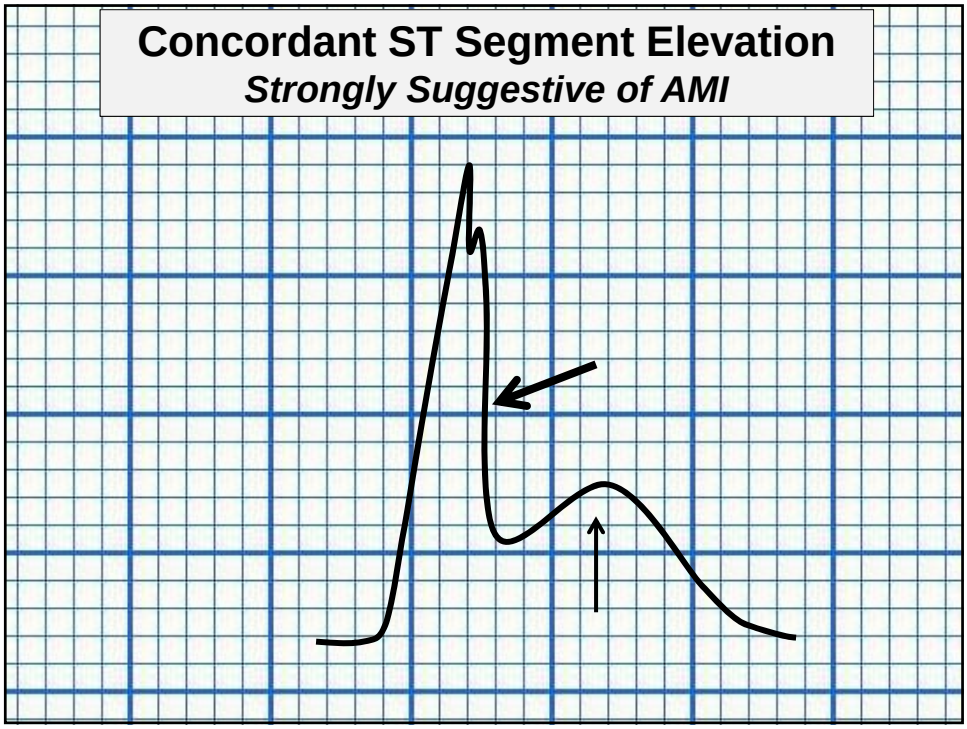


Abnormal Findings in LBBB

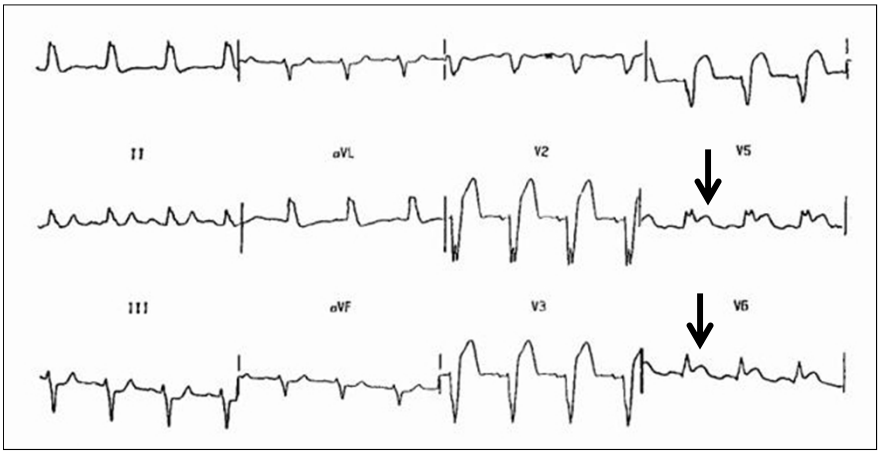

"Sgarbossa's Criteria"
ST Segment & T Wave Configurations Suggestive of AMI in LBBB
Concordant
ST Segment Elevation
(> 1 mm)
Concordant
ST Segment Depression
(in leads V1, V2, or V3)
"Excessive" Discordant
ST Segment Elevation
(> 5 mm)
NEJM 1996;334:481


Sgarbossa's Criteria
Clinical Decision Tool
Patient with chest pain and LBBB
Is there ST-segment elevation ≥1 mm that is concordant with the QRS complex?
Yes
No
Is there ST-segment depression ≥1 mm in lead V1, V2, or V3?
Yes
No
Yes
No
Is there ST-segment elevation ≥5 mm that is discordant with the QRS complex?
Yes
No
Yes
No
Yes
No
Yes
No
No. of patients/ controls 4/0 22/2 26/2 43/6 1/0 6/3 9/9 20/109
Probability of MI (%) 100 92 93 88 100 66 50 16
Total score 10 8 7 5 5 3 2 0
NEJM 1996;334:481

Concordant ST Segment Elevation
Strongly Suggestive of AMI

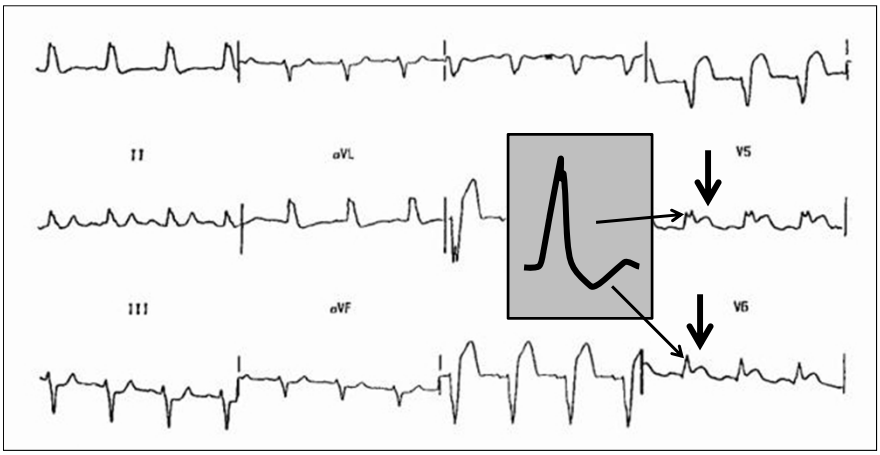


LBBB with AMI
Concordant ST Segment Elevation



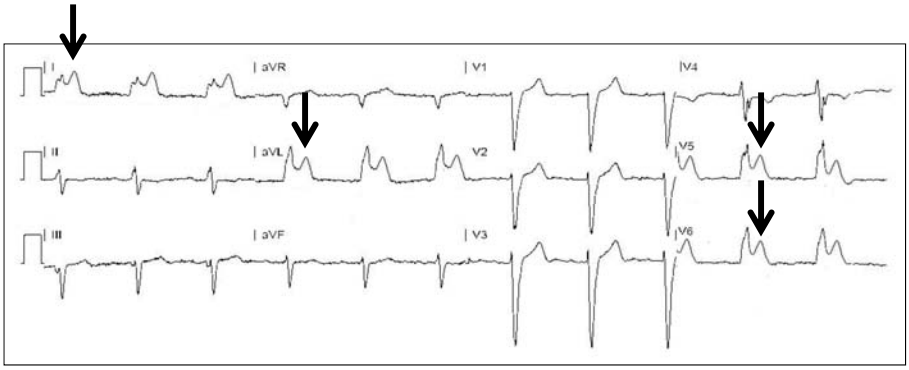
LBBB with AMI

Concordant ST Segment Elevation



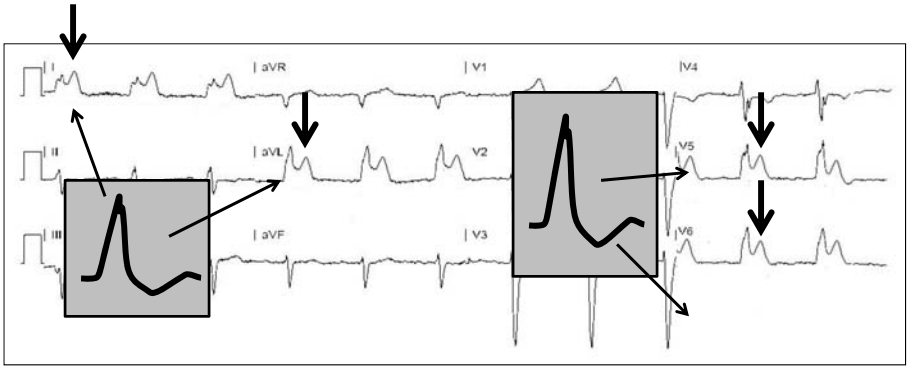
LBBB with AMI

Concordant ST Segment Elevation



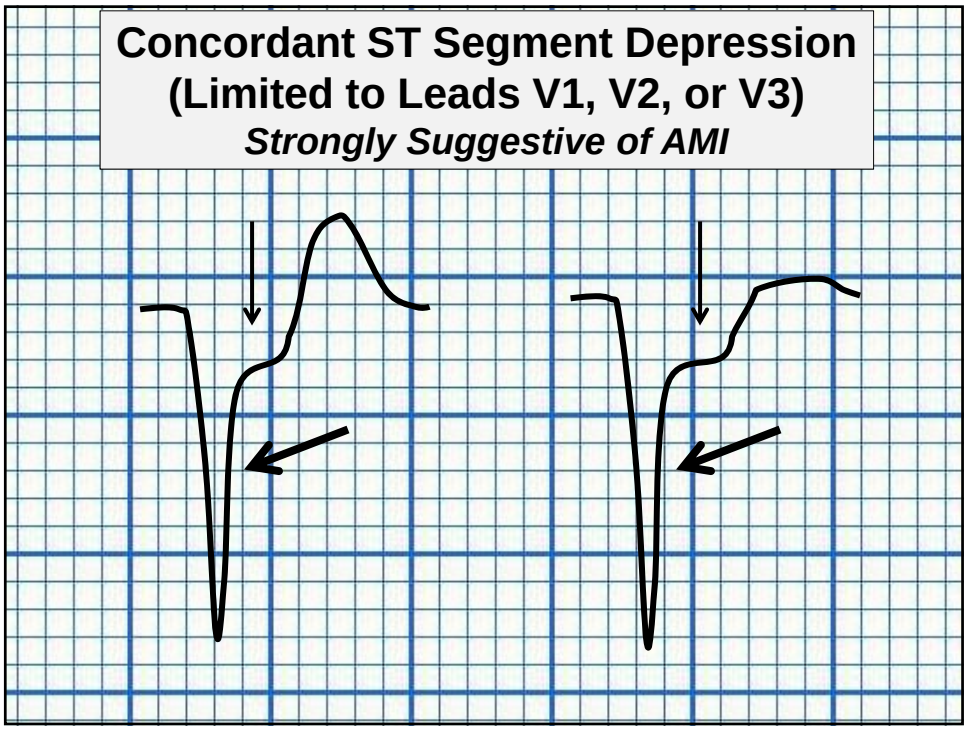
LBBB with AMI

Concordant ST Segment Elevation



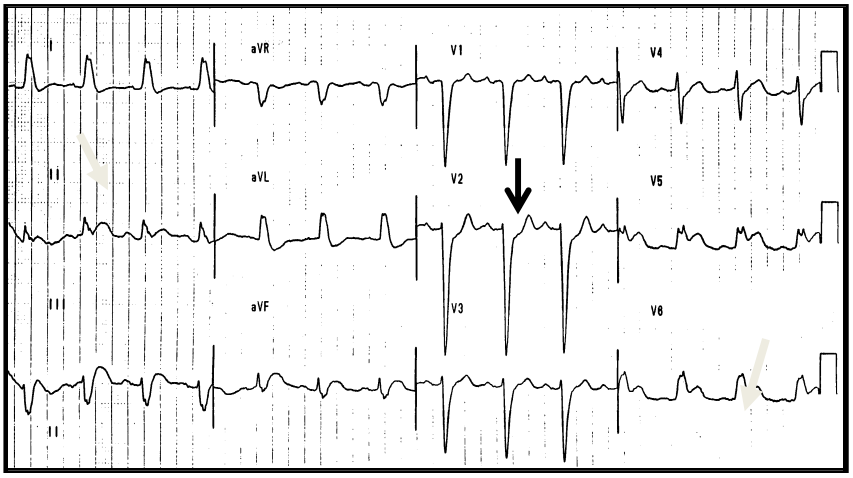
Concordant ST Segment Depression (Limited to Leads V1, V2, or V3)

Strongly Suggestive of AMI



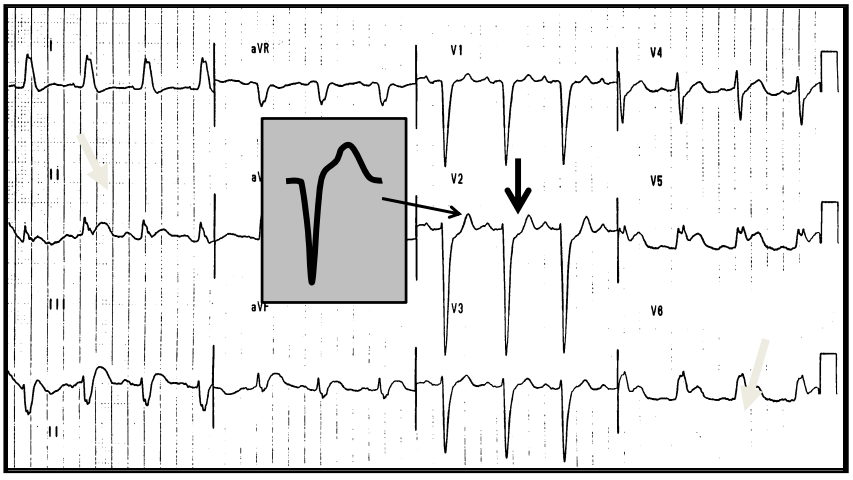
LBBB with AMI

Concordant ST Segment Depression



LBBB with AMI

Concordant ST Segment Depression



LBBB with AMI

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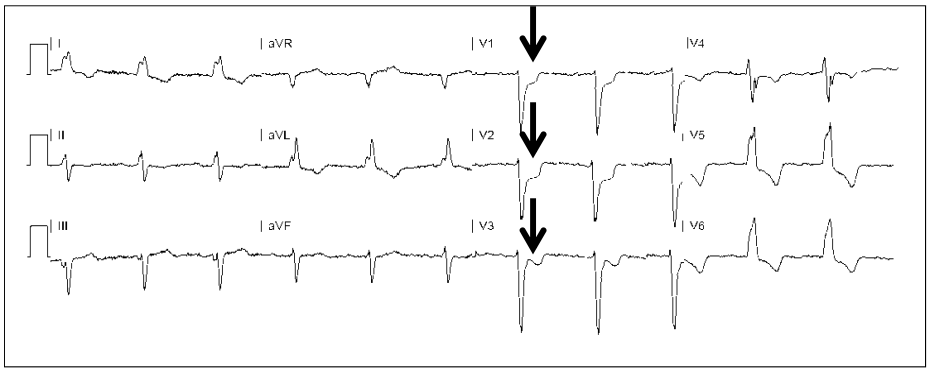
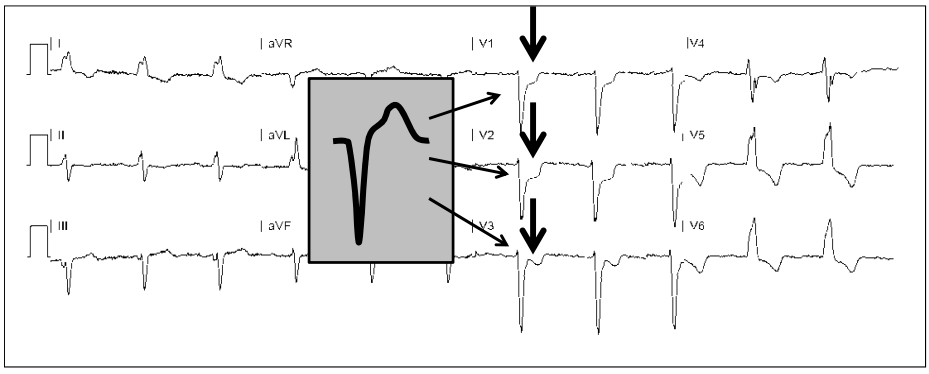


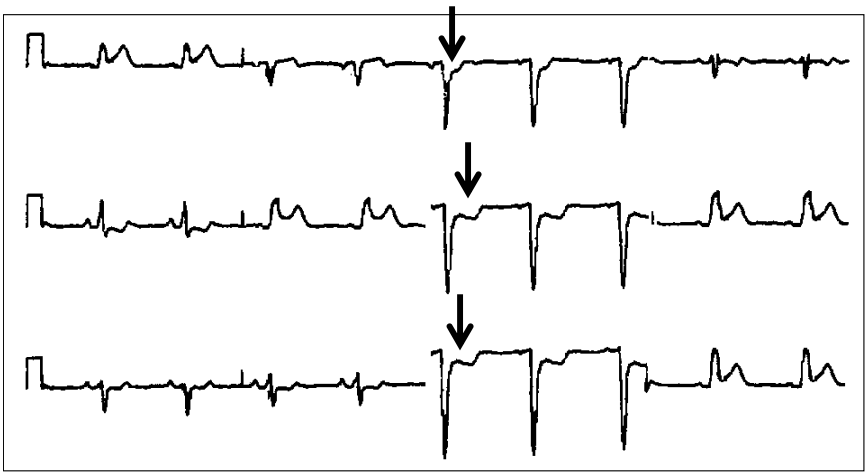
LBBB with AMI

Concordant ST Segment Depression



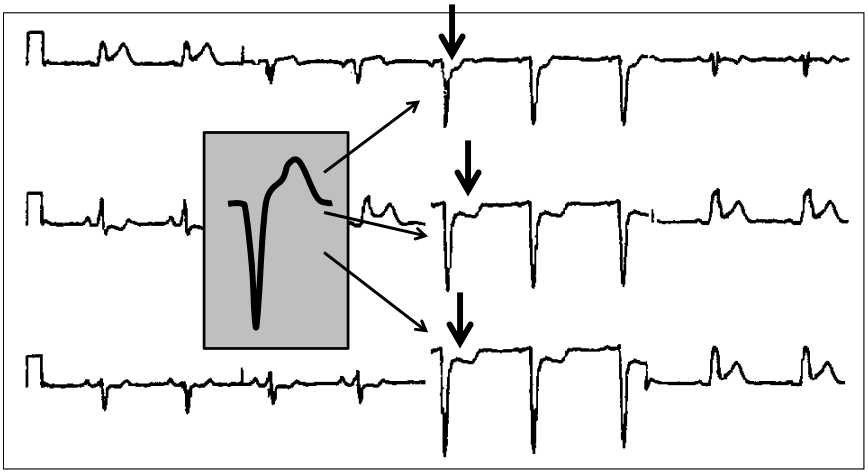
LBBB with AMI

Concordant ST Segment Depression



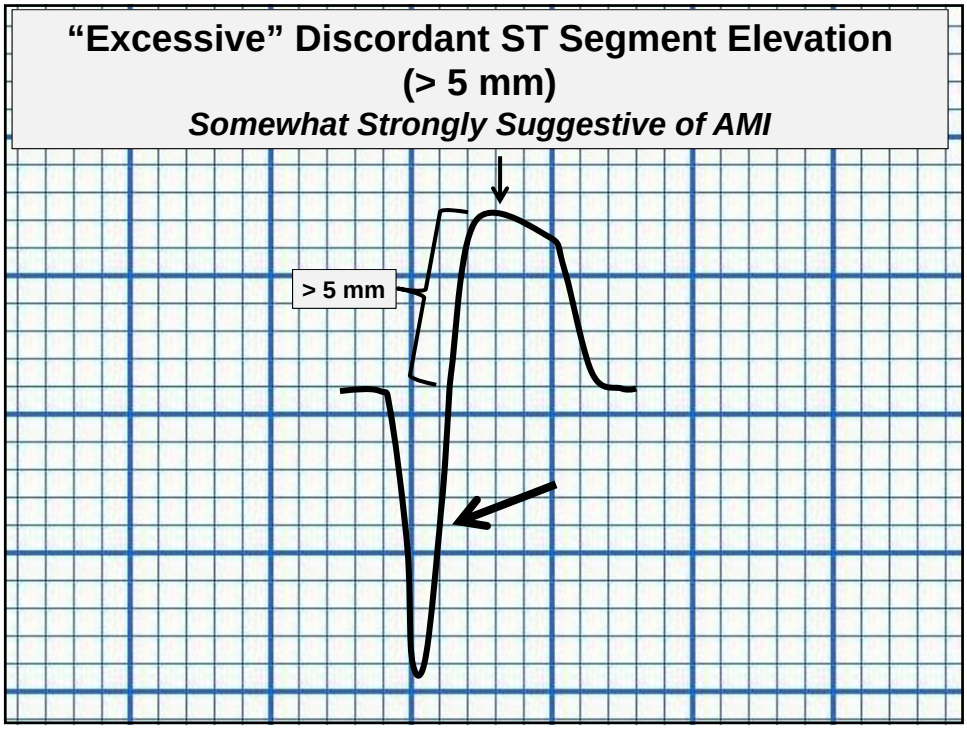
LBBB with AMI

Concordant ST Segment Depression



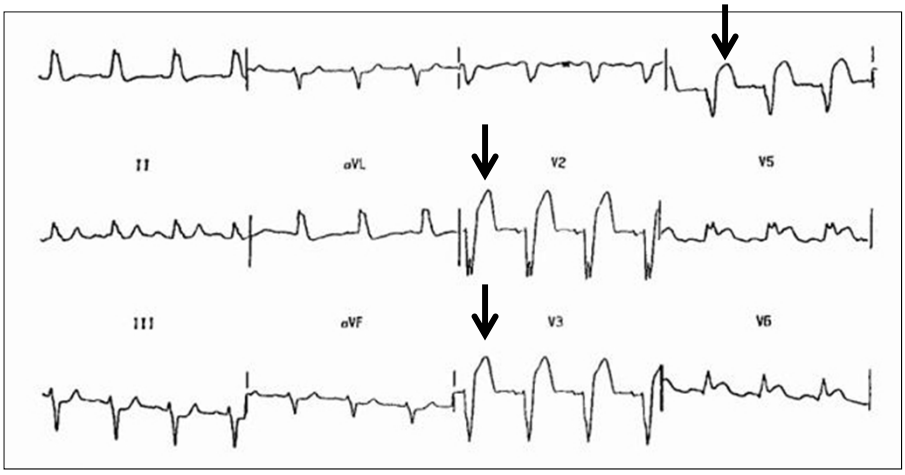
"Excessive" Discordant ST Segment Elevation (> 5 mm)

Somewhat Strongly Suggestive of AMI



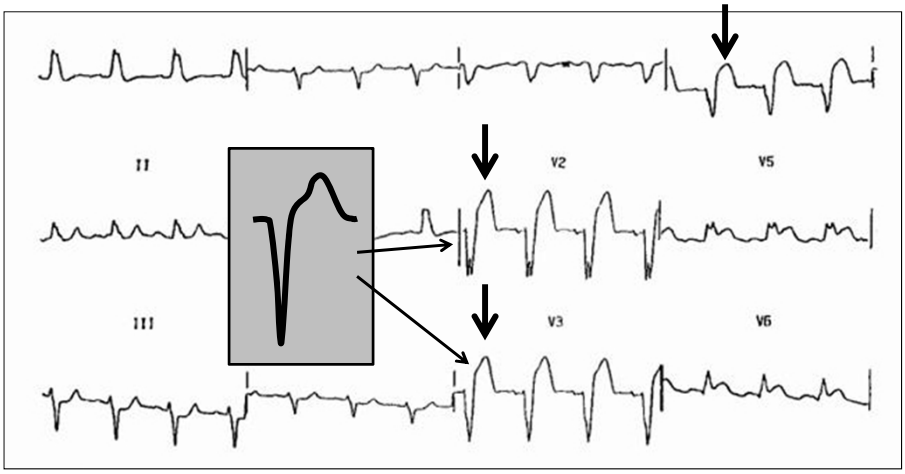
LBBB with AMI

Excessive Discordant ST Segment Elevation



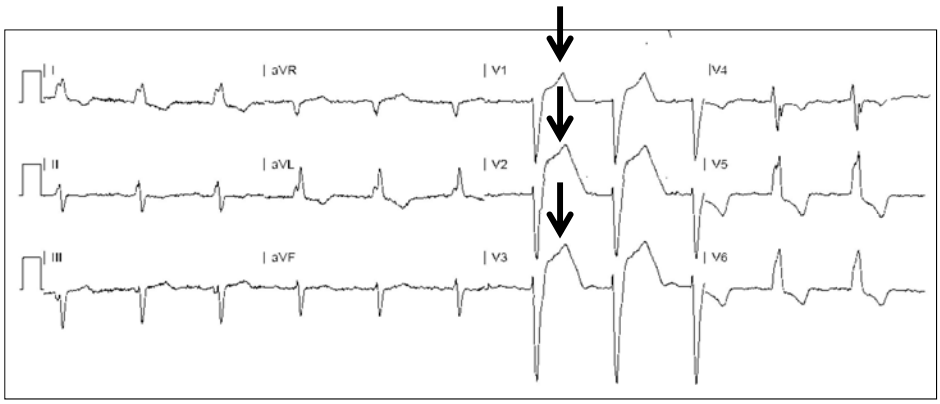
LBBB with AMI

Excessive Discordant ST Segment Elevation



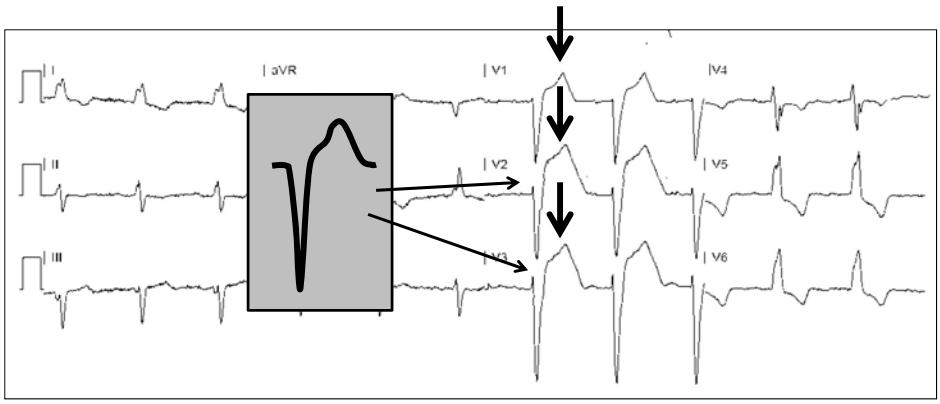
LBBB with AMI

Excessive Discordant ST Segment Elevation



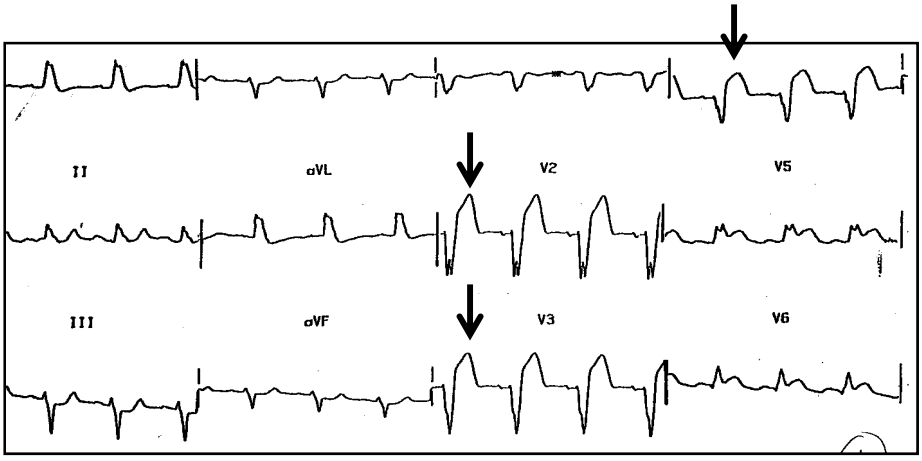
LBBB with AMI

Excessive Discordant ST Segment Elevation



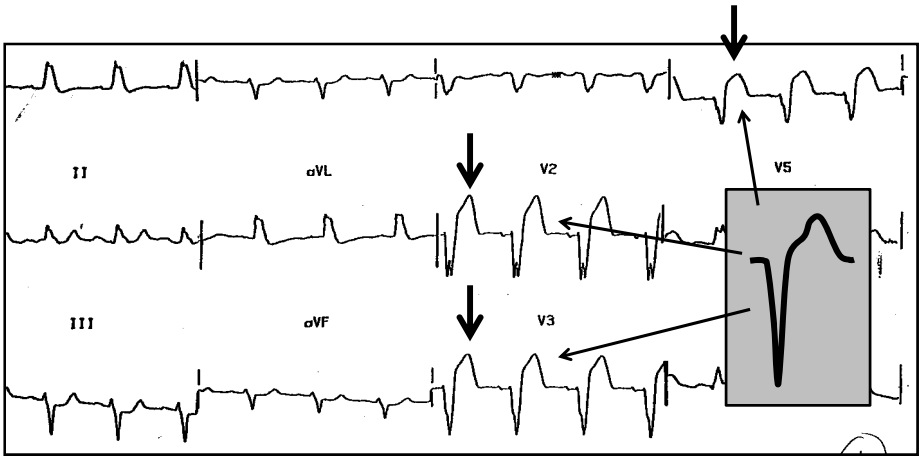
LBBB with AMI

Excessive Discordant ST Segment Elevation

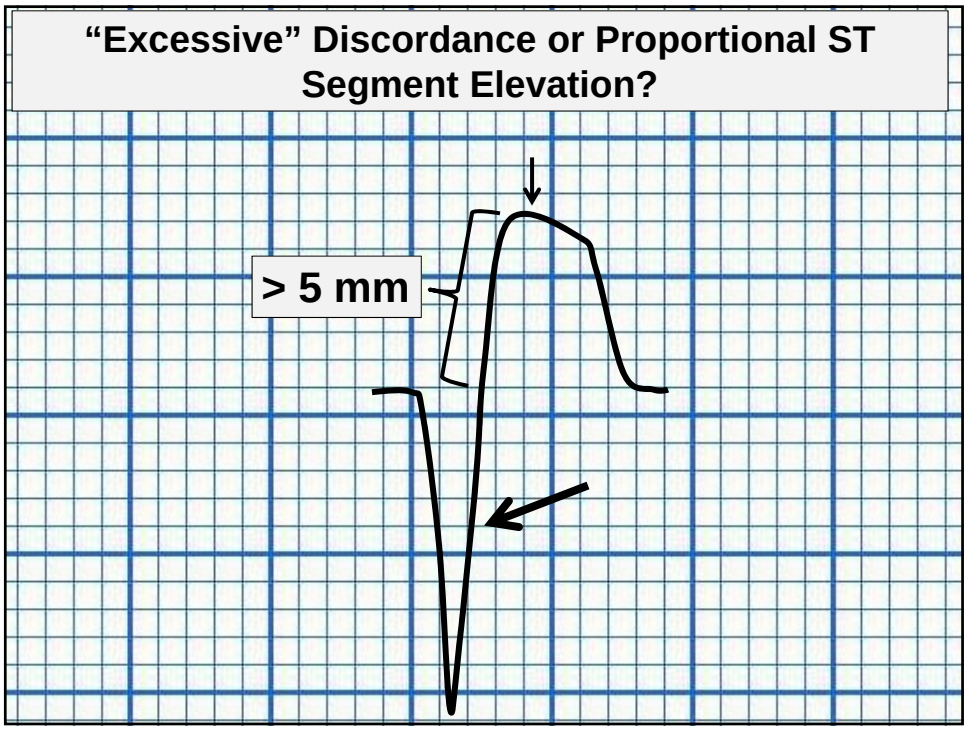


LBBB with AMI

Excessive Discordant ST Segment Elevation

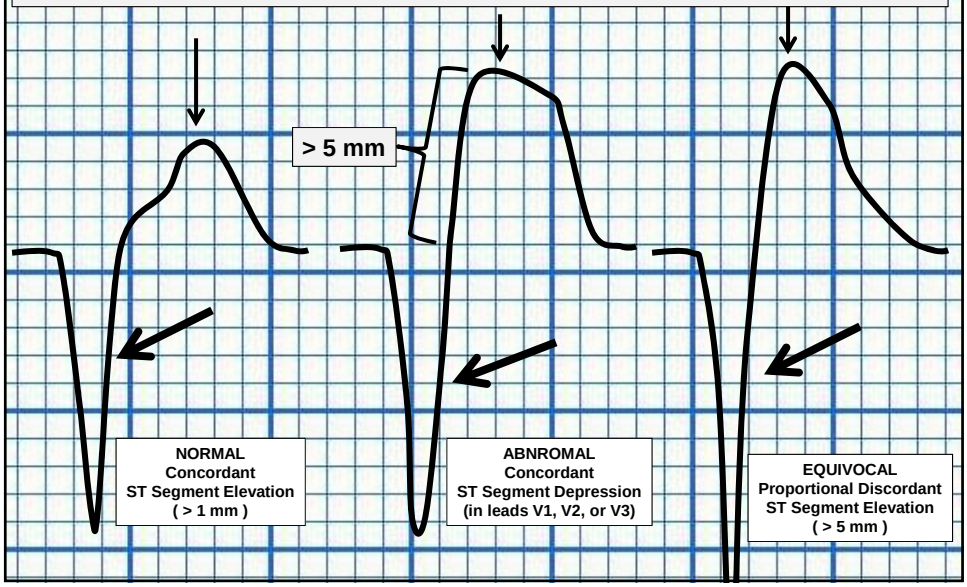


“Excessive” Discordance or Proportional ST Segment Elevation?



"Excessive" Discordant ST Segment Elevation (> 5 mm)

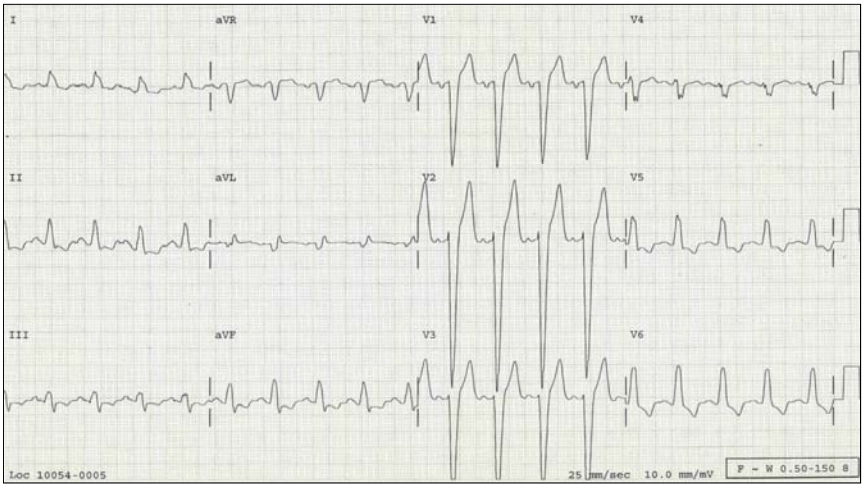
Somewhat Strongly Suggestive of AMI



Excessive Discordant ST Segment Elevation

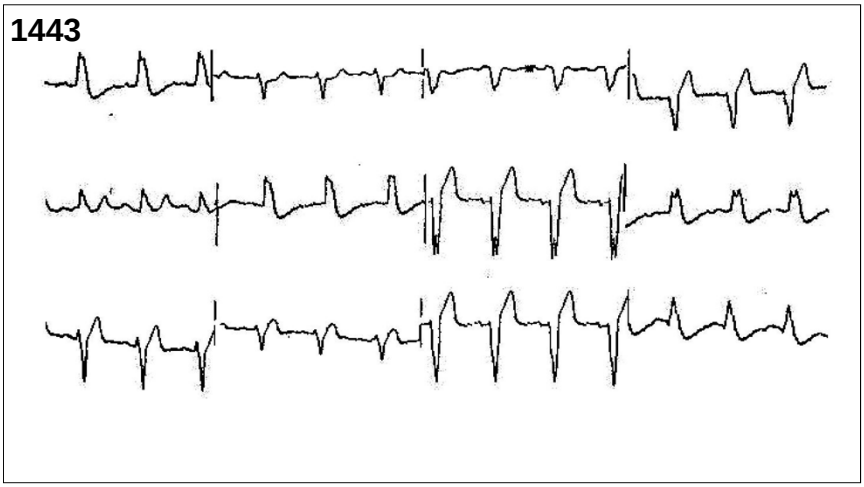
ST Segment Elevation is Proportional to Size of QRS Complex

NOT INDICATIVE OF ELECTROCARDIOGRAPHIC AMI



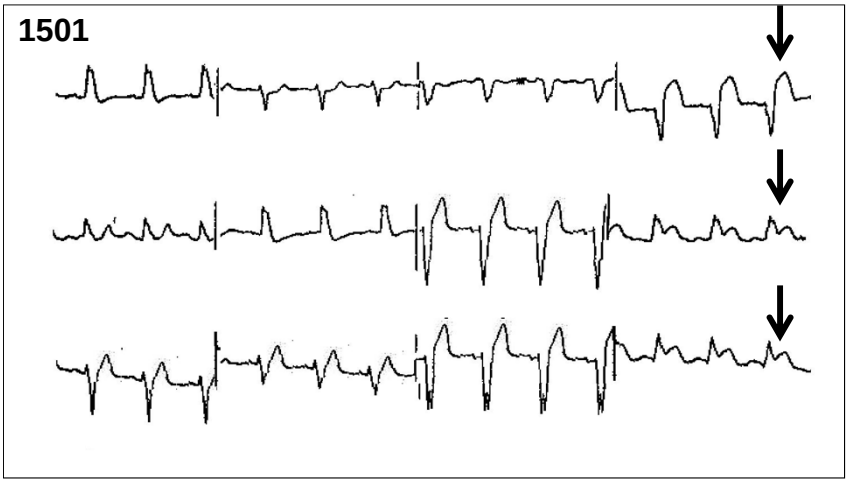
Serial ECGs: 1 of 2

"Concerning" Chest Pain Presentation

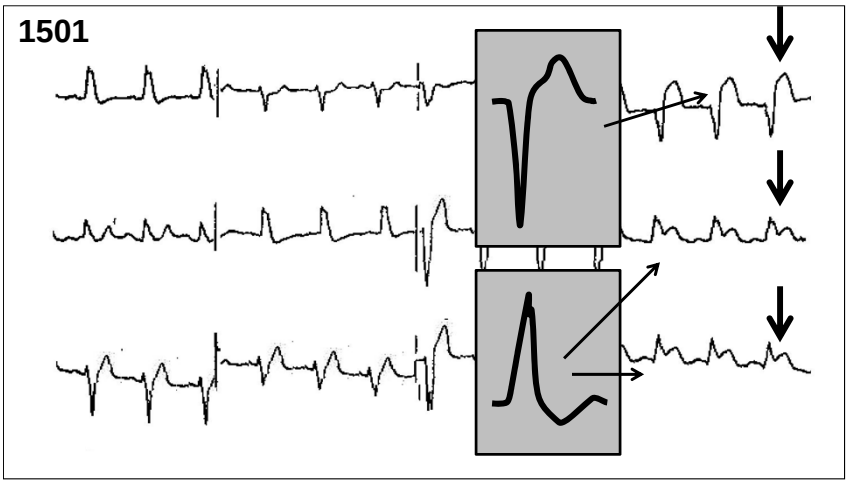


Serial ECGs: 2 of 2

Evolution of AMI with LBBB

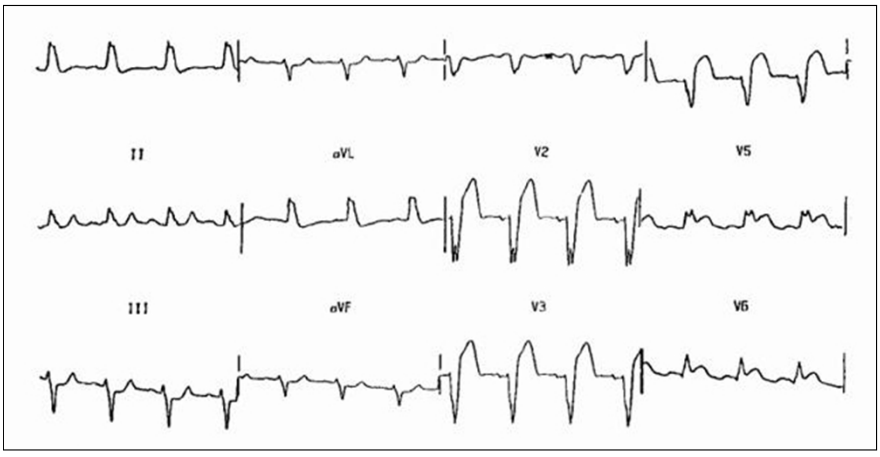


Serial ECGs: 2 of 2
Evolution of AMI with LBBB



In this ill appearing, chest pain patient with known past LBBB pattern, what would YOU do based upon this ECG?

A. Repeat the ECG and administer ASA
B. Activate STEMI ALERT, repeat the ECG, and administer ASA
C. Activate STEMI ALERT, repeat the ECG, administer ASA, & give metoprolol
D. Wish that you had paid attention in this lecture



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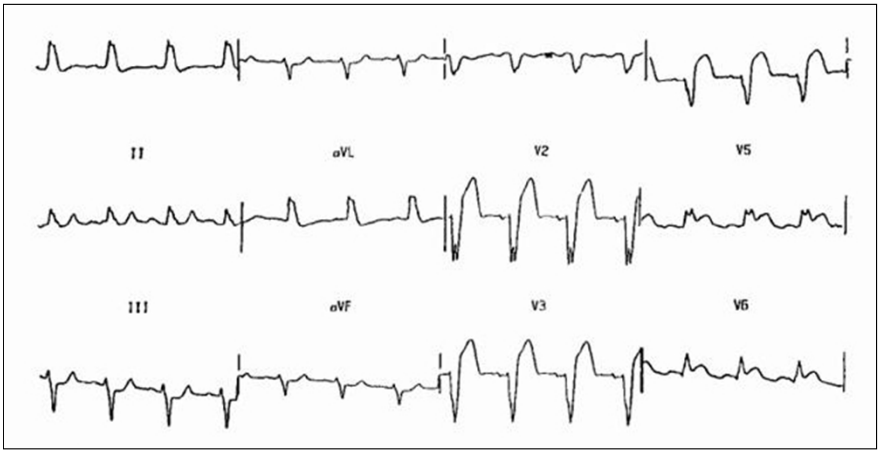
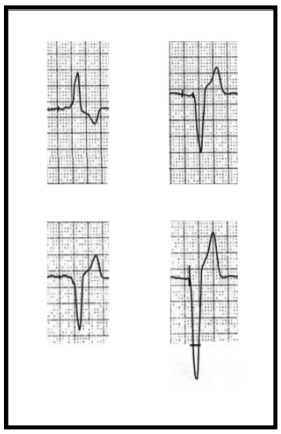


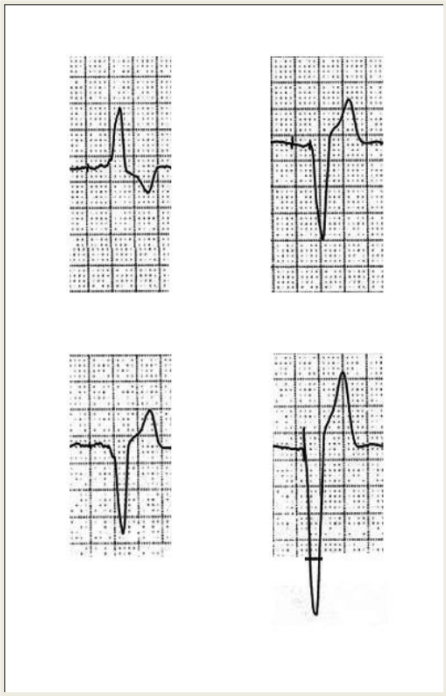
Ventricular Paced Rhythm

- Elderly population w/ pre-existing heart disease
- ECG characteristics
  - Broad, mainly negative QS complexes (leads V_1 to V_6)
  - QS complexes may also seen in leads II, III & aVf
  - Large monophasic R wave -- leads I & aVL

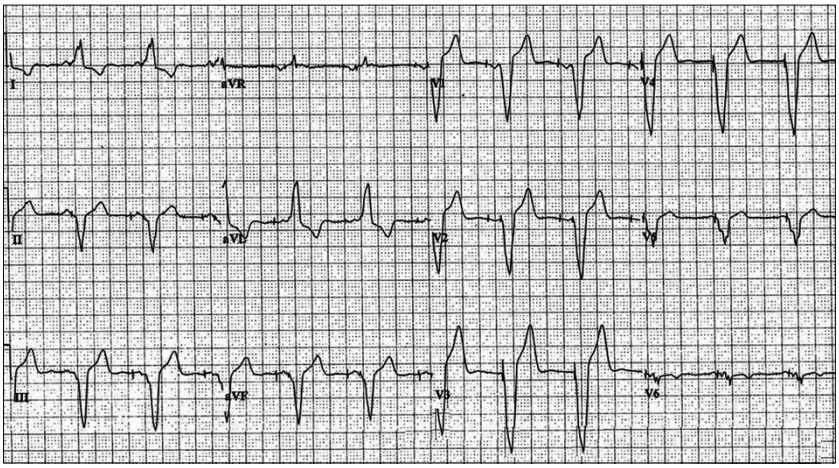


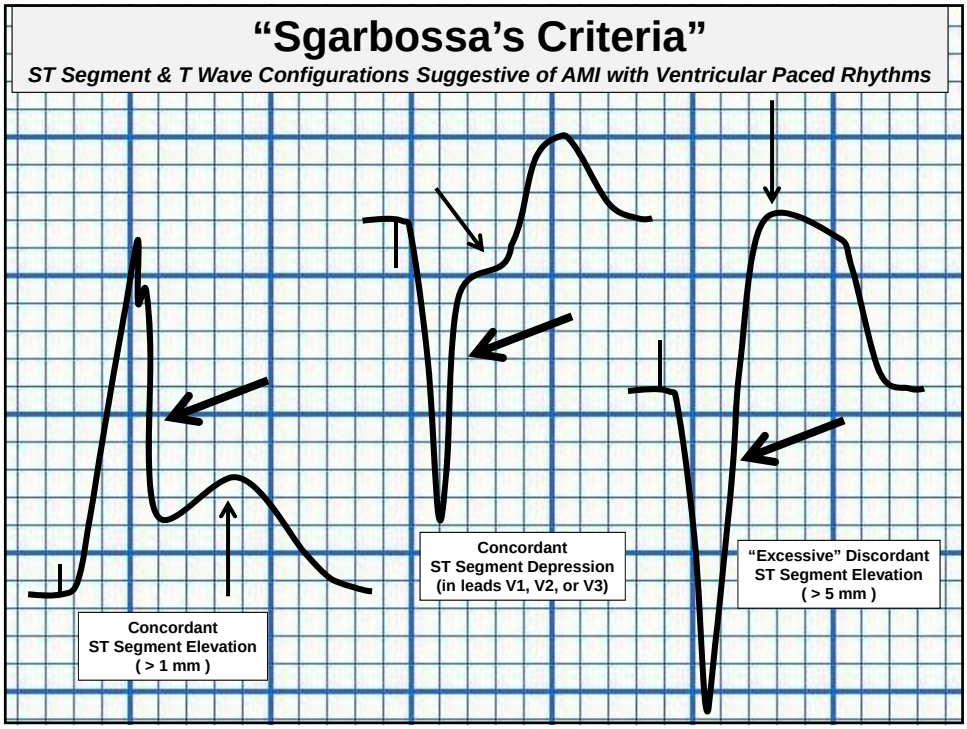
Ventricular Paced Rhythm

Normal Findings



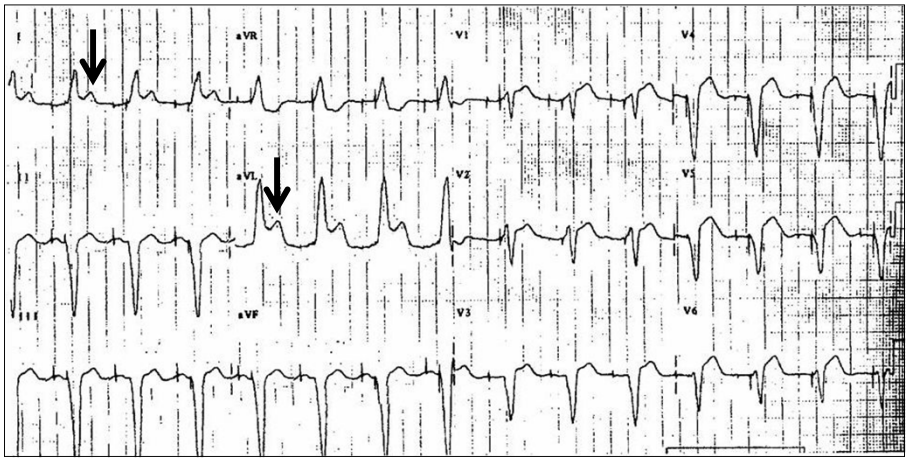
Ventricular Paced Pattern
Normal ST Segment & T Wave





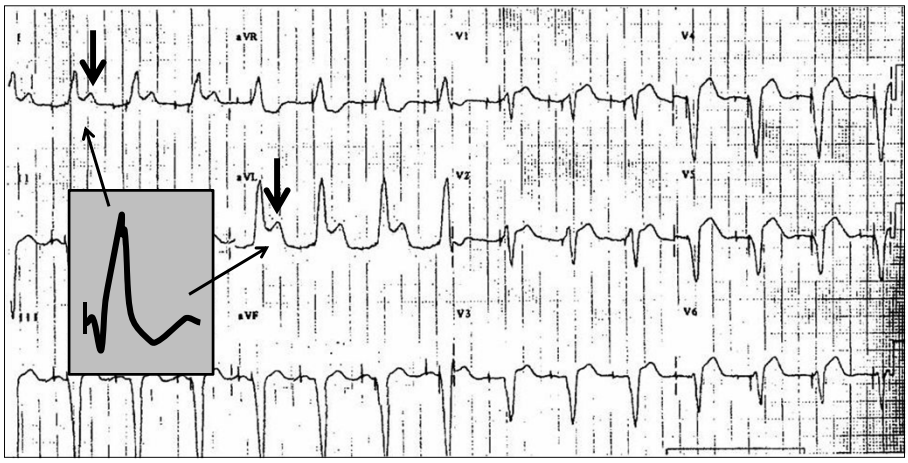
Ventricular Paced Pattern with AMI

Concordant ST Segment Elevation



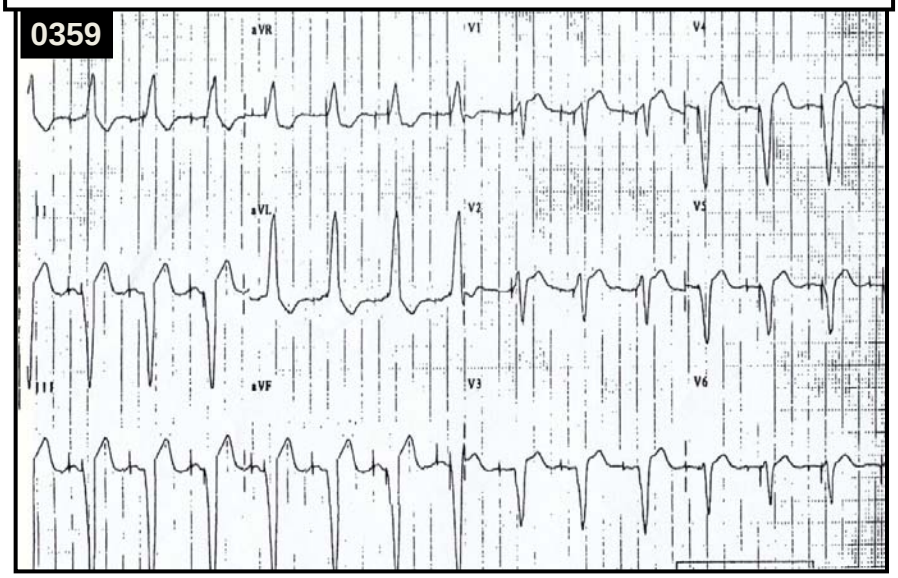
Ventricular Paced Pattern with AMI

Concordant ST Segment Elevation



Serial ECGs: 1 of 2

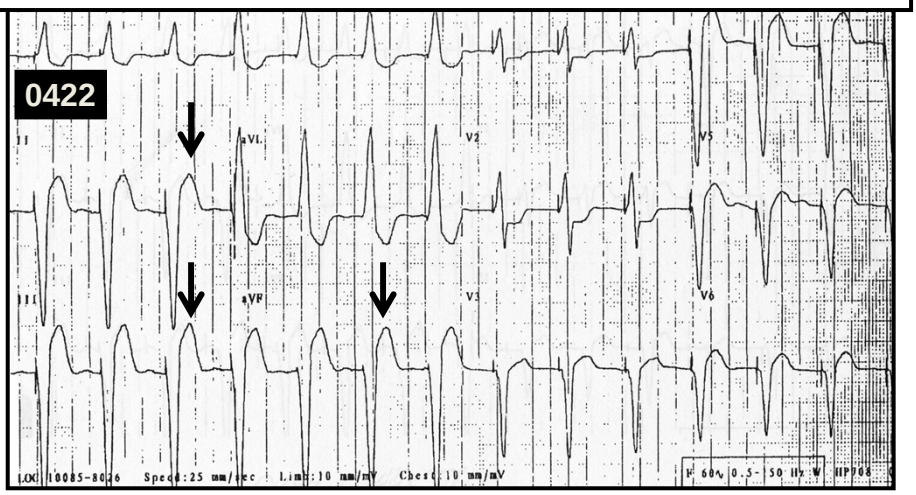
Ventricular Paced Pattern with Chest Pain



Serial ECGs: 1 of 2

Ventricular Paced Pattern with Chest Pain

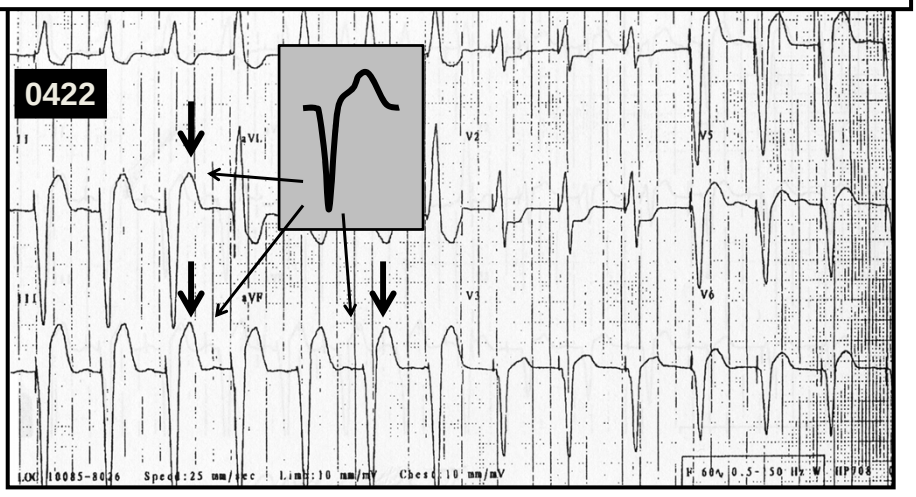
Excessive Discordant ST Segment Elevation



Serial ECGs: 1 of 2

Ventricular Paced Pattern with Chest Pain

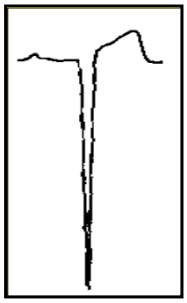
Excessive Discordant ST Segment Elevation



Left Ventricular Hypertrophy with Strain Pattern

- LVH pattern reduces diagnostic power of ECG
- Like LBBB, changes mask & mimic ACS-related findings
- LVH by voltage criteria
  - Many
  - S (Q) wave V1 + R wave V6 > 35 mm
- "Strain" pattern
  - ST segment & T wave changes
  - Seen in 75% of LVH pattern presentations

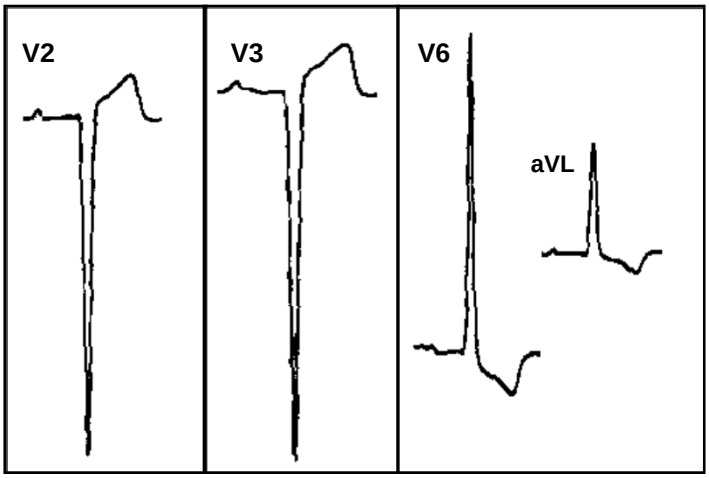
LVH with Strain Pattern



- LVH seen frequently in adult chest pain patients suspected of ACS
- Final hospital Dx
  - 26% ultimately ACS
  - 74% non-ACS
- ECG ***incorrectly*** interpreted > 70% of cases
  - Frequently did not identify LVH pattern
  - Attributed ST / T changes to ischemia or infarction
  - Observed changes resulted from
- Stress importance of correct ECG interpretation
  - Directly impacts therapeutic & diagnostic decisions

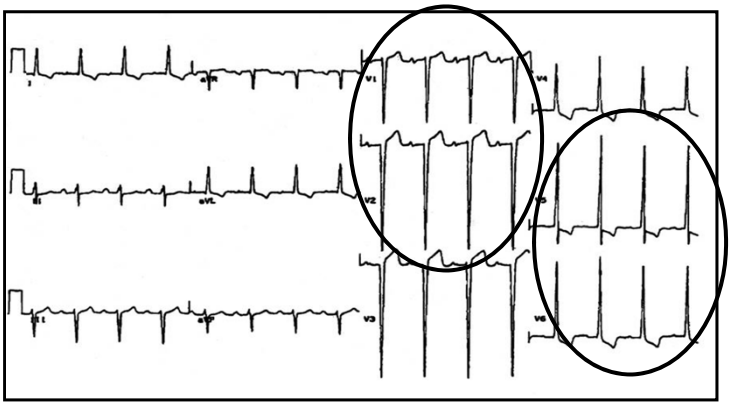
Larsen et al, J Gen Intern Med 1994

LVH with Strain Pattern



QRS Complex Size?

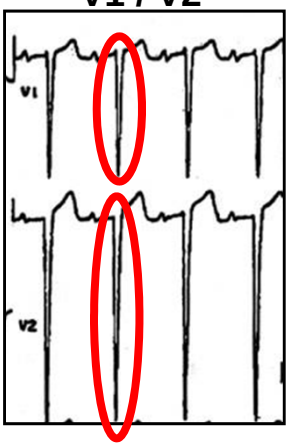
The LVH Pattern



QRS Complex Size?

Determination of QRS Complex Size

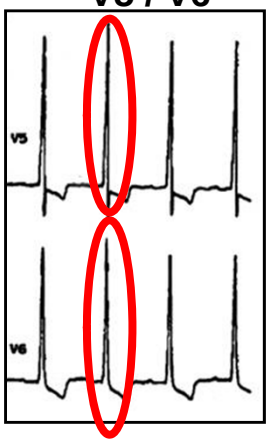
V1 / V2



Q wave

+

V5 / V6



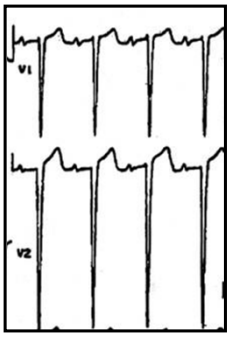
R Wave

> 35 mm*

* In a patient > age 35 years

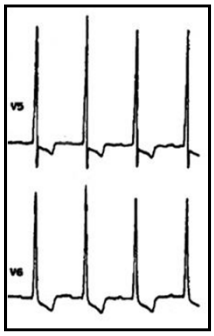
QRS Complex Size?

- ST segment & T wave changes in LVH
- 80% of patients with this ECG pattern
- Not indicative of ACS
- Mimic & mask ACS

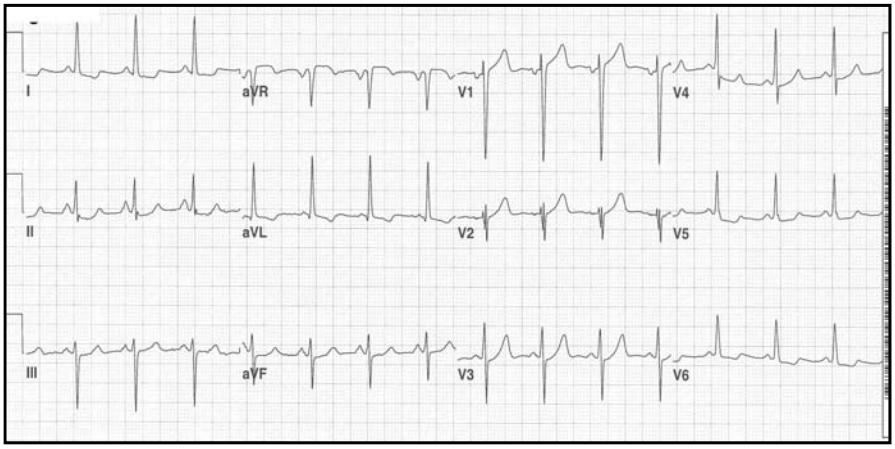


ST Segment Elevation

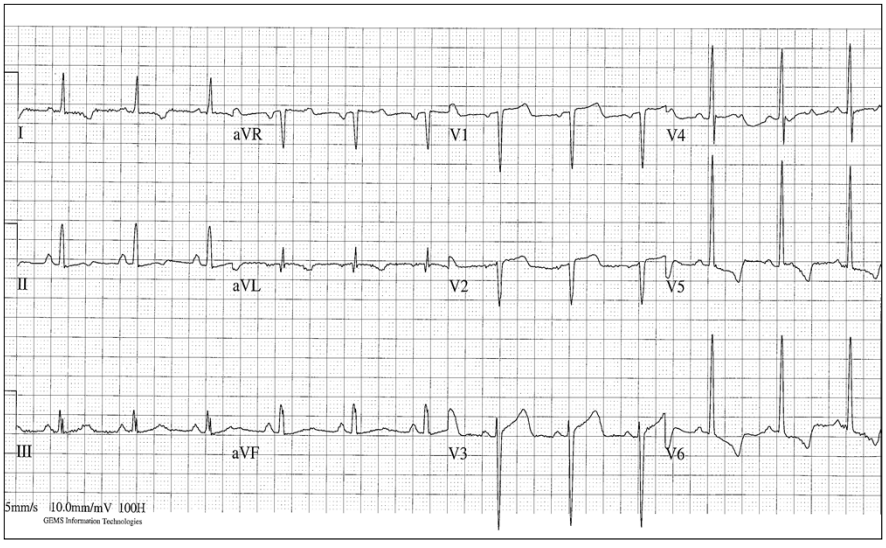
ST Segment Depression & T Wave Inversion



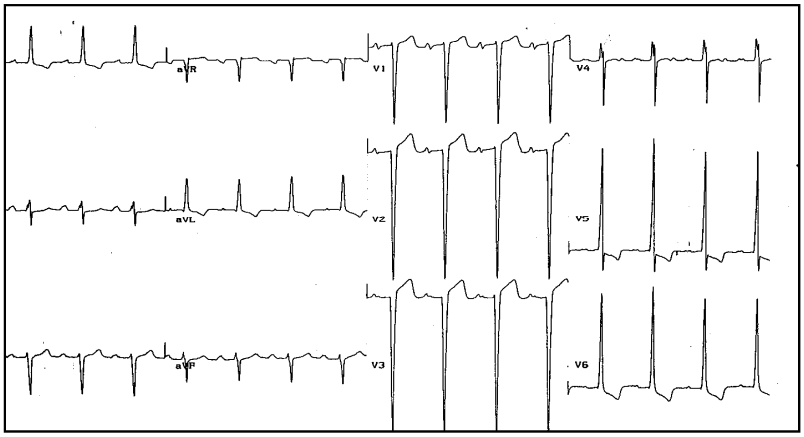
Left Ventricular Hypertrophy



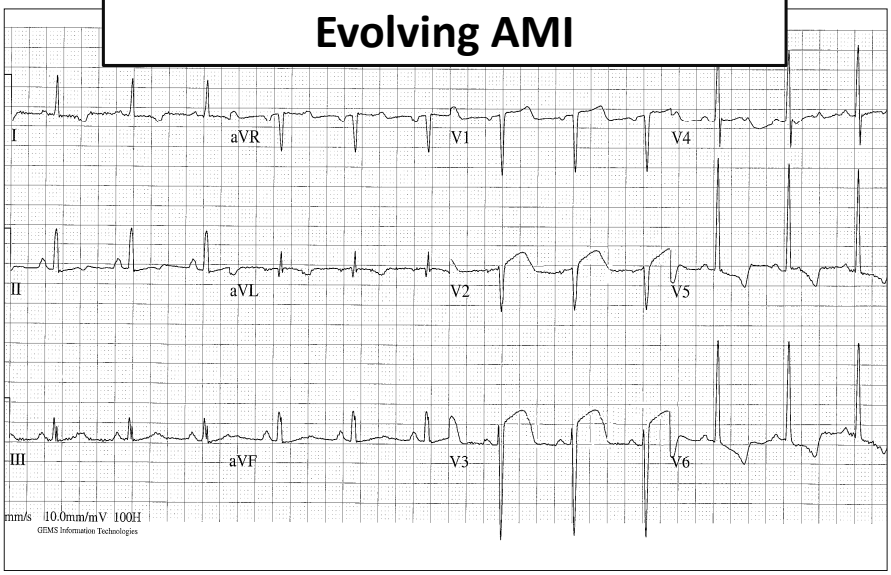
Left Ventricular Hypertrophy with Strain Pattern



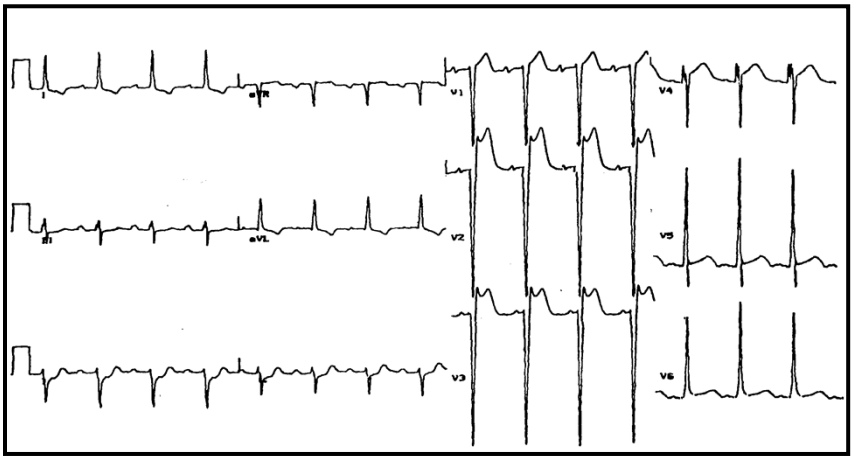
Left Ventricular Hypertrophy with Strain Pattern



Left Ventricular Hypertrophy with Strain Pattern Evolving AMI



Left Ventricular Hypertrophy with Strain Pattern Evolving AMI



BREAK

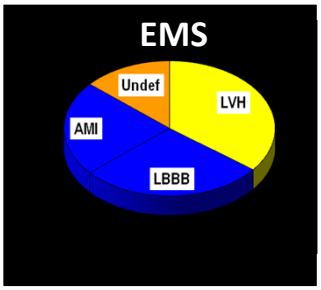
STEMI Mimics

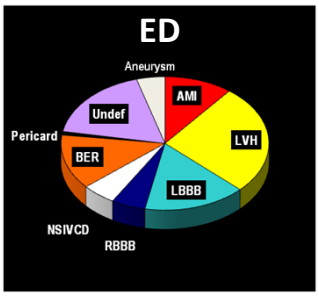
STEMI Mimics

- **Left bundle branch block**
- **Ventricular paced pattern**
- **Left ventricular hypertrophy pattern with strain**
- **Benign early repolarization**
- **Acute pericarditis**
- **Left ventricular aneurysm**
- **etc…….**

ST Segment Elevation

Electrocardiographic Cause of ST Elevation





Benign Early Repolarization

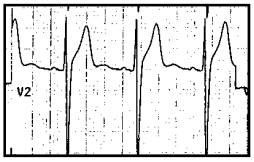
Benign Early Repolarization

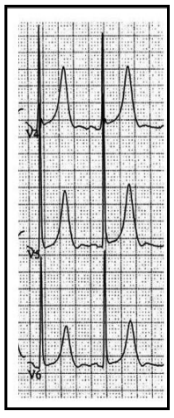
- **Normal variant**
- **No pathologic correlation**
- **Found in many patient groups**
  - General population -- 2%
  - ED chest pain patients – 5-7%
  - ED cocaine chest pain patients – 20%
- **Pattern encountered in younger patients**
- **Represents the patient's baseline ECG**

Benign Early Repolarization

Electrocardiographic findings

- ST segment elevation at "J" point
  - ST segment evenly lifted from baseline at J point
  - Preservation of initial ST segment concavity



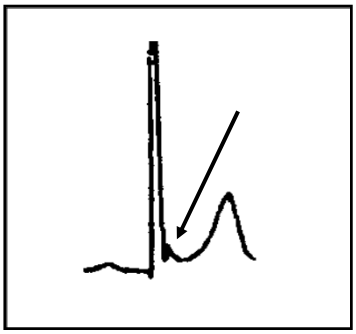


- Symmetric, large T waves
  - Concordant with QRS complex
  - Usually in precordial leads
  - More prominent in precordial leads

Benign Early Repolarization

Notching of the J point

- **Irregularity of terminal portion of QRS complex**
- **Highly suggestive *but not diagnostic* of BER**

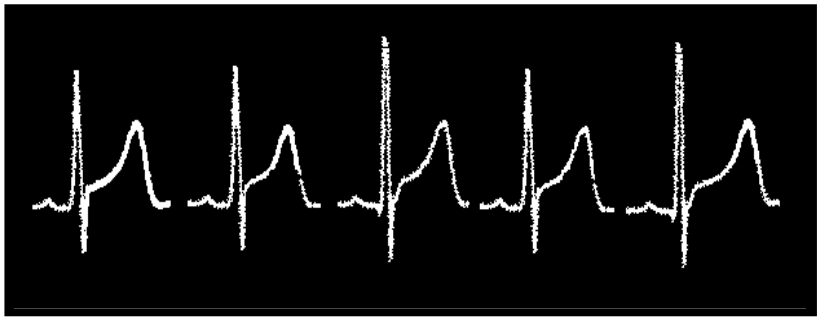


Benign Early Repolarization

- Distribution of BER
  - Most often in leads V2 to V5
  - ~ 50% cases also limb leads
  - "Isolated" limb leads -- rare
- Magnitude of ST elevation in BER
  - 1 to 3 mm – range 0.5 - 5 mm
  - 90% patients ST elevation
    - < 0.5 mm in limb leads
    - ~ 2 mm in precordial leads
  - > 5 mm in only 5% patients

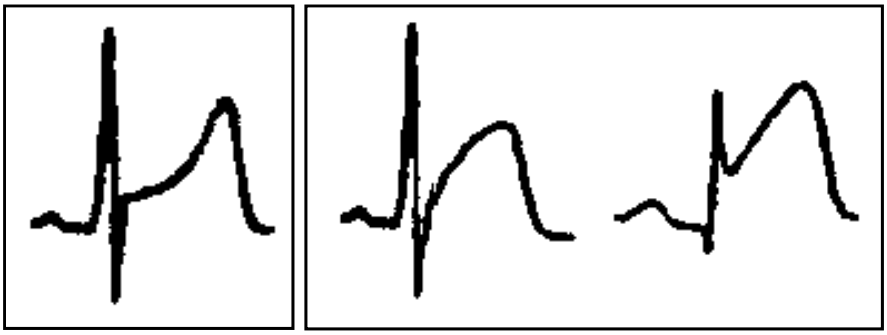
Temporal Stability
Serial ECGs
BER in Cocaine Chest Pain Patient

0219----------0225---------0234----------0239------//------0356



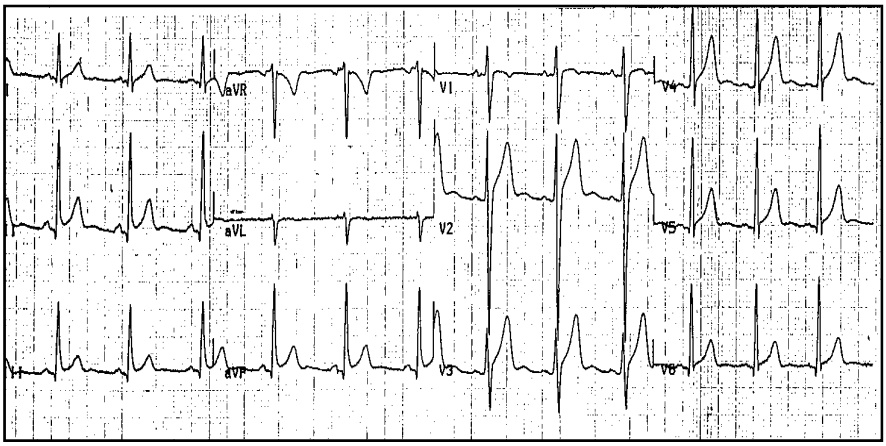
Lead V_3

BER *vs* STEMI

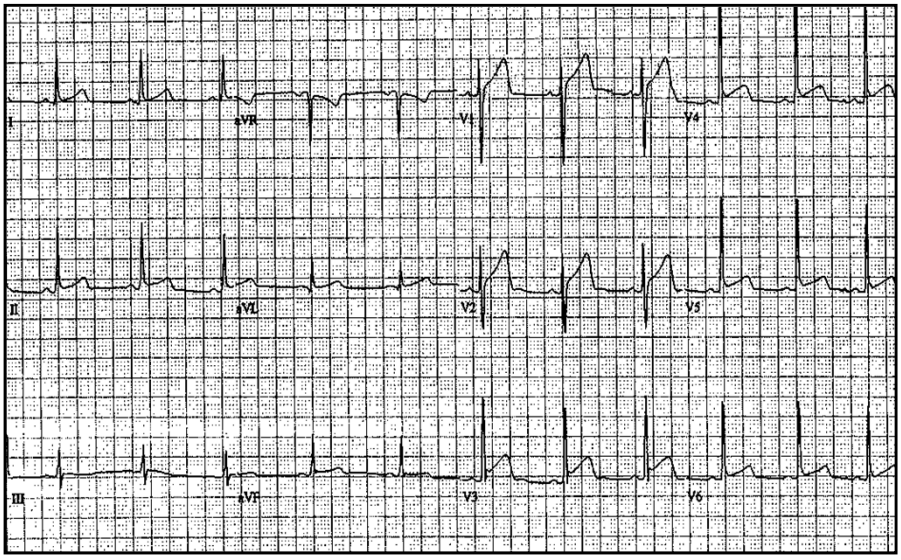


BER **STEMI**

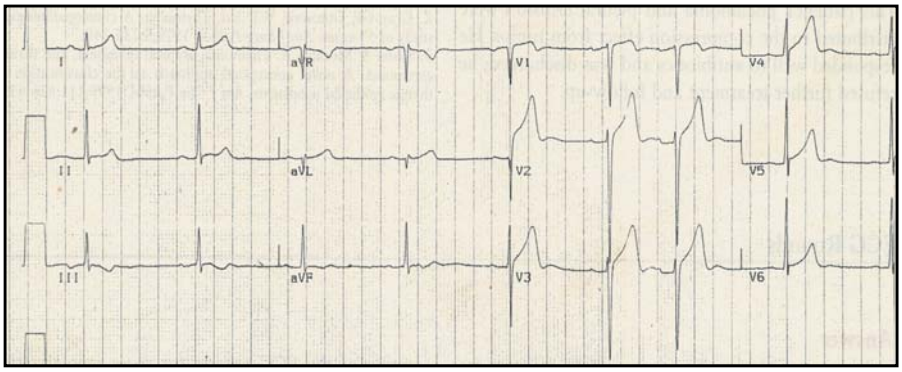
Benign Early Repolarization



Benign Early Repolarization



Benign Early Repolarization



Right Bundle Branch Block

Right Bundle Branch Block

- Does not obscure ECG DX of AMI
- May confuse ECG Dx of ACS

- Lack of knowledge of anticipated ST segment & T wave patterns
  - "Hide" ACS
  - Incorrectly "suggest" ACS

Right bundle branch block is a high risk pattern in the ACS patient

Right Bundle Branch Block

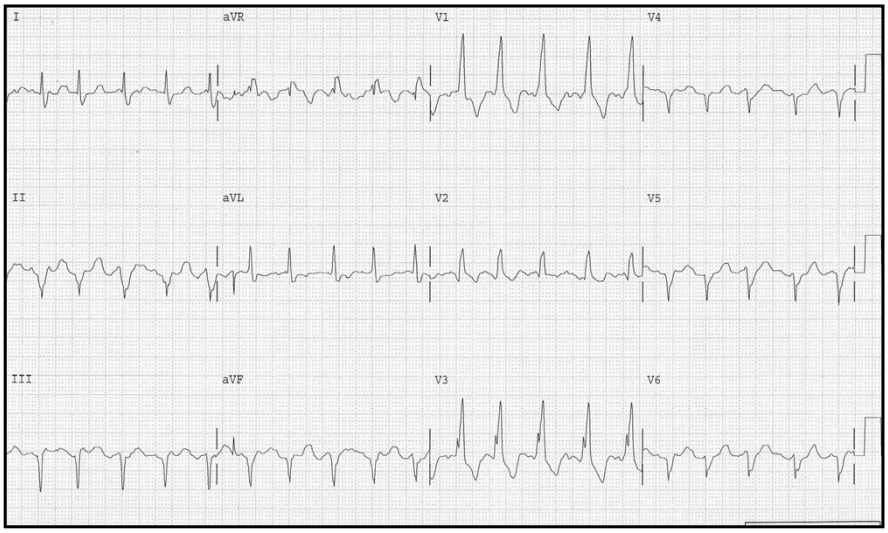
- **May also hinder ECG diagnosis**
  - **Not due to electrophysiologic issues**
  - **Resulting from interpretative errors**
- **Age of RBBB**
  - **Chronicity not an issue for fibrinolysis**
  - **ECG can be interpreted – consider ST segments**
  - **Marker for poor outcome**
- **NRMI-2 registry**
  - **RBBB pattern in approximately 6% of AMI patients**
  - **Less often received fibrinolysis**
  - **Increased poor outcome [64% increased odds ratio of death]**
    - **Worse than LBBB!**

Right Bundle Branch Block

- Characteristics of RBBB
  - QRS complex > 0.12 sec
  - Broad, monophasic R or RSR' wave in lead V_1
  - Wide S or RS wave in lead V_6

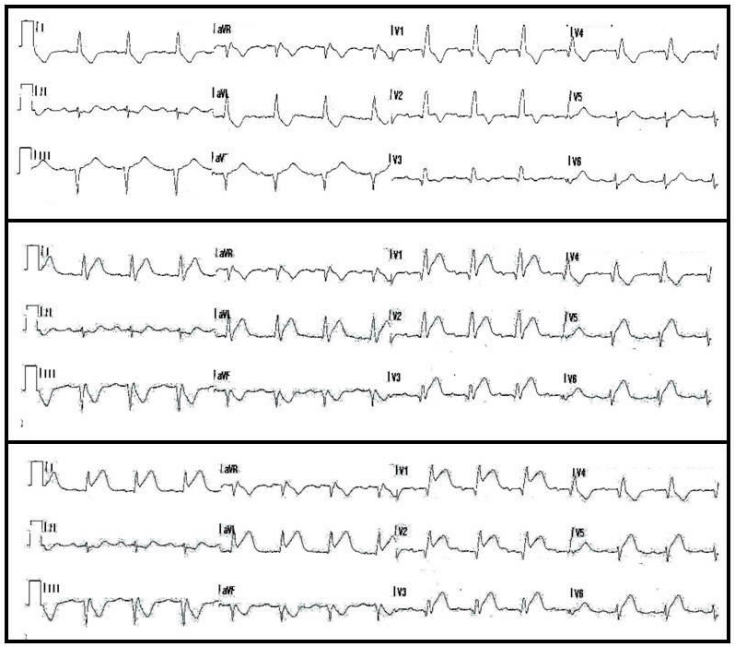
- Marked ST segment changes are seen
  - Right precordial leads -- ST depression
  - Inferior & left precordial leads -- upright T wave & ST elevation

Right Bundle Branch Block



RBBB with Anterior Wall STEMI

RBBB with Anterior Wall STEMI

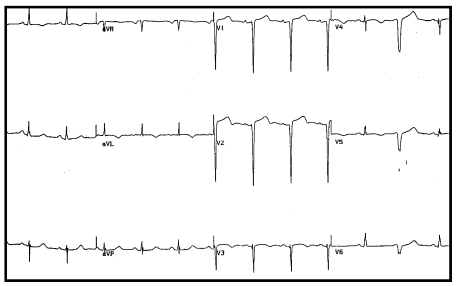


Left Ventricular Aneurysm

Left Ventricular Aneurysm

- Persistent ST elevation after AMI
  - Suggested by ECG
  - Diagnosed via other modalities
  - Difficult to distinguish from ST changes due to AMI
- ST elevation may present with varying morphologies
  - Minimal elevation / concave
  - Pronounced elevation / convex
- Seen in anterior > inferior > lateral > posterior MI

Left Ventricular Aneurysm ECG Features



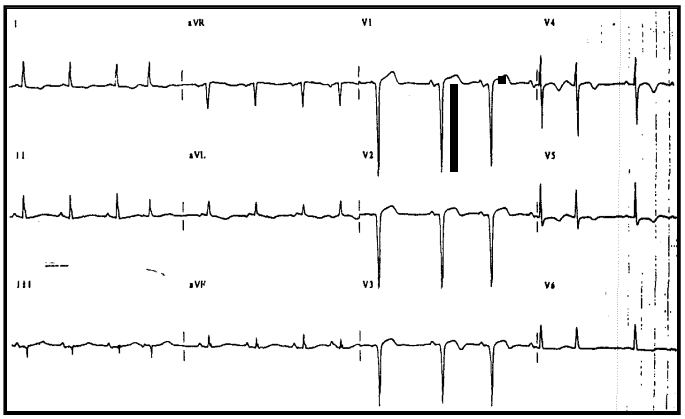
- **QRS configurations**
  - QS or Qr waves (V1 to V3)
  - QR waves (II, III, & aVf)
- **Minimal ST elevation, usually < 3 mm**
- **Flattened, small, or inverted T waves**
- **Ratio T / QRS amplitude is low (<0.36)**
  - Prominent T waves in AMI
  - Loss of T wave prominence after acute event

Smith SW, Acad Emerg Med, 2003

Left Ventricular Aneurysm

Ratio T / QRS amplitude

Ratio T / QRS amplitude < 0.36



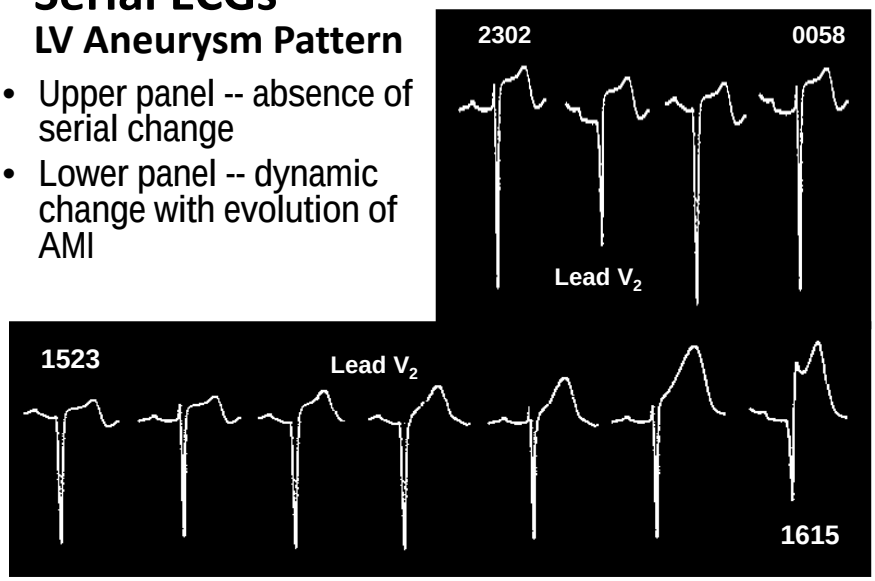
Smith SW, Acad Emerg Med, 2003

Left Ventricular Aneurysm

Varying Forms of ST Segment Elevation

Serial ECGs
LV Aneurysm Pattern

- Upper panel -- absence of serial change
- Lower panel -- dynamic change with evolution of AMI

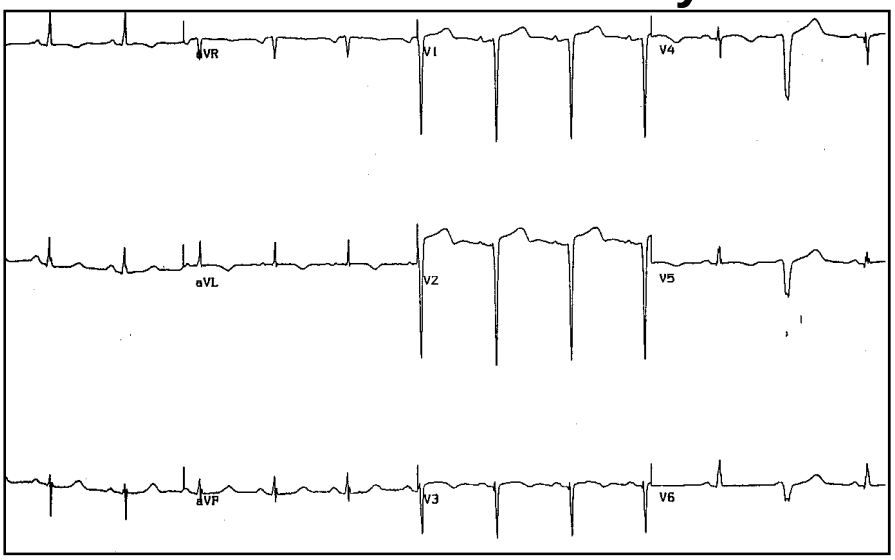


LV Aneurysm *vs* STEMI

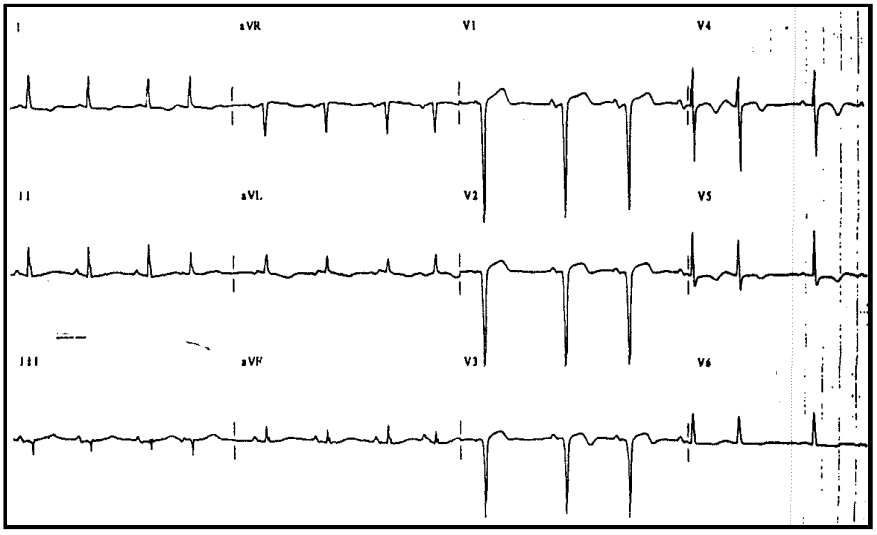
LV Aneurysm

STEMI

Left Ventricular Aneurysm



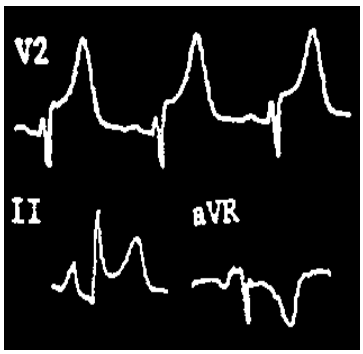
Left Ventricular Aneurysm



Left Ventricular Aneurysm

Pericarditis

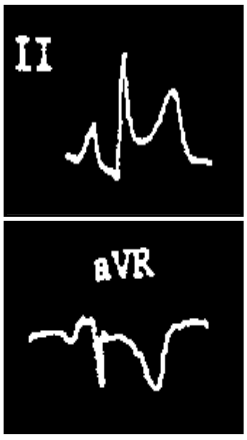
Acute Pericarditis



- ST segment elevation
  - Usually < 5 mm
  - Observed in numerous leads simultaneously
  - Focal process is possible
  - Reciprocal ST depression in aVr & V_1
- Characterized by initial concavity -- in some instances, the ST elevation may actually be obliquely flat

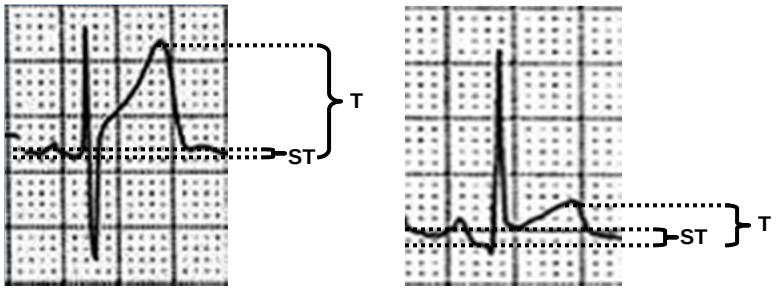
Acute Pericarditis

PR segment Abnormality



- **Atrial epicardial irritation results in PR segment abnormalities**
- **PR depression is best seen in leads II, II, aVf, & V_6**
- **"Reciprocal" PR segment elevation is seen in lead aVr – very useful finding**

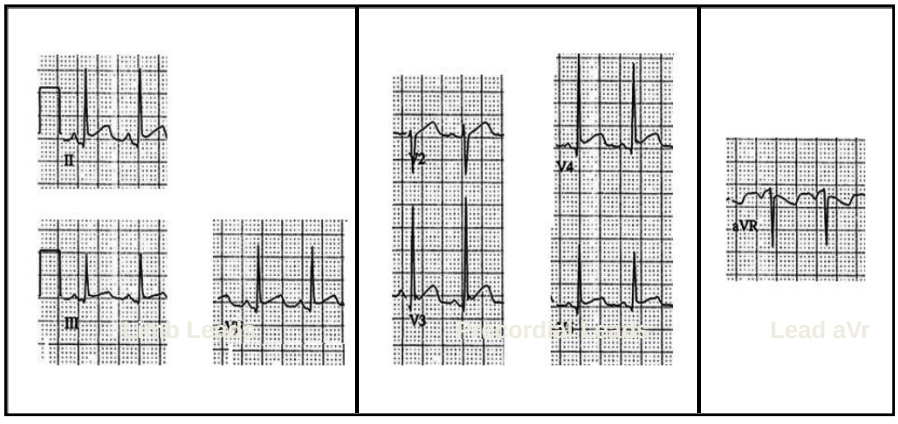
BER vs Acute Pericarditis



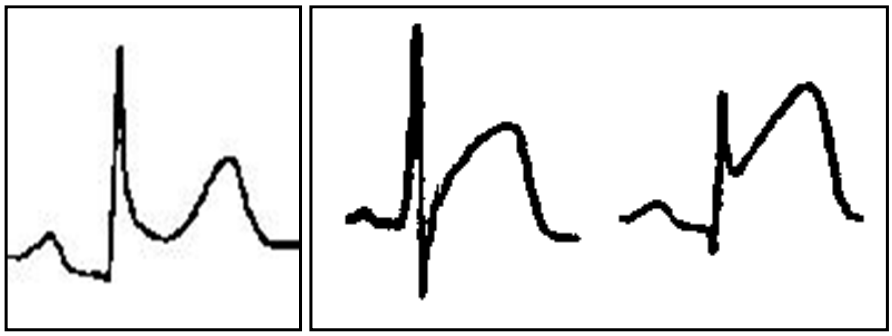
BER | Acute Pericarditis

ST / T Ratio

Acute Pericarditis
ECG Features

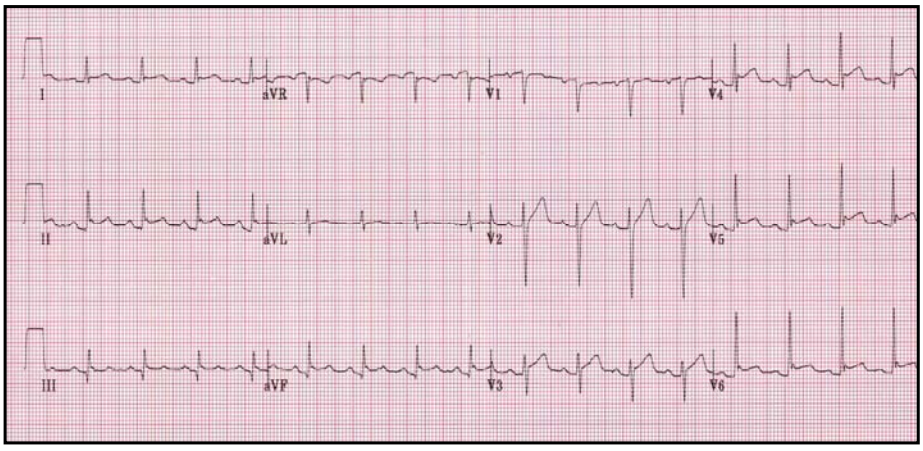


Pericarditis *vs* STEMI

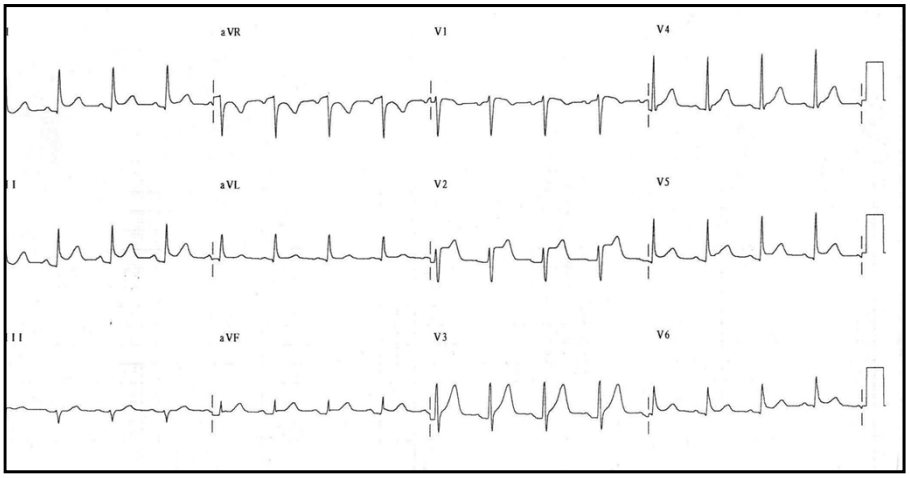


Pericarditis STEMI

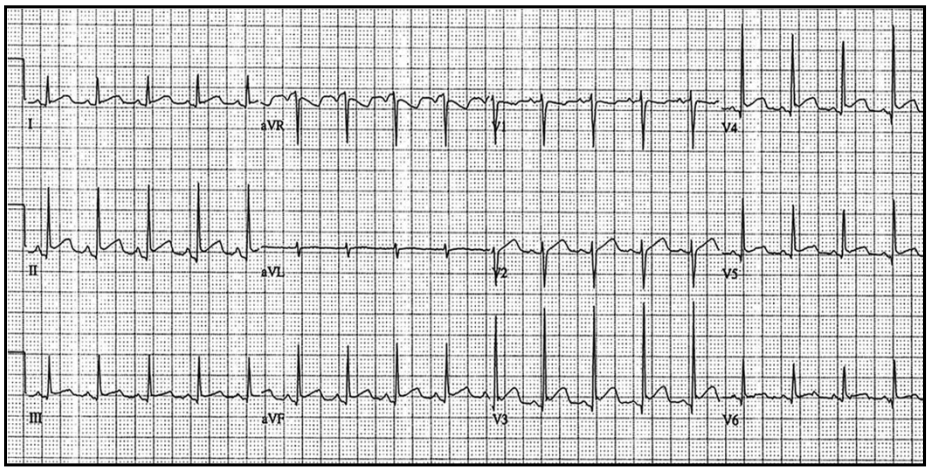
Pericarditis



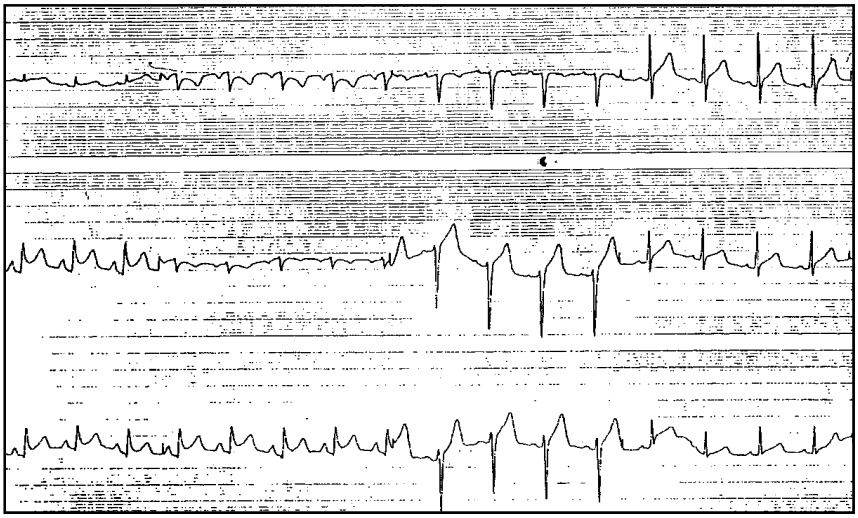
Pericarditis



Pericarditis

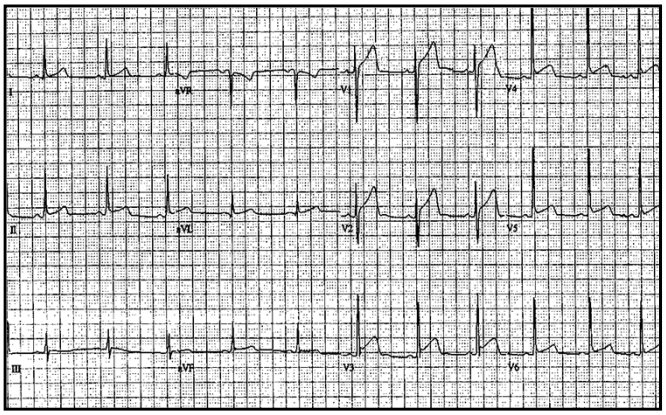


Pericarditis



In this 39 year old male with ST segment elevation, what ECG diagnosis will you make?

A. Acute pericarditis
B. Benign early repolarization
C. STEMI
D. Not sure…….really not sure.



In this 39 year old male with ST segment elevation, what ECG diagnosis will you make?

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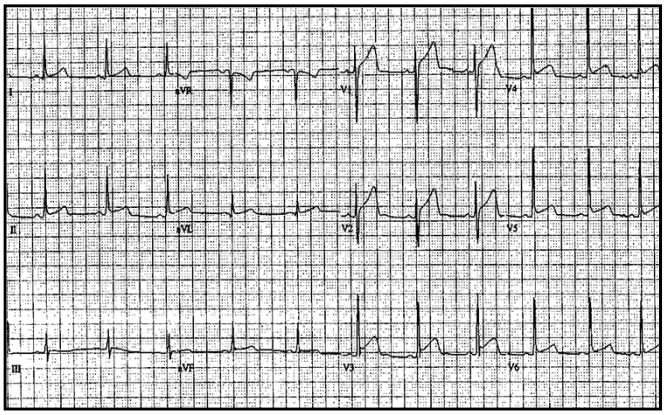


BREAK

Four-step Algorithm

1. **ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads?**
2. **QRS complex normal size?**
   - **Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm**
3. **QRS complex normal width?**
   - **QRS complex < 0.08 second**
4. **ST segment depression present in at least 1 lead?**

Four-step Algorithm

- **This algorithm will……**
  - **Detect only certain STEMI presentations**
  - **Miss certain AMI patterns:**
    - **All NSTEMI**
    - **Subtle STEMI**
    - **LVH & LBBB AMI**

QUESTION #1

Four-step Algorithm

1. **ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads?**
2. QRS complex normal size?
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width?
   - QRS complex < 0.08 second
4. ST segment depression present in at least 1 lead?

ST Segment Elevation

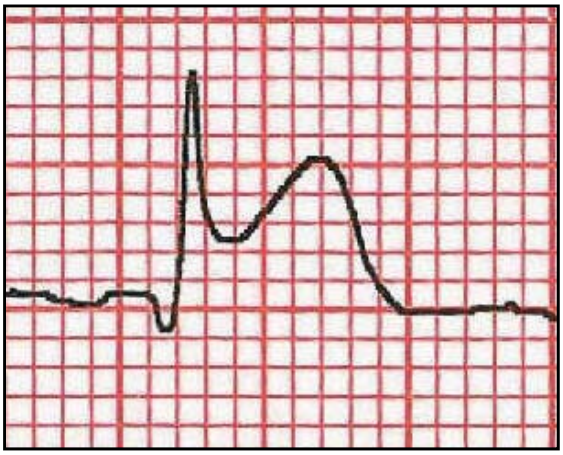
CARDIOLOGY/CLINICAL POLICY

Clinical Policy: Indications for Reperfusion Therapy in Emergency Department Patients with Suspected Acute Myocardial Infarction

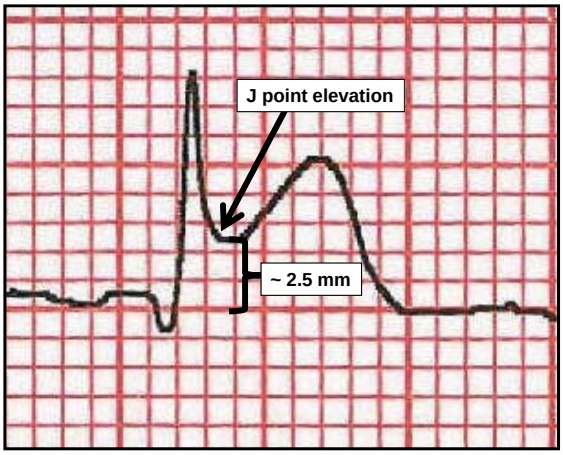
From the American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on Reperfusion Therapy in Emergency Department Patients with Suspected Acute Myocardial Infarction:
Francis M. Fesmire, MD (Subcommittee Chair)
William J. Brady, MD
Sigrid Hahn, MD
Wyatt W. Decker, MD
Deborah B. Diercks, MD
Chris A. Ghaemmaghami, MD
Devorah Nazarian, MD
Andy S. Jagoda, MD (Clinical Policies Committee Chair)

"ST segment elevation greater than or equal to 1 mm in at least 2 anatomically contiguous leads …….and lacking features of non-infarction causes of ST segment elevation."

ST Segment Elevation?

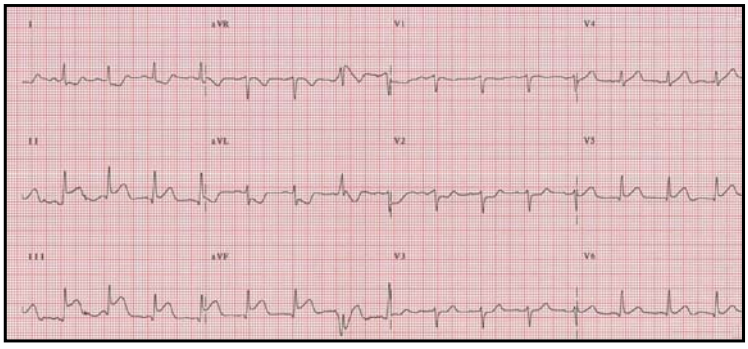


ST Segment Elevation?



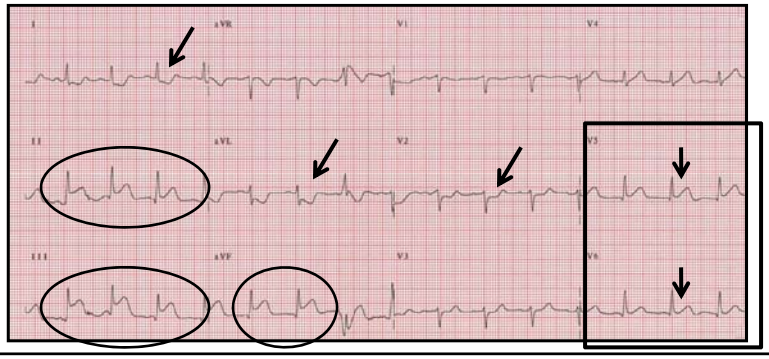
ST Segment Elevation?

- In at least 2 anatomically contiguous leads
  - Inferior: II, III, aVf
  - Lateral: I, aVl, V5, V6
  - Anterior: V1, V2, V3, V4



ST Segment Elevation?

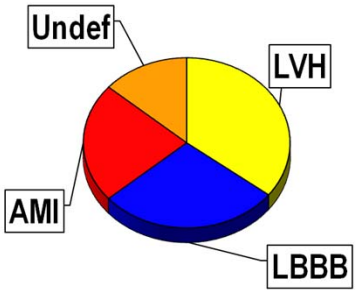
- **In at least 2 anatomically contiguous leads**
  - **Inferior: II, III, aVf**
  - **Lateral: I, aVl, V5, V6**
  - **Anterior: V1, V2, V3, V4**



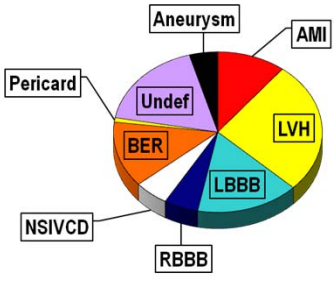
Causes of ST Segment Elevation

"lacking features of non-infarction causes of ST segment elevation"

Prehospital



Emergency **Department**



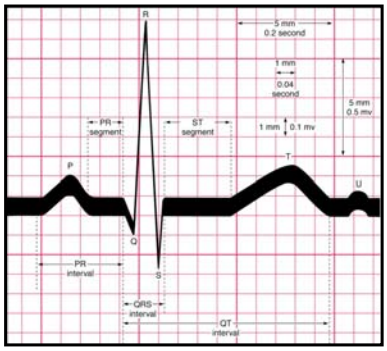
Chest Pain Patients with at least 1 mm ST Elevation in 2 Contiguous Leads. Only *20 to 30%* of Individuals with STEMI.

Ok, so there's ST segment elevation.

Now let's evaluate the QRS complex.

ECG Cycle

ST Segment & T Wave (& QRS Complex)

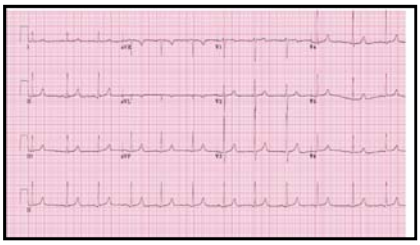


QUESTION: Why is the QRS complex Important when considering the ST segment?

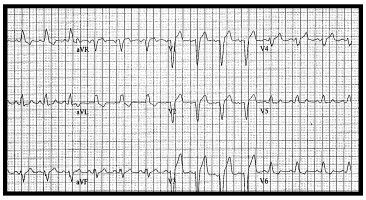
ANSWER: If BBB, paced rhythm, or LVH pattern is present, interpretation of ST segment / T wave will be altered.

With LBBB, LVH, & VPR, the ST segment & T wave are altered.

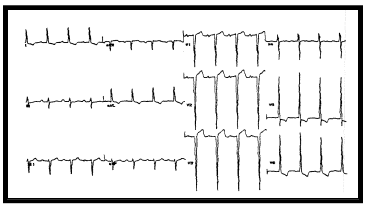
Normal



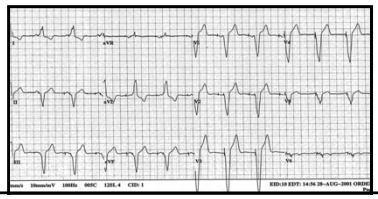
LBBB



LVH



Paced



QUESTION #2

Four-step Algorithm

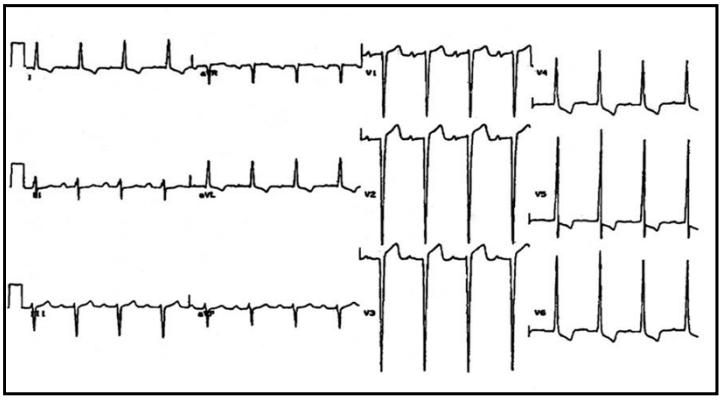
1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads?
2. **QRS complex normal size?**
   - **Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm**
3. QRS complex normal width?
   - QRS complex < 0.08 second
4. ST segment depression present in at least 1 lead**?**

QRS Complex Size?

- **Why are we asking this question?**
  - We are considering the presence of the left ventricular hypertrophy (by voltage) pattern.
- **Why is the LVH pattern important?**
  - Approximately 80% of LVH pattern patients will also have significant ST segment elevation & depression.
  - These LVH-related ST segment changes do not always represent STEMI.

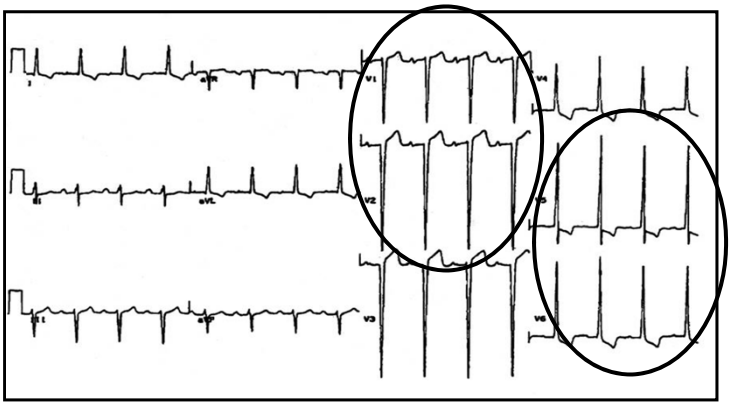
QRS Complex Size?

The LVH Pattern



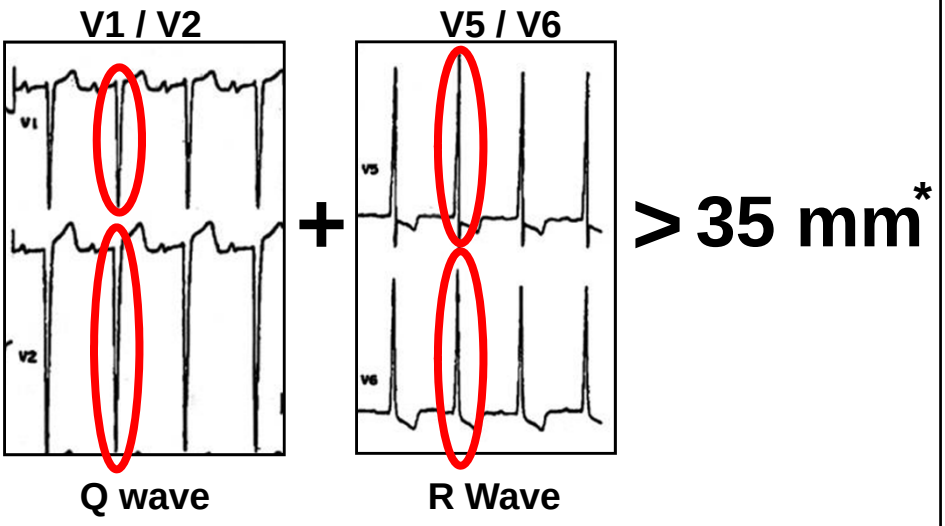
QRS Complex Size?

The LVH Pattern



QRS Complex Size?

Determination of QRS Complex Size



* In a patient > age 35 years

QRS Complex Size?

- The absence of a large QRS complex "rules out" LVH
- …….and LVH-related ST segment / T wave changes
- On to QUESTION #3

QUESTION #3

Four-step Algorithm

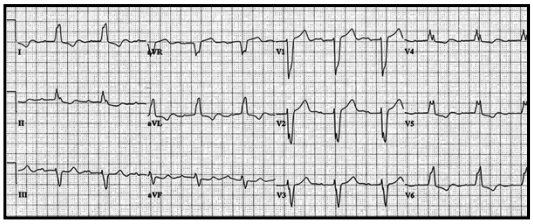
1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads?
2. QRS complex normal size?
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. **QRS complex normal width?**
   - **QRS complex < 0.08 second**
4. ST segment depression present in at least 1 lead?

QRS Complex Width?

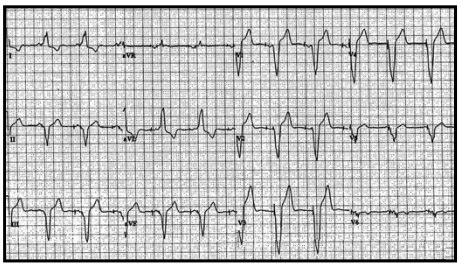
- **Why are we considering the QRS complex width?**
- Certain abnormal ECG patterns with widened QRS complex demonstrate ST segment & T wave abnormalities, representing the expected findings in certain patterns:
  - LBBB (& RBBB)
  - Ventricular paced rhythms
- And, as with the LVH pattern, these ST segment & T wave abnormalities are not necessarily indicative of ACS.

QRS Complex Width?

- **LBBB**

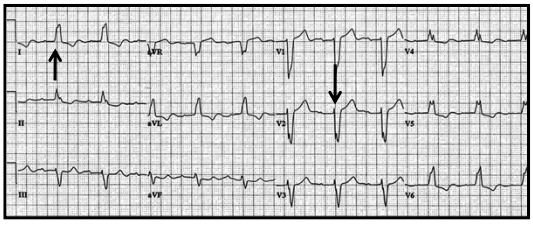


- **Ventricular paced rhythm**

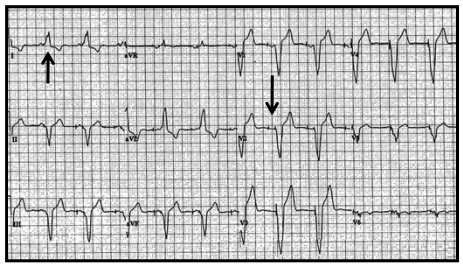


QRS Complex Width?

- **LBBB**



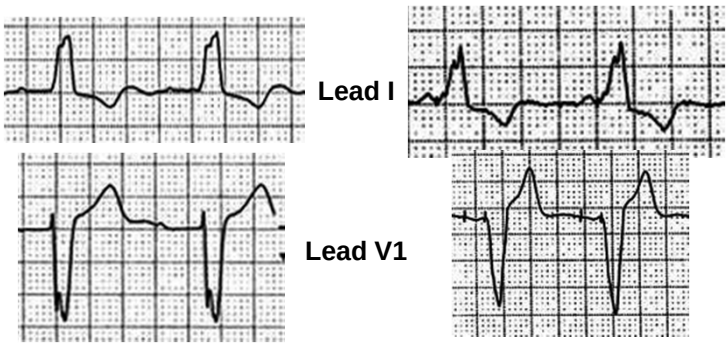
- **Ventricular paced rhythm**



QRS Complex Width?

ST Segment & T Wave Abnormalities

LBBB **Ventricular Paced**



- **These ST segment & T wave abnormalities are NOT indicative of ACS**

QRS Complex Width?

- **The absence of a widened QRS complex rules out bundle branch block & ventricular paced patterns**
- **…….and related ST segment / T wave abnormalities**

QRS Complex Width?

- **Now, we have removed LVH, LBBB, & paced rhythms as a cause of ST segment / T wave abnormalities.**
- **What's left?**
- **STEMI & several STEMI mimic patterns.**

QUESTION #4

Four-step Algorithm

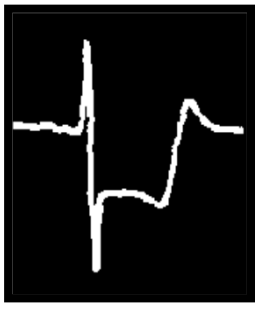
1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads?
2. QRS complex normal size?
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width?
   - QRS complex < 0.08 second
4. **ST segment depression present in at least 1 lead?**

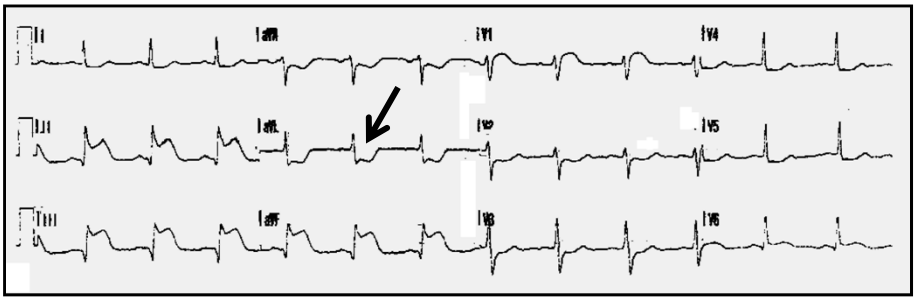
ST Segment Depression?

- **ST segment depression with co-existing ST segment elevation resulting from STEMI is termed reciprocal ST segment depression or reciprocal change.**
- **The presence of reciprocal change on an ECG with ST segment elevation provides very strong evidence that STEMI is present.**

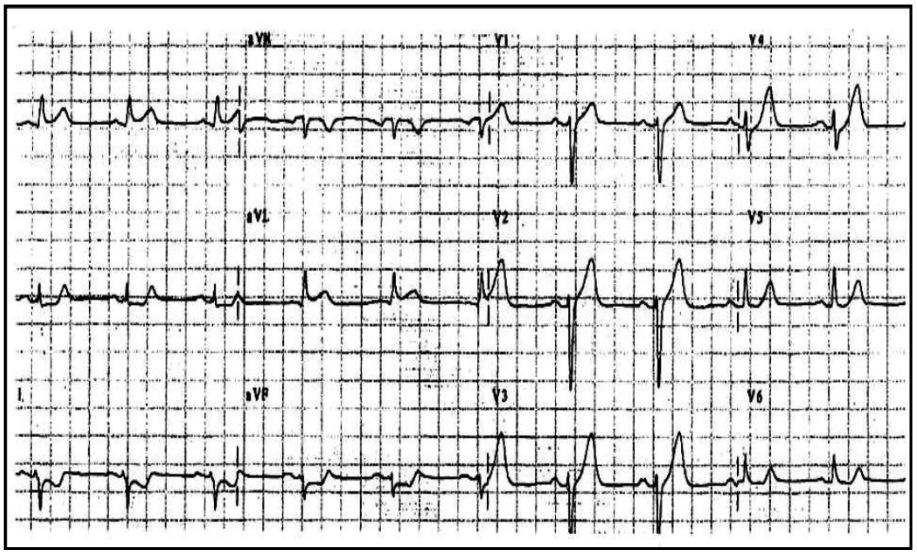
Reciprocal Change

- **ST segment depression > 1 mm distant from ST elevation AMI**
- **Increases diagnostic accuracy of STEMI**
  - **Specificity -- 95%**
  - **Positive predictive value -- 93%**

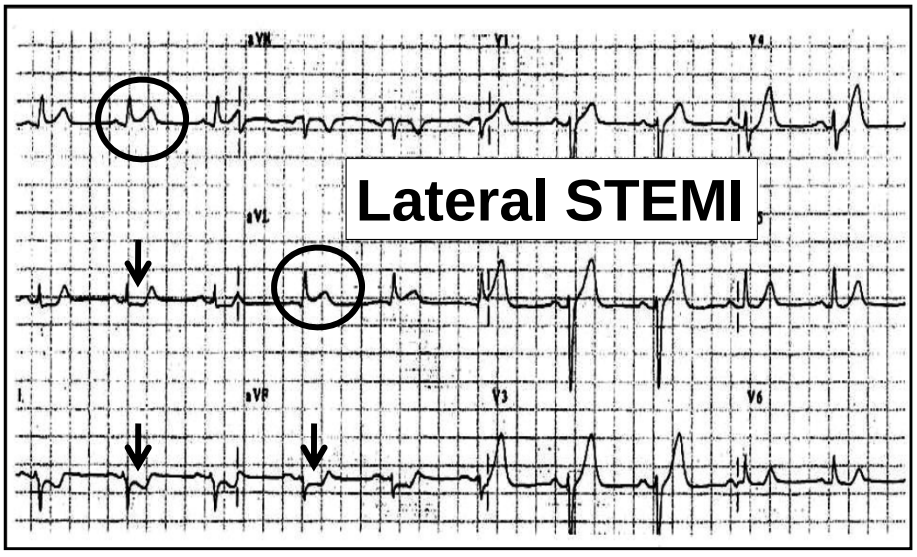




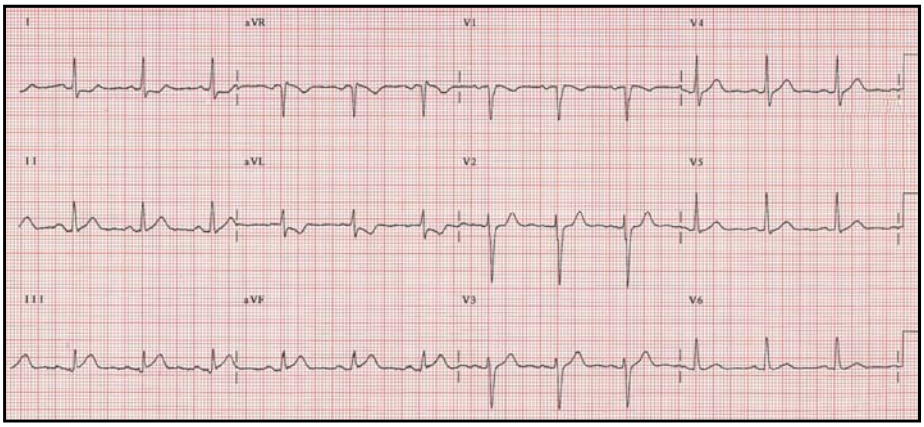
Reciprocal Change



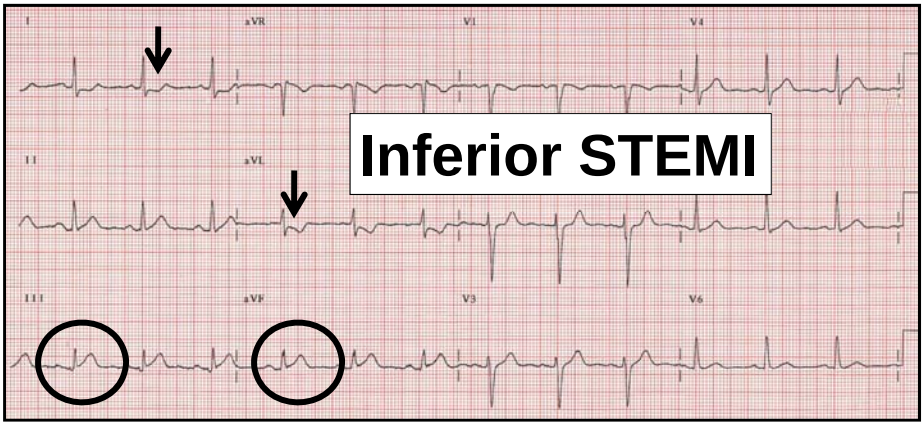
Reciprocal Change



Reciprocal Change



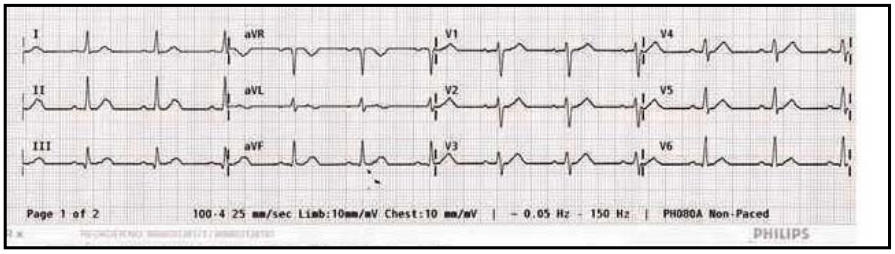
Reciprocal Change



Four-step Algorithm

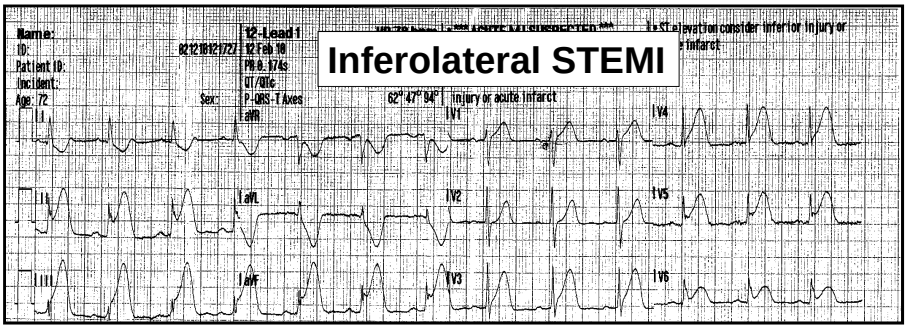
- We have now determined that STEMI is likely
- The four steps have confirmed the following:
  - Presence of ST segment elevation
  - The absence of ST segment elevation related to LVH, LBBB, RBBB, & ventricular paced rhythms
  - Confirmed STEMI by noting the presence of reciprocal change
- In patients who do not "meet" the algorithmic criteria, STEMI can still exist but further analysis is needed

Illustrative Cases



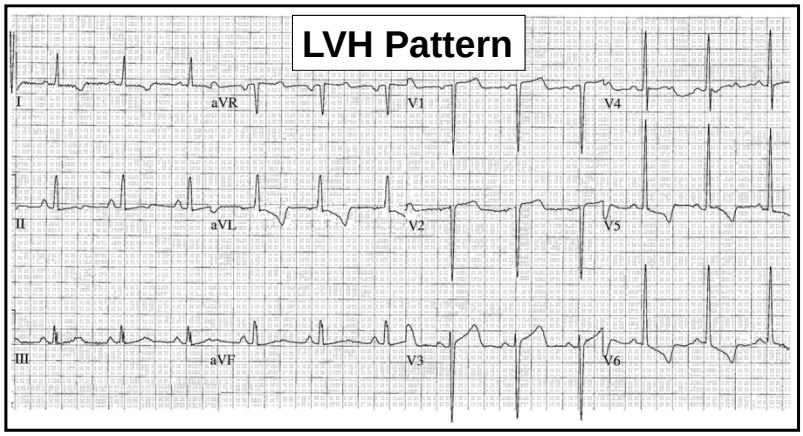
1. **ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? NO**
2. **QRS complex normal size?**
   - **Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm**
3. **QRS complex normal width?**
   - **QRS complex < 0.08 second**
4. **ST segment depression present in at least 1 lead?**

NORMAL ECG



1. **ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? YES**
2. **QRS complex normal size? YES**
   - **Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm**
3. **QRS complex normal width? YES**
   - **QRS complex < 0.08 second**
4. **ST segment depression present in at least 1 lead? YES**

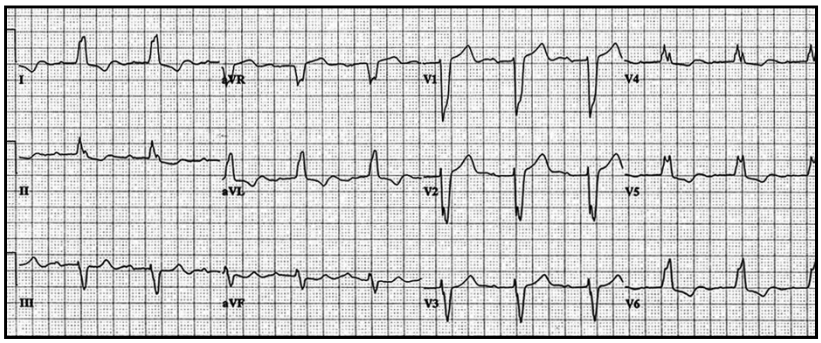
LVH Pattern



1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? **YES**
2. QRS complex normal size? **NO**
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width?
   - QRS comp… < 0.08 second
4. ST segment d…pr…ssion present in at least 1 lead?

X

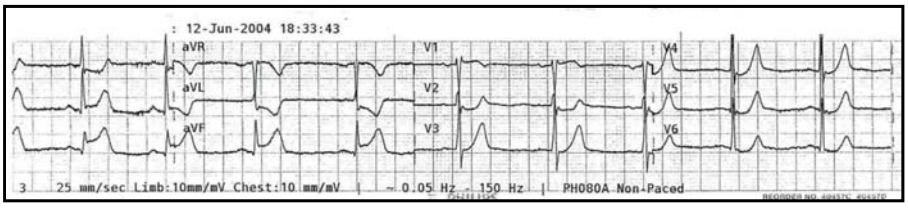
LBBB Pattern



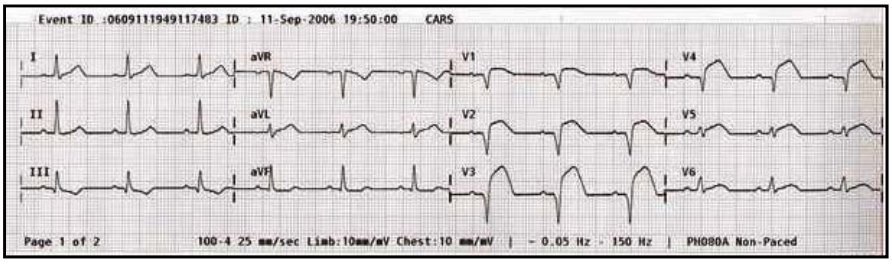
1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? **YES**
2. QRS complex normal size? **YES**
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width? **NO**
   - QRS complex < 0.08 second
4. ST segment d…pr…ssion present in at least 1 lead?

X

Inferior STEMI



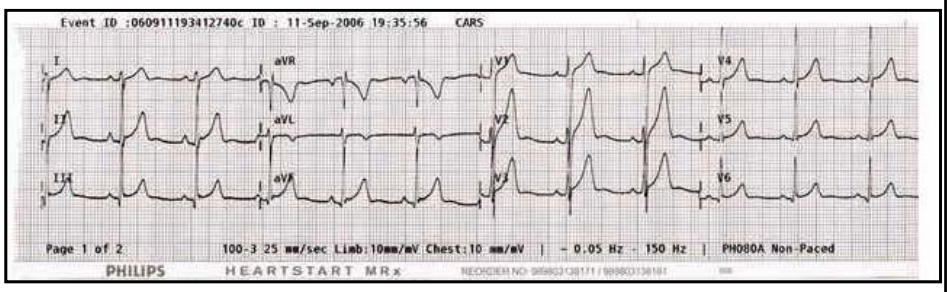
1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? **YES**
2. QRS complex normal size? **YES**
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width? **YES**
   - QRS complex < 0.08 second
4. ST segment depression present in at least 1 lead? **YES**



1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? **YES**
2. QRS complex normal size? **YES**
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width? **YES**
   - QRS complex < 0.08 second
4. ST segment depression present in at least 1 lead? **NO**

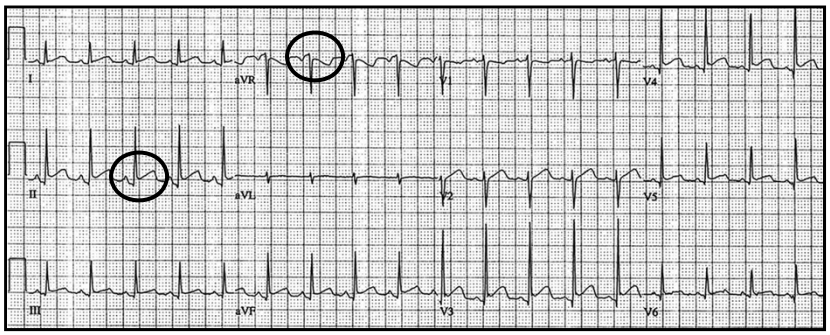
Anterolateral STEMI

Benign Early Repolarization

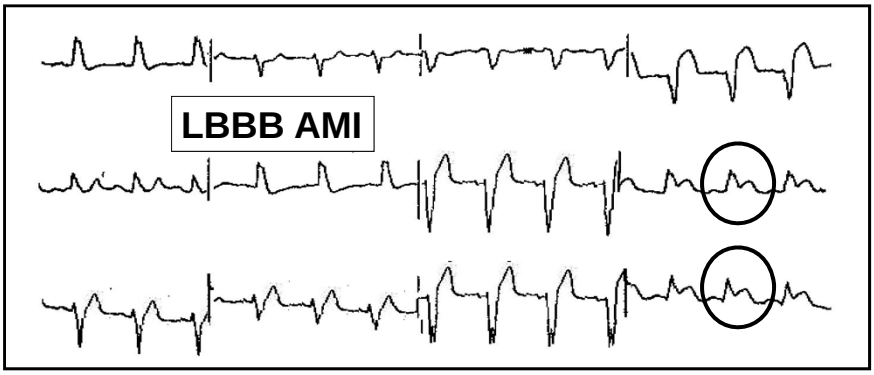


1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? **YES**
2. QRS complex normal size? **YES**
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width? **YES**
   - QRS complex < 0.08 second
4. ST segment depression present in at least 1 lead? **NO**

Acute Pericarditis



1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? **YES**
2. QRS complex normal size? **YES**
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width? **YES**
   - QRS complex < 0.08 second
4. ST segment depression present in at least 1 lead? **NO**



1. ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads? YES
2. QRS complex normal size? YES
   - Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm
3. QRS complex normal width? NO
   - QRS complex < 0.08 second
4. ST segment depression present in at least 1 lead? X

The End

wjbrady@virginia.edu

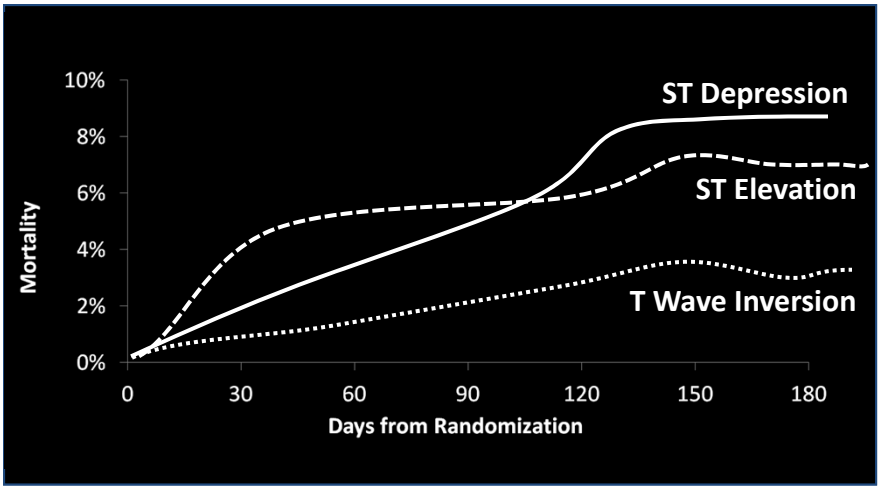
BREAK

ECG Risk Prognostication

ECG Risk Prognostication

- Any ST Segment Deviation
  - Any ST Segment Deviation
  - ST Segment Elevation in Lead aVr
- Bundle Branch Block (Left & Right)
- Left Ventricular Hypertrophy

Prognostic Value of ECG Changes GUSTO IIb



Adapted from Savonitto S, et al. *JAMA*. 1999;281:707-713.

Any change in the ST segment with chest pain has important diagnostic & prognostic implications.

Risk Stratification at Triage *Using the ECG*

Risk Stratification

-- *Immediate* --

- Rapid, focused evaluation
  - History
  - Exam
  - 12-lead ECG
- ECG within 5 to 7 minutes of ED arrival
- Nurse assessment of ECG
- Immediate emergency physician availability

Risk Stratification

-- *Immediate* --

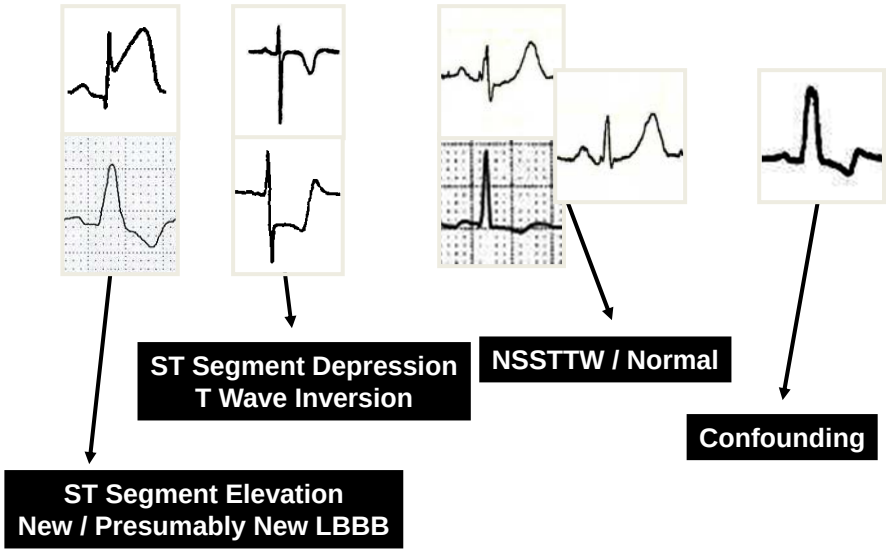
- Four ECG classes with respect to ACS
- Emphasis on STEMI
- Implications
  - Additional diagnostic
  - Management

ECG Risk Stratification

-- *Immediate* --

- **Diagnostic**
  - **ST segment elevation**
  - **LBBB (new)**
- **Abnormal / non-Dx**
  - **T wave inversion**
  - **ST segment depression**
- **Nonspecific / Normal**
- **Confounding**
  - **LBBB**
  - **LVH**
  - **Paced**

ECG Classification



ECG Risk Stratification

-- *Immediate Diagnostic & Treatment* --

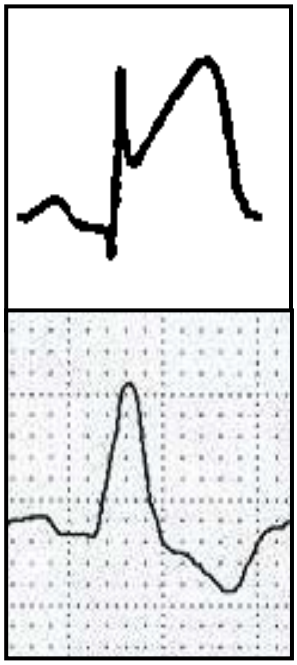
- **Diagnostic**
  - **Dx: confirm STEMI**
  - **Rx: revascularization**

  Risk +++++
- **Abnormal / non-Dx**
  - **Dx: history & markers**
  - **Rx: anti-anginal, -platelet, & -coagulant**

  Risk ++ to ++++
- **Nonspecific / Normal**
  - **Dx: history & markers**
  - **Rx: ASA & anti-anginal**

  Risk + to +++
- **Confounding**
  - **Dx: history, markers, echocardiogram, angiography**
  - **Rx: revascularization**

  Risk ++ to +++++



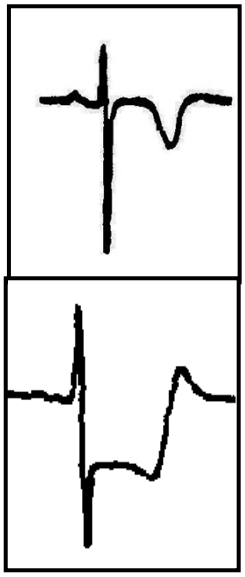
ST Segment Elevation

- **Potentially diagnostic for STEMI**
- **Beware of ST elevation mimickers**
- **If STEMI, candidate for emergent Rx**
  - **Fibrinolysis**
  - **PCI**
- **High risk**

New / Presumably New LBBB

- **Candidate for emergent Rx***
  - **Fibrinolysis**
  - **PCI**
- **Extremely high risk**

***If Appropriate Clinical Presentation**



ST Segment Depression T Wave Inversion

- Potentially diagnostic for ACS
- Beware of non-ACS syndromes
- **Moderate - high risk**
- **Management issues**
- **Additional diagnostic issues**

NSSTTW / Normal

- "NSSTTW" ≠ "normal"
- Emphasis on history
- Management per history
- Additional diagnostic issues
  - Markers
  - **Risk stratification**

Confounding

- Power of ECG reduced
- Significant emphasis on history & examination
- Pre-existing heart disease
- Extremely high risk presentation
  - Cardiovascular complication
  - Death

ECG Interpretation

Clinician ECG Expertise

The eye does not see what the mind does not know!

Academic Emergency Medicine Volume 9, Number 4 317-319,

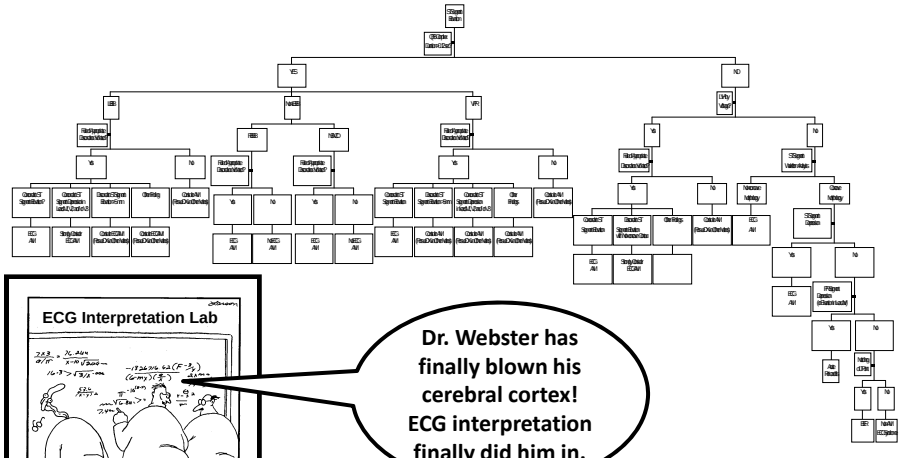
COMMENTARIES

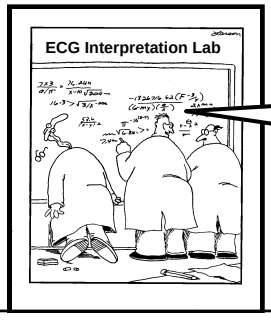
Emergency Physician Interpretation of the Electrocardiogram

Edward A. Michelson, MD and William J. Brady, MD

Division of Emergency Medicine, Northwestern University, Chicago, IL; Department of Emergency Medicine, University of Virginia, Charlottesville, VA

ST Segment Elevation Clinical Decision Pathway
A Complex Decision-making Process





Dr. Webster has finally blown his cerebral cortex! ECG interpretation finally did him in.

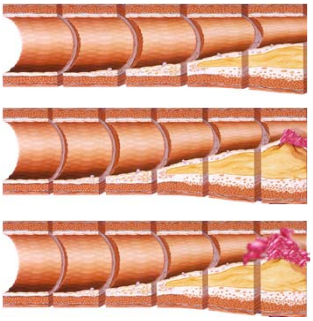
Four-step Algorithm

1. **ST segment elevation of at least 1-2 mm in 2 anatomically oriented leads?** **Is ST elevation present?**
2. **QRS complex normal size?** **Is ST elevation present due to LVH?**
   - **Q wave (negative) in lead V_1 / V_2 + R wave (positive) in lead V_5 / V_6 < 35 mm**
3. **QRS complex normal width?** **Is ST elevation present due to BBB ?**
   - **QRS complex < 0.08 second**
4. **ST segment depression present in at least 1 lead?** **Is reciprocal change present?**

Limitations & Challenges in the ECG Diagnosis of ACS

Acute Coronary Syndrome & The ECG

- Pathophysiology
  - Chronic
    - Plaque development
  - Acute
    - Plaque rupture, followed by…
    - Thrombus formation &
    - Vasoconstriction



- Very dynamic process
- ECG is only a surface reflection of this process
- "A snap shot in time"

ECG Limitations

- Nondiagnostic ECG
- Evolving event
- Confounding patterns
- Anatomical issues

ECG Limitations

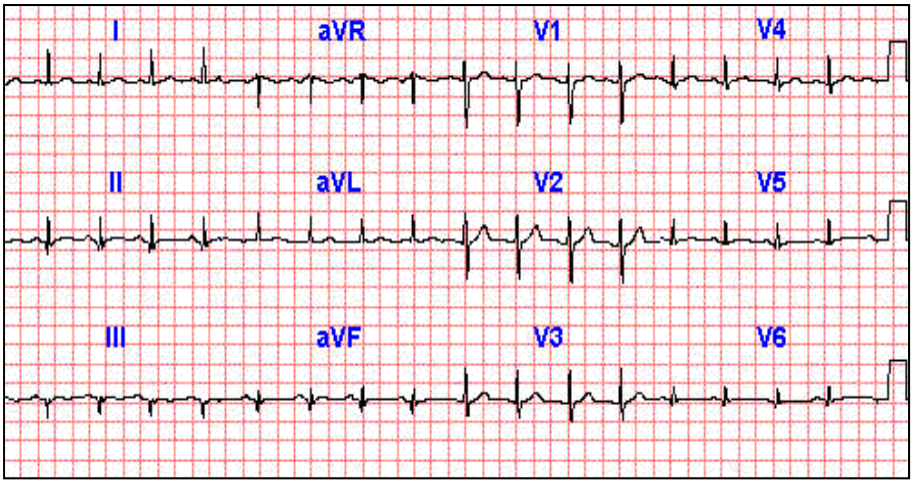
- **Nondiagnostic ECG**
  - **Normal**
  - **Near-normal**
  - **Nonspecific**
  - **Abnormal / nondiagnostic**
- Evolving event
- Confounding patterns
- Anatomical issues

Initial ECG Findings in Adult Chest Pain Patients Association with Acute Coronary Syndromes

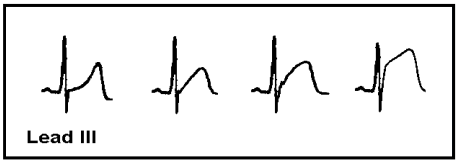
	Number (%) of patients			
Reading	**Total**	**AMI**	**USAP**	**Other**
Normal	114	1 (1)	5 (4)	108 (95)
NSSTTW	150	4 (3)	34 (23)	112 (75)

Lee, Arch Intern Med, 1985

Nonspecific ST Segment – T Wave Abnormalities

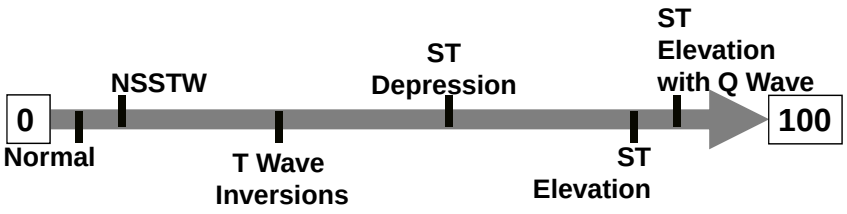


ECG Limitations



- Nondiagnostic ECG
- **Evolving event**
  - **Initially normal or nonspecifically abnormal**
  - **Interrupted pathophysiology**
- Confounding patterns
- Anatomical issues

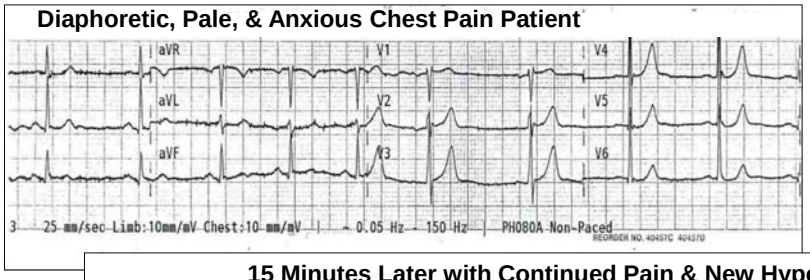
Electrocardiographic Changes of AMI



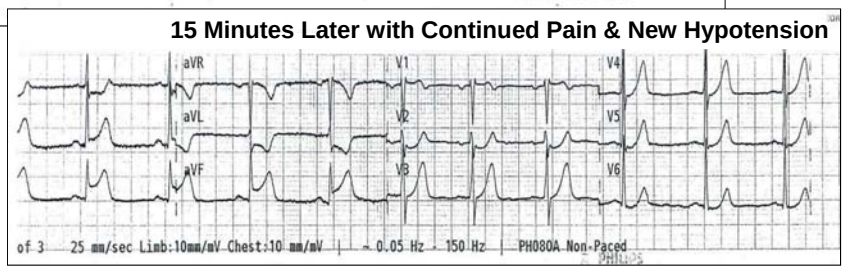
Increasing Likelihood of AMI

Nonspecific ST Segment – T Wave Abnormalities

Diaphoretic, Pale, & Anxious Chest Pain Patient



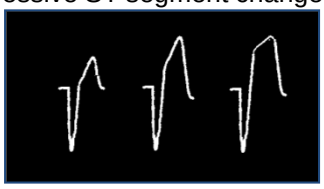
15 Minutes Later with Continued Pain & New Hypotension



ECG Limitations

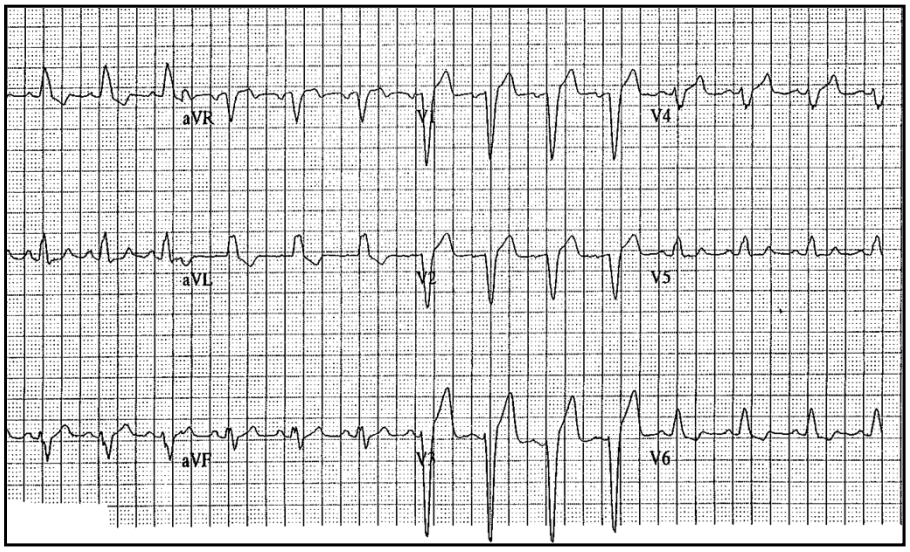
- Nondiagnostic ECG
- Evolving event
- **Confounding patterns**
  - **Left bundle branch block**
  - **Left ventricular hypertrophy**
  - **Ventricular paced rhythms**
- Anatomical issues

Lead V2 in LBBB Pattern
Progressive ST segment change



Significant ST Segment – T Wave Abnormalities

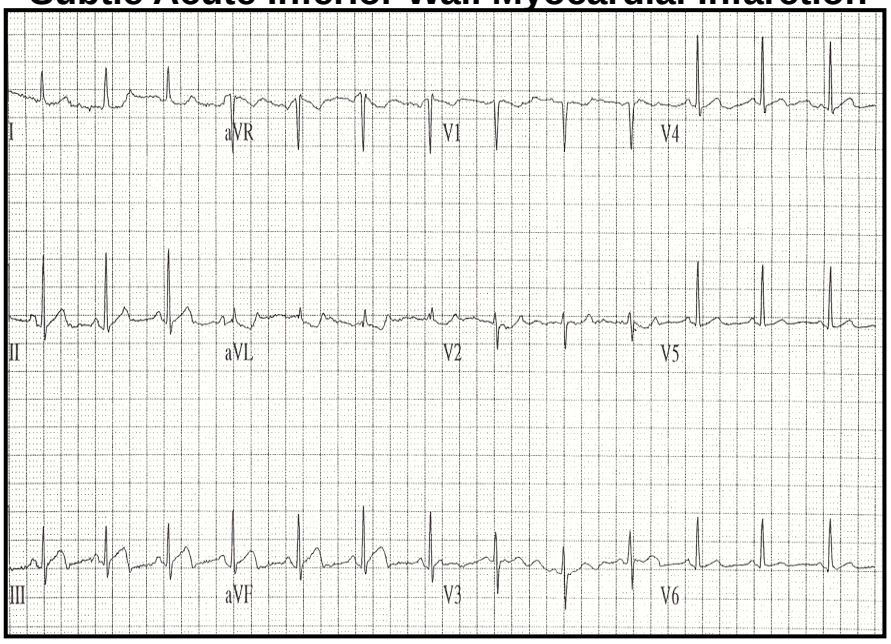
Left Bundle Branch Block Pattern in a Chest Pain Patient



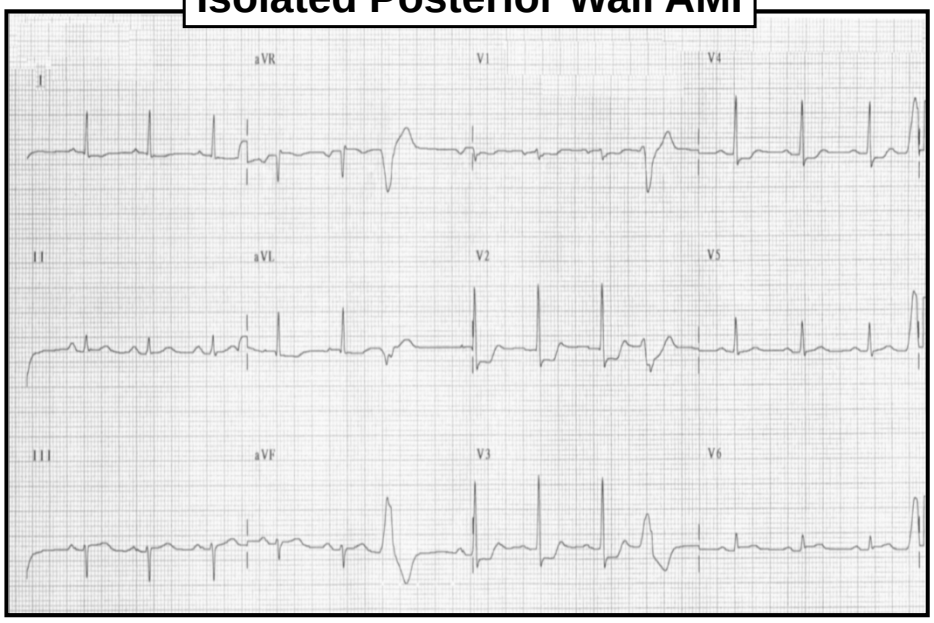
ECG Limitations

- Nondiagnostic ECG
- Evolving event
- Confounding patterns
- **Anatomical issues**
  - **Inferior wall**
  - **Lateral wall**
  - **Posterior wall**
  - **Right ventricle**

Subtle Acute Inferior Wall Myocardial Infarction



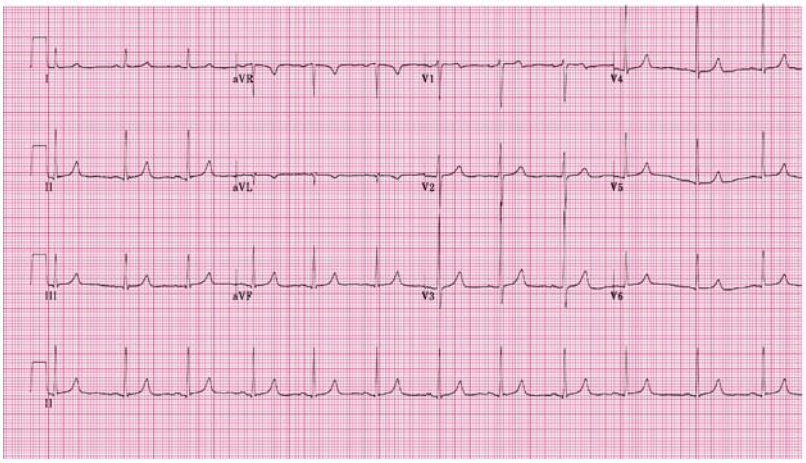
Isolated Posterior Wall AMI



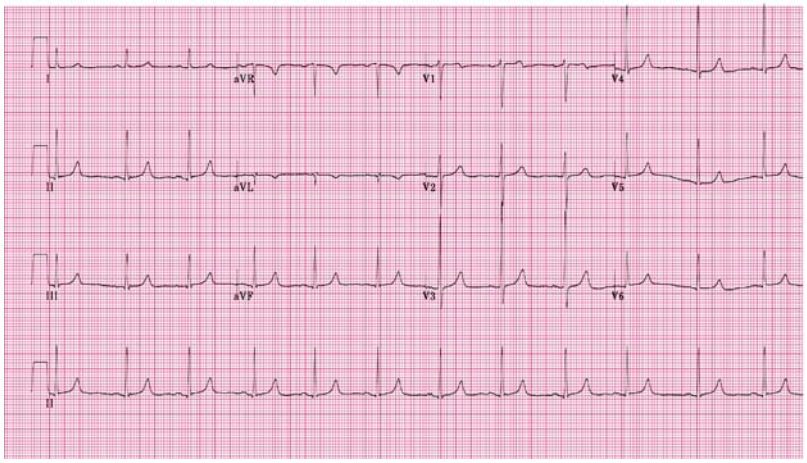
BREAK

Cases

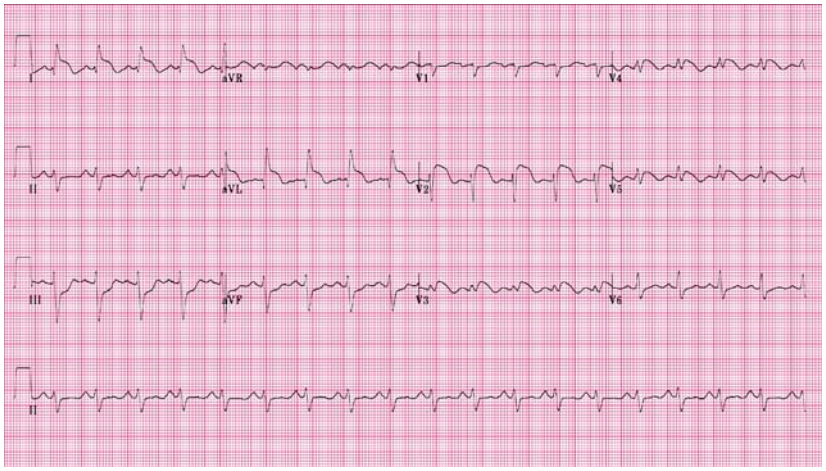
43 Year-old Male
Chest Pain



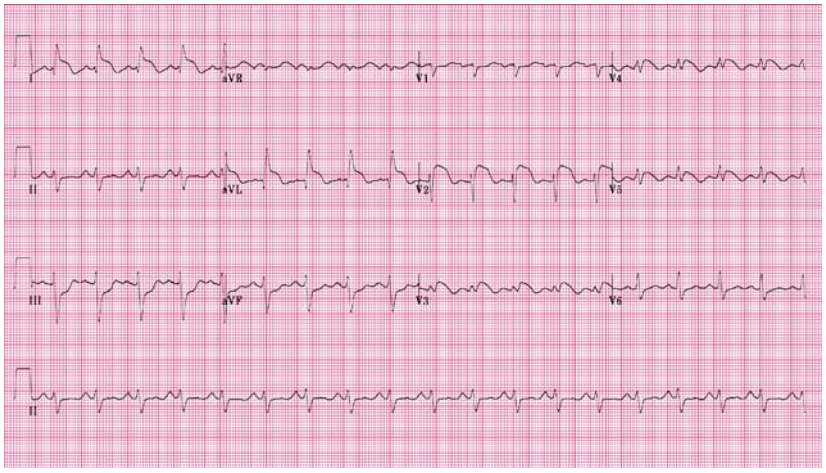
43 Year-old Male
NORMAL ECG



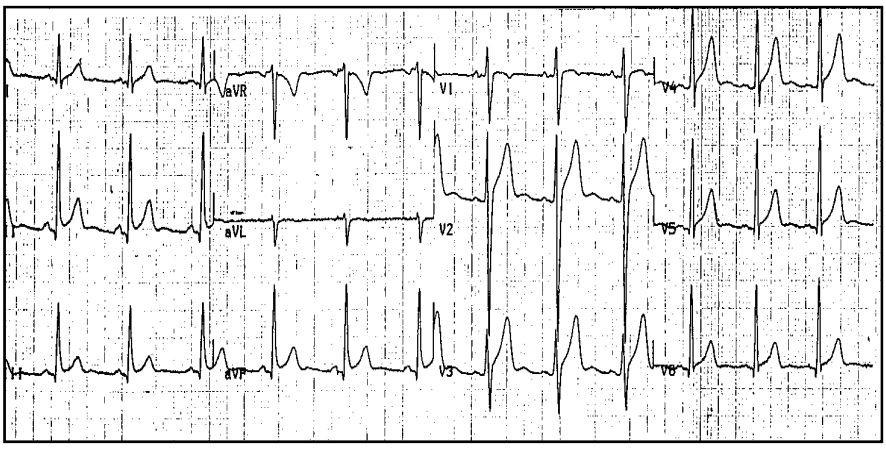
67 year-old Female
Weakness with Dyspnea



67 year-old Female
ANTERLOATERAL STEMI

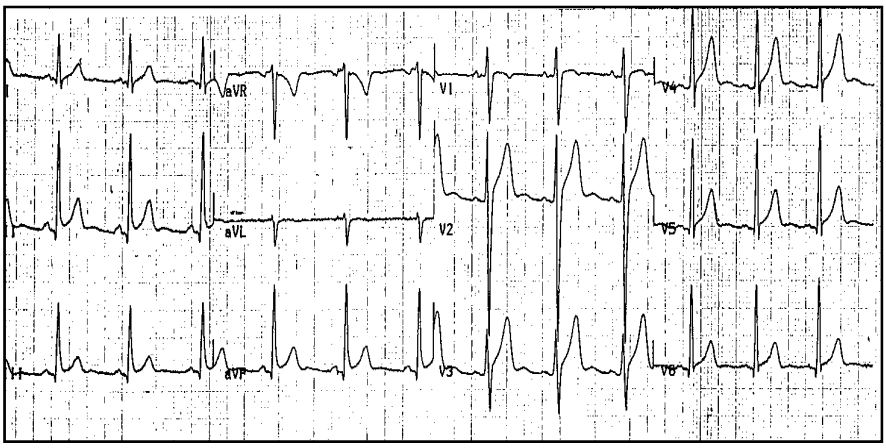


39 year old Male
Chest Pain



39 year old Male

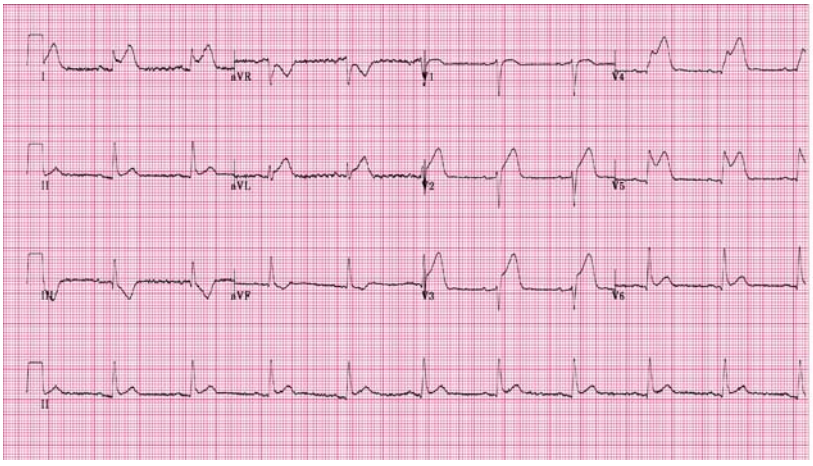
Benign Early Repolarization



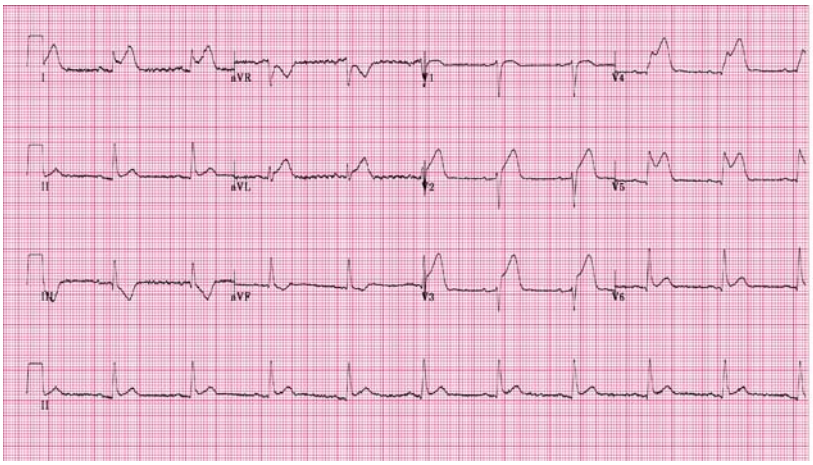
52 year-old Male

Chest Pain

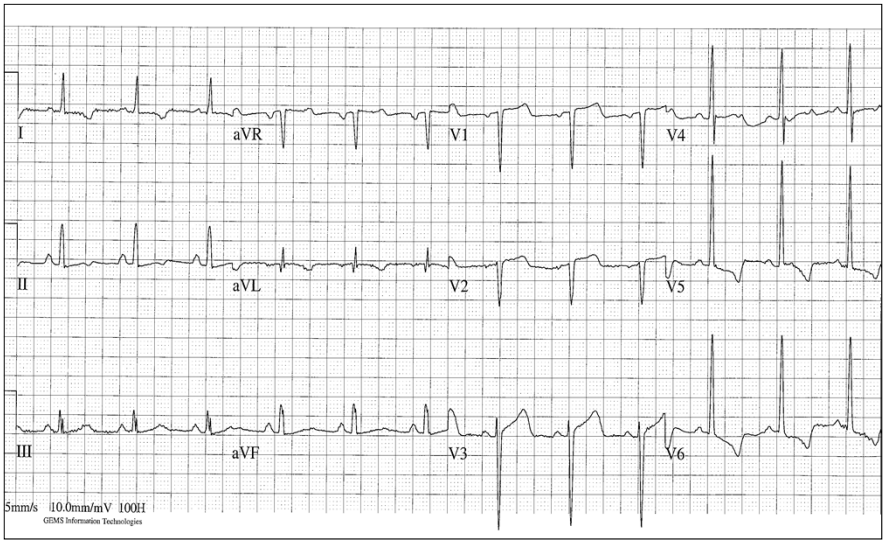
Hypotension with Pulmonary Edema



52 year-old Male
ANTEROLATERAL STEMI

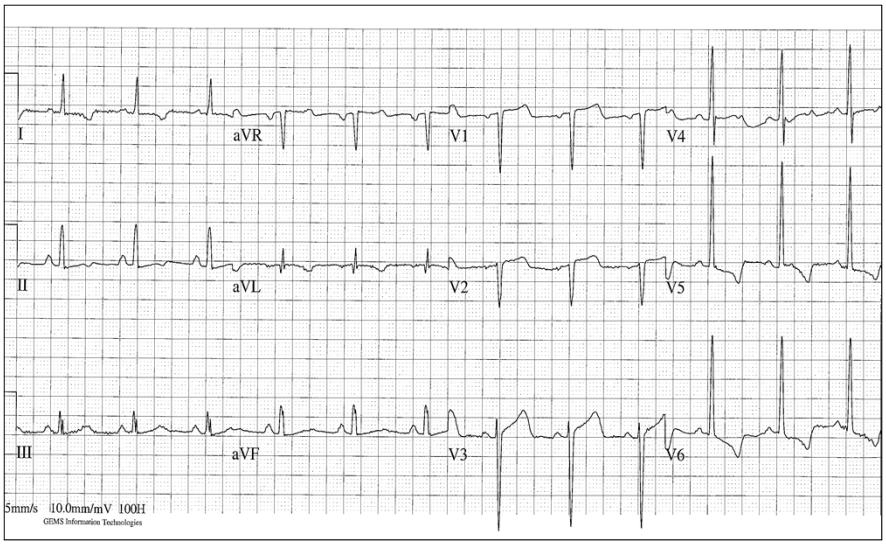


72 year old Male
Chest Pain

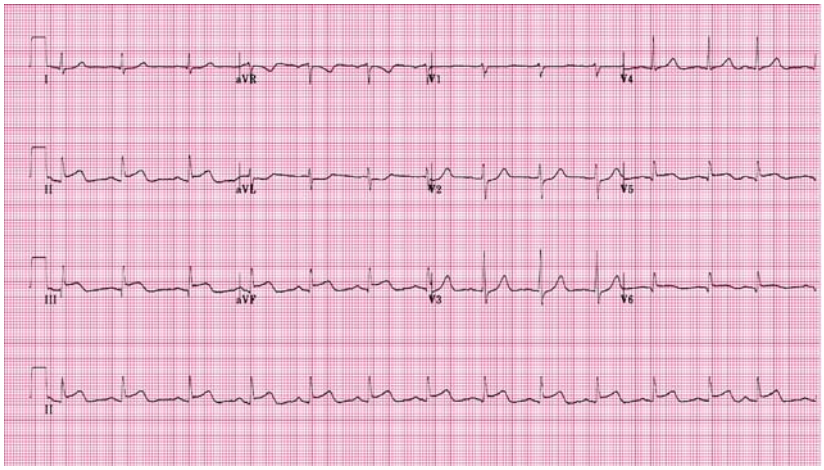


72 year old Male

Left Ventricular Hypertrophy with Strain Pattern

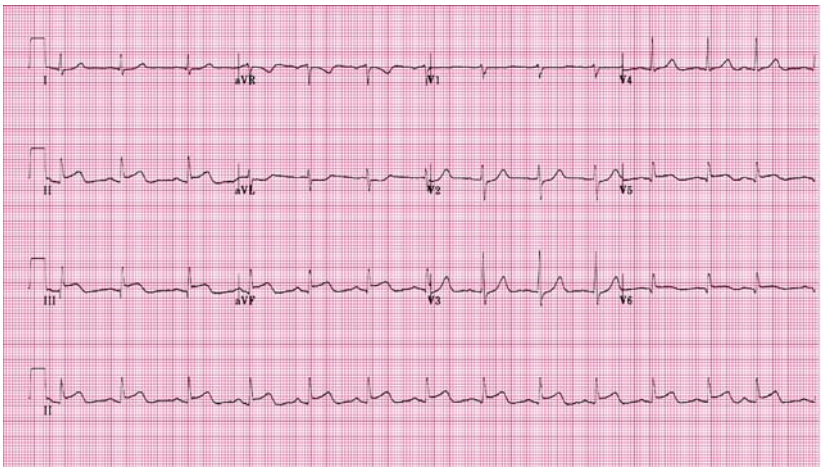


59 year-old Female
Bradycardia &
Hypotension after NTG



59 year-old Female

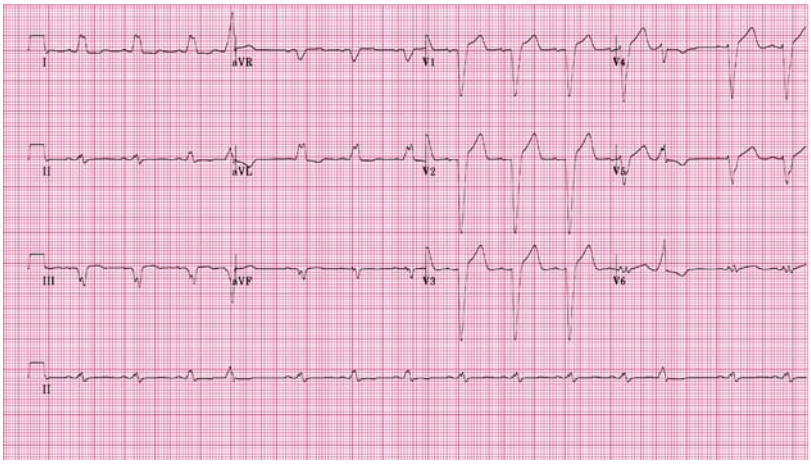
INFERIOR STEMI (? RV AMI)



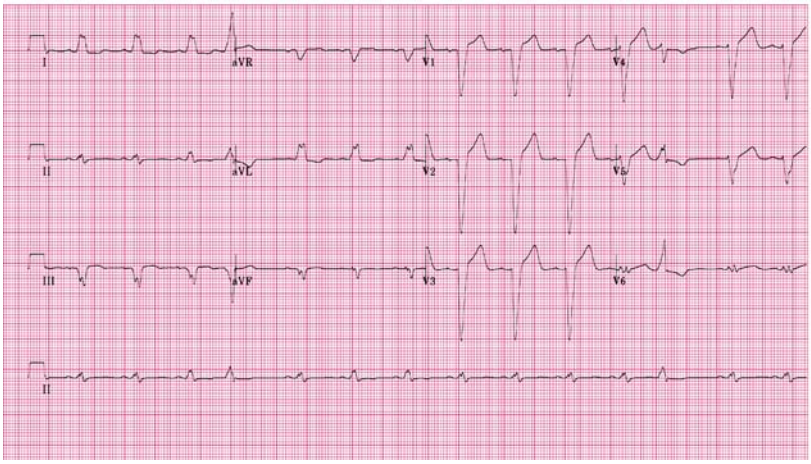
78 year-old Female

Dyspnea

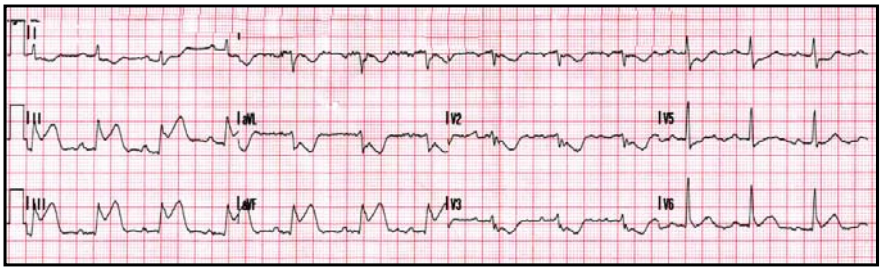
Prior ECG “normal”



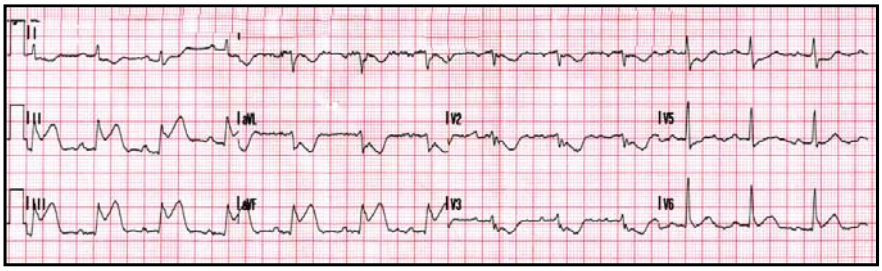
78 year-old Female
Dyspnea
LBBB (WITHOUT ECG AMI)



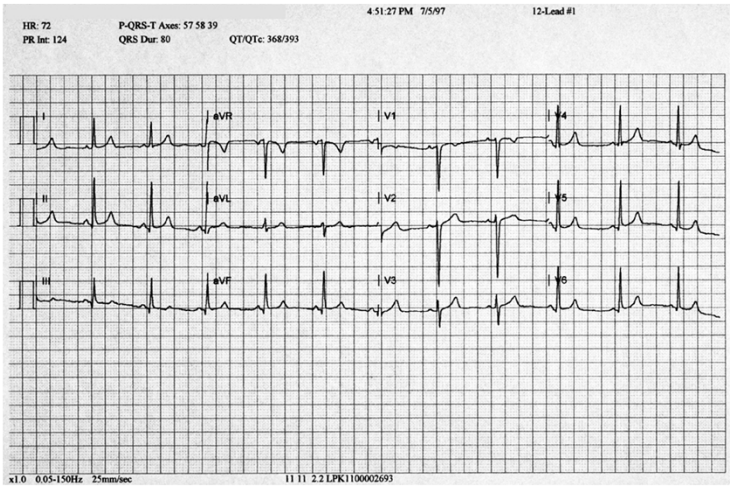
48 year old Female
Chest Pain



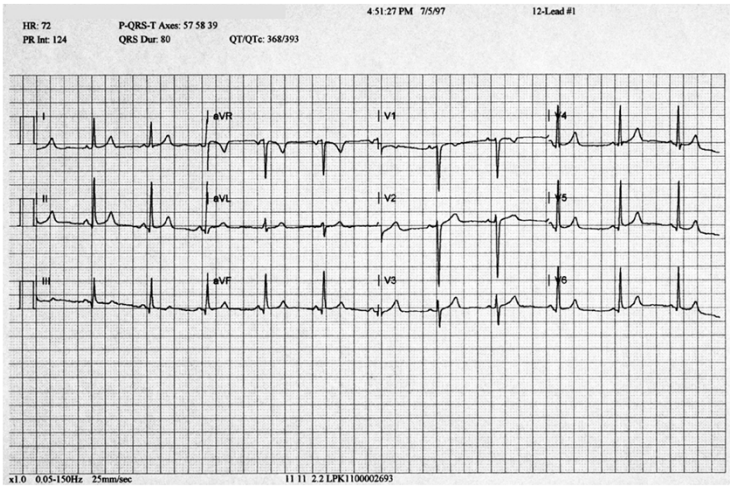
48 year old Female
Inferior STEMI with RV Infarction



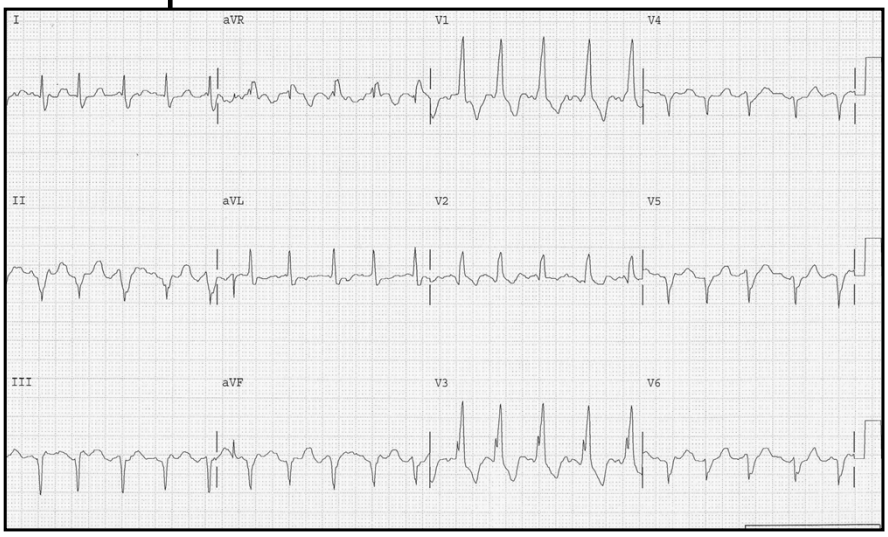
65 year-old Male
Chest Pain



65 year-old Male
NORMAL

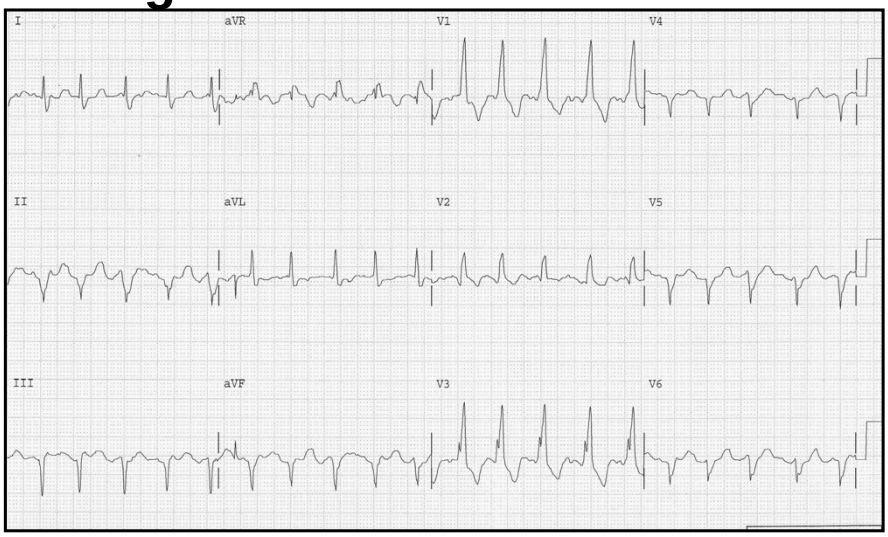


59 year old Male
Chest pain with Shortness of Breath



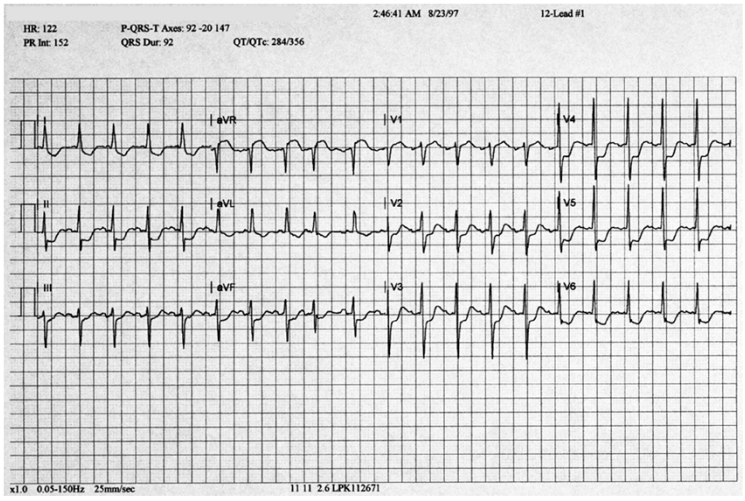
59 year old Male

Right Bundle Branch Block



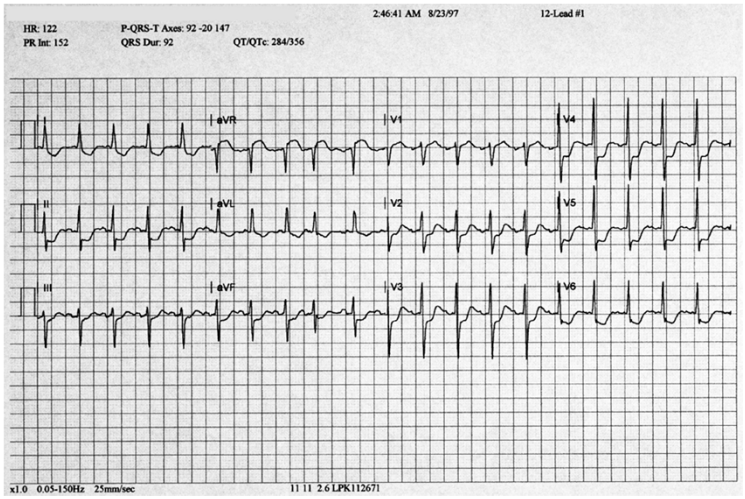
49 year-old Female

Emesis, Diaphoresis, & Chest Pain

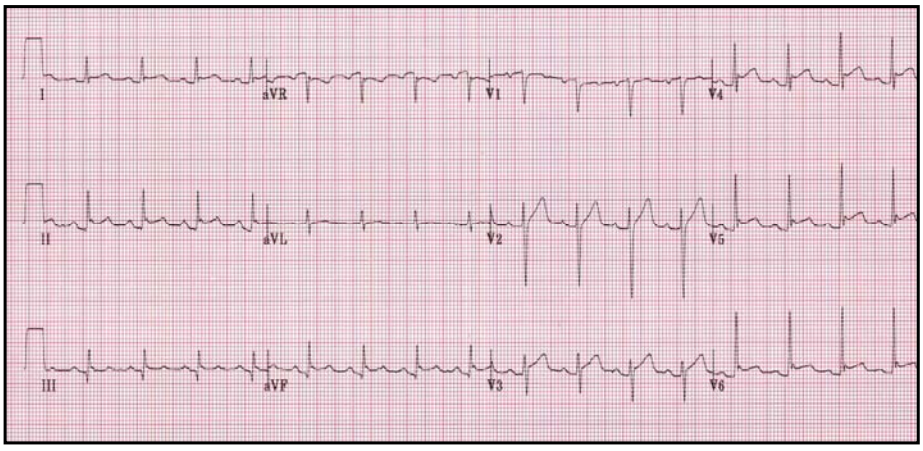


49 year-old Female

DIFFUSE ISCHEMIA (? LEFT MAIN LESION)

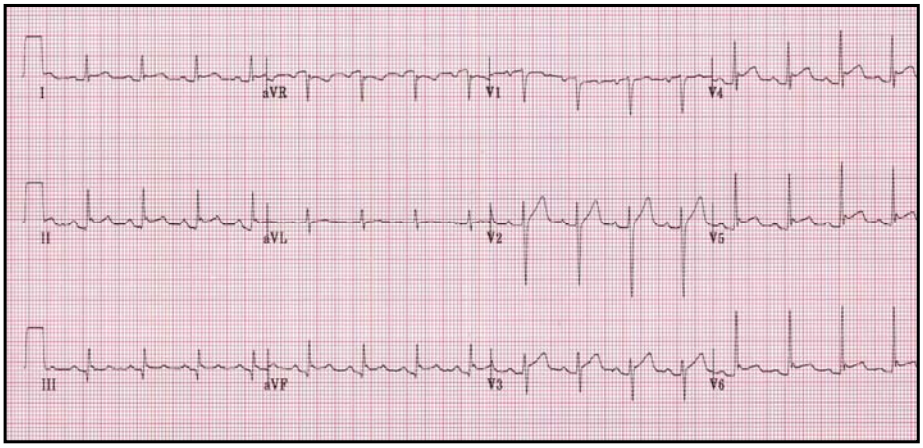


39 year old Male
Chest Pain



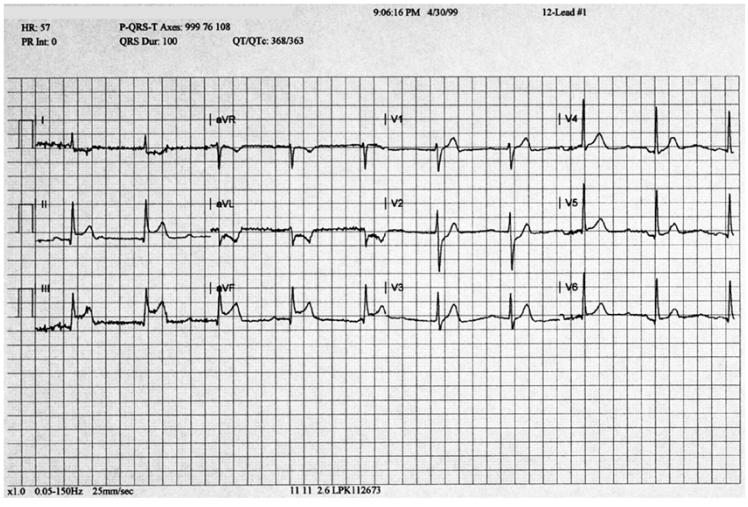
39 year old Male

ACUTE (MYO)PERICARDITIS

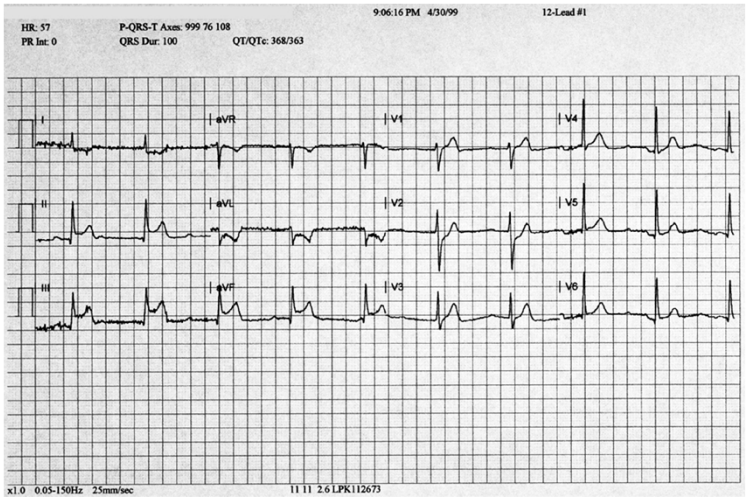


38 year-old Male

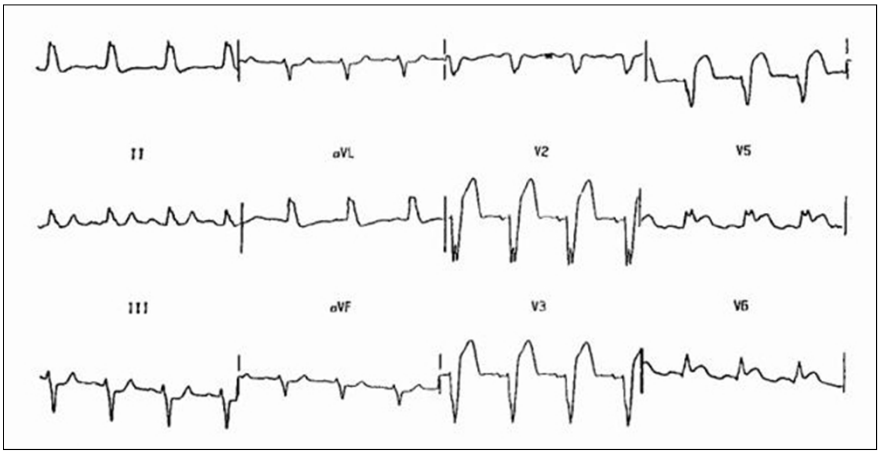
Weakness with Chest Tightness



38 year-old Male
INFERIOR STEMI



68 year old Female
Chest Pain



68 year old Female

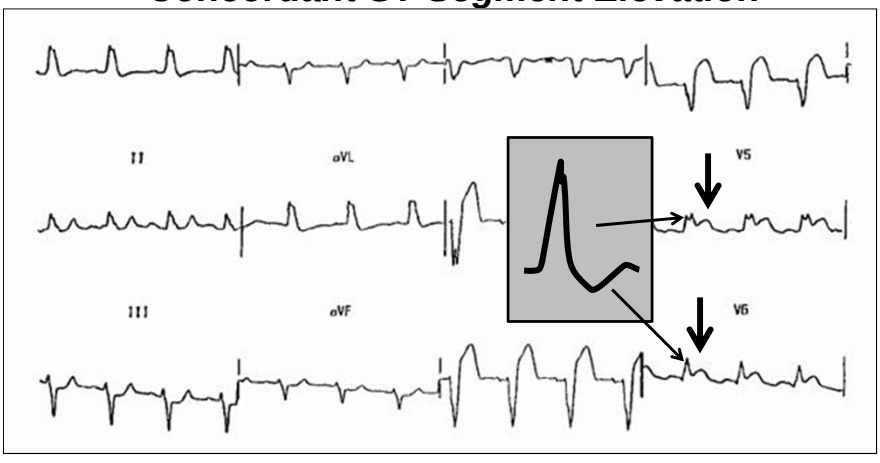
LBBB with AMI

Concordant ST Segment Elevation

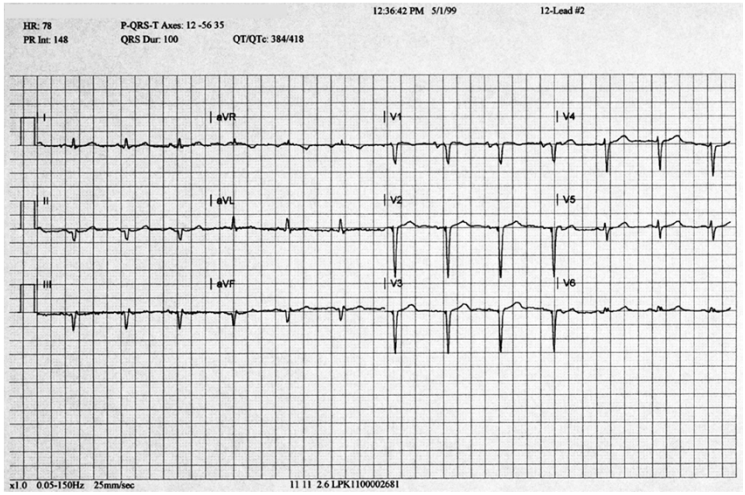
68 year old Female

LBBB with AMI

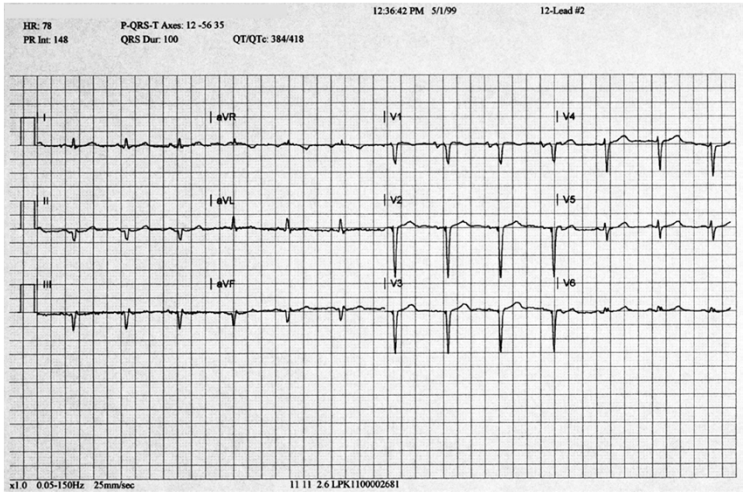
Concordant ST Segment Elevation



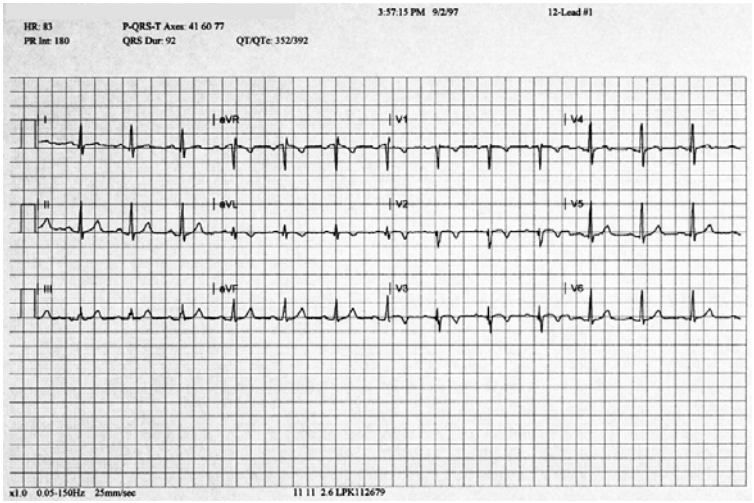
66 year-old Female
Recurrent Chest Pain



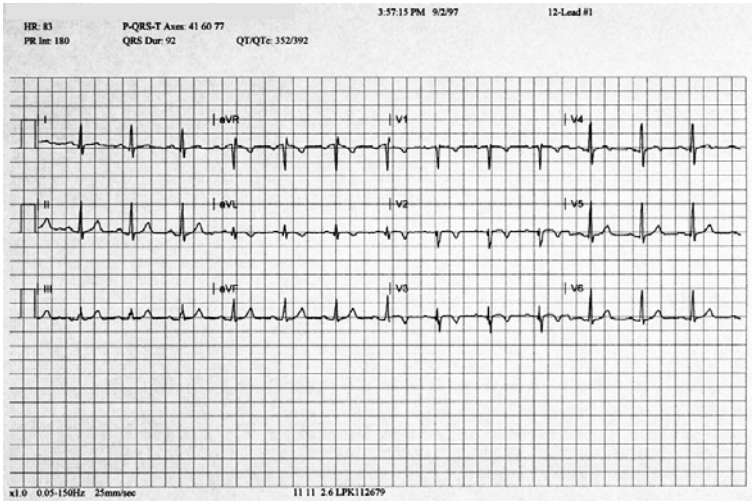
66 year-old Female
PAST MI



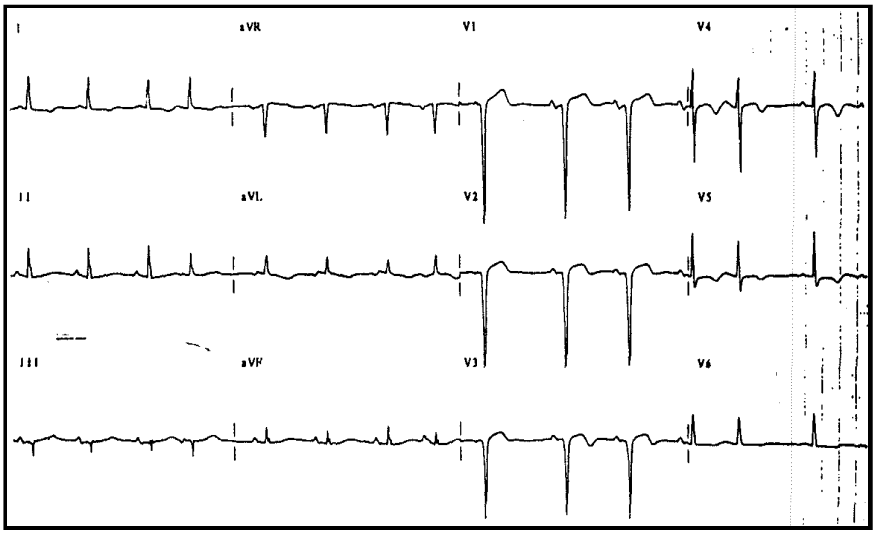
65 year-old Female
Chest Pain



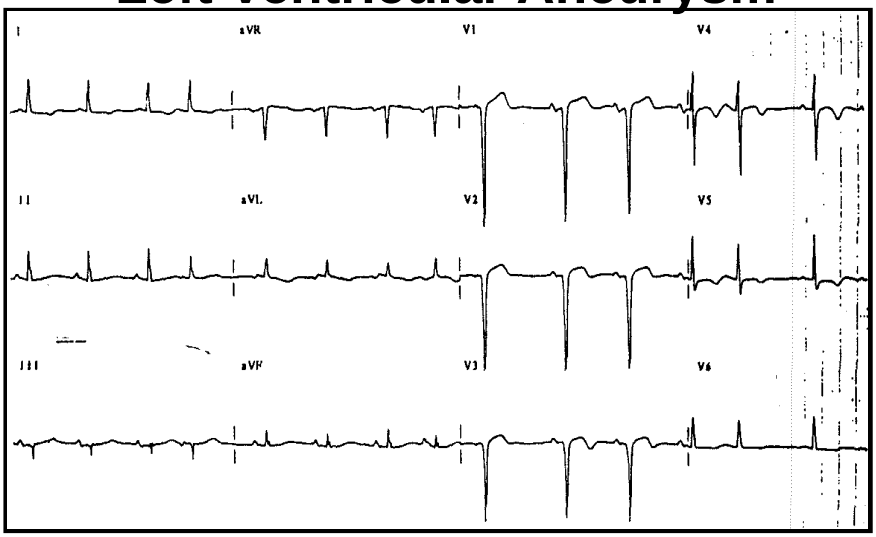
65 year-old Female
ANTERIOR ISCHEMIA



63 year old Female
Chest Pain



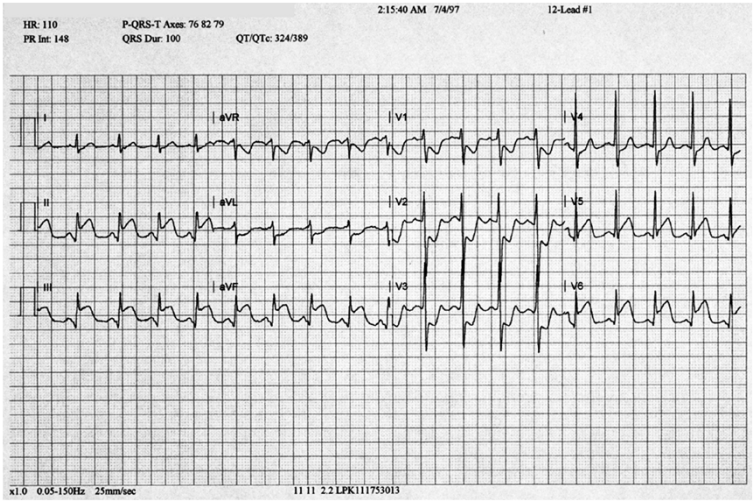
63 year old Female
Left Ventricular Aneurysm



60 year-old Female

Chest Pain

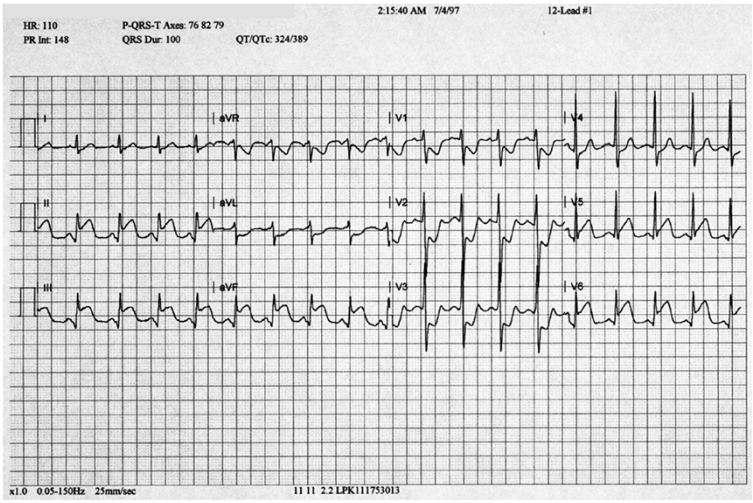
Hypotension & Pulmonary Edema



60 year-old Female

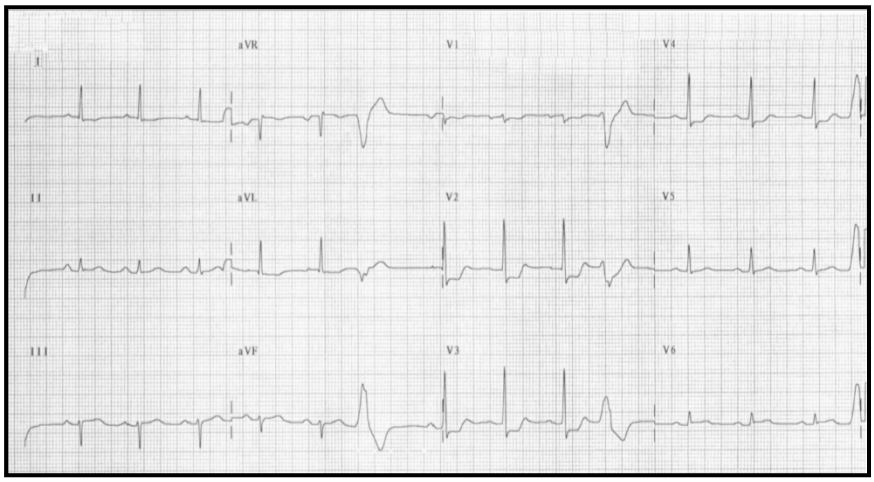
Chest Pain

INFEROLATERAL STEMI WITH POSTERIOR AMI



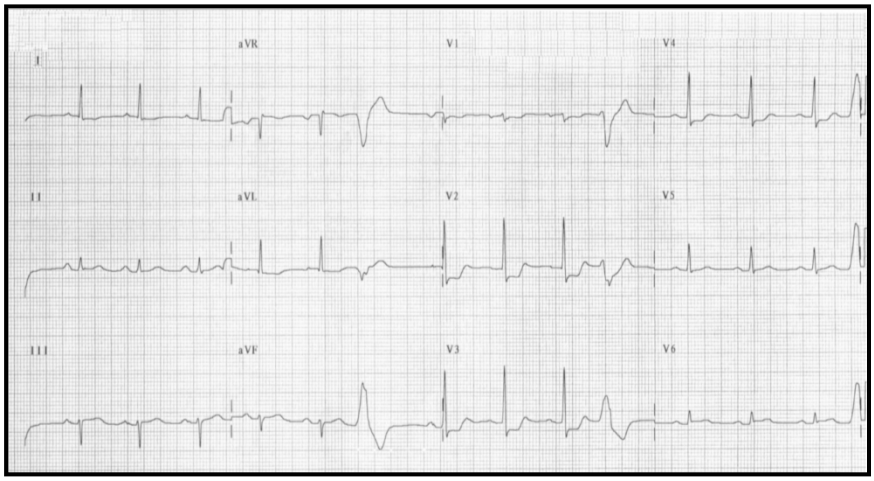
45 year old Female

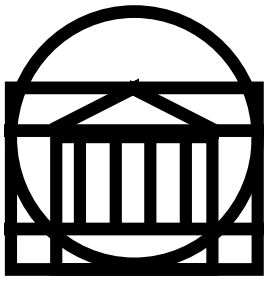
Chest Pain



45 year old Female

“Isolated” Posterior AMI





The End

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