American College of Cardiology
20th Congress 2017

Observation Medicine ECG
Instructor Workshop,  Session 3

Serial 12 Lead ECG Interpretation
Part 2

By: Wayne W Ruppert, CVT, CCCC, NREMT-P
About this Curriculum:

This curriculum is designed to provide nurses with evidence-based education and recommended practices for identifying changes in serial ECGs, and identifying ECG changes consistent with Acute Coronary Syndrome.
Observation Medicine ECG Course

BASIS:

- Current ACC/AHA Guidelines and Recommendations
- Multiple additional recent Evidence-Based Publications
- ECGs from case files of the author, Wayne Ruppert
- Graphic art / images from published textbooks authored by Wayne Ruppert
• Acute Coronary Syndrome
• Acute Coronary Syndrome
• Atrial Fibrillation
• Heart Failure
• QT syndrome abnormalities
• Wayne Ruppert, Cardiovascular Coordinator
Bayfront Health Dade City, Dade City, Florida
Community Health Systems
Wayne Ruppert bio:

- Cardiovascular Coordinator 2012-present (coordinated 4 successful accreditations)
- Interventional Cardiovascular / Electrophysiology Technologist, 1995-Present.
- Author of: “12 Lead ECG Interpretation in Acute Coronary Syndrome with Case Studies from the Cardiac Cath Lab,” 2010, TriGen publishing / Ingram Books
- Author of: “STEMI Assistant,” 2014, TriGen publishing / Ingram Books
- Florida Nursing CE Provider # 50-12998
- 12 Lead ECG Instructor, 1994-present (multiple hospitals, USF College of Medicine 1994)
- Website: www.ECGtraining.org
To download this course, go to [www.ECGtraining.org](http://www.ECGtraining.org), select “Downloads PDF” then select download(s) desired:

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- Download Sudden Cardiac Death Prevention - ACC / SCPC 19th Congress
- Download Initial Stabilization of the Atrial Fib Patient - SCPC 19th Congress
- Download QTc Monitoring Policy for Patients on QT Prolonging Meds
- Download A-Fib / Flutter ER Physician's Order Set - BHDC
- Download A-Fib / Flutter Flowchart Emerg Care BHDC
- Download Team Driven Performance Improvement - SCPC 19th Congress
- Download TDPI in Ambulance Industry Journal
- Download TJC Sentinel Event Alert - Disruptive Physicians
- Download ACLS 2015 Algorithm Cheat Sheets
- Download 2015 ACLS Algorithms with ECG examples
- Download Neighbors Saving Neighbors Program
- Download Basic ECG Course with 2015 ACLS Algorithms
- Download STEMI Assistant
- Download ECG ID of SADS CONDITIONS
- Download ECG Review of Hypertrophy
- Download 14 Point AHA Screening Form for Genetic and Congenital Heart Conditions
- Download Preoperative ECG Evaluation 2016
- Download Perioperative Considerations for Patients with CIEDs
- Download 12 Lead ECG in ACS Handout
- Download LQTS in Anesthesia
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All cardiovascular subject-related images, graphics and diagrams were created by the author, Wayne Ruppert, and have been taken from his two published textbooks, “STEMI Assistant” and “12 Lead ECG Interpretation in ACS with Case Studies from the Cardiac Cath Lab,” are Copyright protected, and may not be removed from this PowerPoint presentation. This presentation may not be used as part of a profit-generating program without prior written consent from the author.

Wayneruppert@aol.com
Suggested **Prerequisite Knowledge:**

**Basic ECG Rhythm Interpretation Skills.**

*This course does not teach how to interpret basic ECG rhythms.* Although it is not necessary to know Basic ECG Rhythms to understand the material in this course, it is strongly suggested that this course be used as “the next level” of education for health care providers who are already proficient in basic single-lead ECG rhythm strip interpretation.
Objectives (Part 2):

• Evaluation of the ECG for ACS
  – Wide QRS Complexes (R & LBBB patterns)
  – Normal Duration QRS Complexes
• Serial ECG Timing Strategies
• Indicators of Evolving Ischemia / STEMI
  – With Case Studies
• Review practice ECGs
• Discuss future “Observation Medicine ECG Proficiency Exam”
Evaluating the ECG for ACS:

A TWO-STEP process:
Evaluating the ECG for ACS:

A TWO-STEP process:

STEP 1: Evaluate QRS Width
Evaluating the ECG for ACS:

A TWO-STEP process:

STEP 1: Evaluate QRS Width

STEP 2: Evaluate J Points, ST-Segment and T waves in EVERY Lead
STEP 1 – evaluate QRS width:

• QRS is ABNORMALLY WIDE (>120 ms),
  – indicates DEPOLARIZATION ABNORMALITY (e.g. “bundle branch block, Wolff-Parkinson-White Syndrome, etc).
STEP 1 – evaluate QRS width:

- QRS is ABNORMALLY WIDE (>120 ms),
  - indicates DEPOLARIZATION ABNORMALITY (e.g. “bundle branch block, Wolff-Parkinson-White Syndrome, etc).
  - DEPOLARIZATION ABNORMALITIES in turn cause REPOLARIZATION ABNORMALITIES, which alters the: \textit{J Points, ST-Segments and/or T Waves}. 
**CONDITIONS THAT INCREASE QRS DURATION RESULT IN SECONDARY REPOLARIZATION ABNORMALITIES:**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pre-Ablation</th>
<th>Post-Ablation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Bundle Branch Block</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
</tr>
<tr>
<td>W-P-W Bypass Tract, Left Lateral Wall</td>
<td><img src="image3" alt="Graph" /></td>
<td><img src="image4" alt="Graph" /></td>
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<tr>
<td>49 y/o Male</td>
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<td></td>
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<tr>
<td>Same Patient As On Left - Immediately After RF Ablation Of Bypass Tract</td>
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</tr>
<tr>
<td>W-P-W Bypass Tract, Right Anterior/Lateral Wall</td>
<td><img src="image5" alt="Graph" /></td>
<td><img src="image6" alt="Graph" /></td>
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<tr>
<td>14 y/o Male</td>
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<tr>
<td>Same Patient As On Left - Immediately After RF Ablation Of Bypass Tract</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacemaker - Right Ventricular Apex</td>
<td><img src="image7" alt="Graph" /></td>
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<tr>
<td>Turned Off Here</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Ventricular Hypertrophy (Strain Pattern)</td>
<td><img src="image8" alt="Graph" /></td>
<td><img src="image9" alt="Graph" /></td>
</tr>
<tr>
<td>Left Ventricular Hypertrophy (Strain Pattern)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventricular Tachycardia Focus: Left Fasicular, 17 y/o Female</td>
<td><img src="image10" alt="Graph" /></td>
<td><img src="image11" alt="Graph" /></td>
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<tr>
<td>Ventricular Tachycardia Focus: Right Ventricular Apex</td>
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</tbody>
</table>
Evaluating the ECG for ACS:

**STEP 1 - EVALUATE WIDTH OF QRS:**

- **NORMAL** (≤ 120 ms)
  - Evaluate for **ST DEPRESSION** in usual manner
- **WIDE** (> 120 ms)
  - Of supraventricular origin
  - Determine QRS morphology:
    - **Right bundle branch block pattern**
    - **Left bundle branch block pattern**

- Do not rely on **ST DEPRESSION** as a marker of ACS. Wide QRS complex rhythms (both L and R BBB patterns) often cause depression of J points, ST segments, & inversion of T waves.

- **ST ELEVATION** is routinely seen in wide QRS complex rhythms with LBBB pattern. Follow AHA criteria (page 109) for diagnosis of STEMI in presence of LBBB.

Use caution -- **ST ELEVATION**
Wide QRS present:
QRSd > 120ms

• Determine RIGHT vs. LEFT Bundle Branch Block Pattern
Simple “Turn Signal Method” . . .

THE "TURN SIGNAL METHOD" for identifying BUNDLE BRANCH BLOCK

**V1**

**USE LEAD V1 for this technique**

To make a **RIGHT TURN**

you push the turn signal lever **UP** . . . .

**THINK:**

"QRS points UP = RIGHT BUNDLE BRANCH BLOCK"

**V1**

To make a **LEFT TURN**

you push the turn signal lever **DOWN** . . . .

**THINK:**

"QRS points DOWN = LEFT BUNDLE BRANCH BLOCK"
“Terminal Phase of QRS Method”. . .

**DIAGNOSING BUNDLE BRANCH BLOCK**

- **L.B.B.B.**
  - Using lead V1
    - QRS wider than 120 ms
    - Beat is supraventricular in origin
    - Terminal phase of QRS complex (last deflection)
  - Negative = Left bundle branch block
  - Positive = Right bundle branch block

- **R.B.B.B.**
DIAGNOSING LBBB IN LEAD V1:

- QRS GREATER THAN 120 ms (.12)
- EVIDENCE THAT THIS IS NOT VENTRICULAR BEAT
- TERMINAL PHASE (LAST PART) OF QRS COMPLEX IS NEGATIVE DEFINITION
- S-T SEGMENTS ARE NORMALLY ALWAYS ELEVATED!
DIAGNOSING RBBB IN LEAD V1:

- WIDER THAN 120 ms (.12)
  (or 3 little boxes)

- TERMINAL PHASE (LAST PART) OF QRS COMPLEX IS POSITIVE DEFLECTION
DIAGNOSING BUNDLE BRANCH BLOCK

USING LEADS V1, V2, and V5, V6:

LOCATING RsR' or RR' COMPLEXES:

V1

V2

V5

V6

RIGHT BUNDLE BRANCH BLOCK

LEFT BUNDLE BRANCH BLOCK
TERMINAL PHASE OF QRS IS POSITIVE

= RIGHT BUNDLE BRANCH BLOCK
Normal sinus rhythm
Left bundle branch block
Abnormal ECG
When compared with ECG of 28-MAY-2003 06:36,
TERMINAL PHASE OF QRS IS NEGATIVE

= LEFT BUNDLE BRANCH BLOCK
Wide QRS present:
(QRSd > 120ms)

• When RIGHT Bundle Branch Block pattern is present:
  – Precordial Leads typically demonstrate ST Depression and T wave Inversion
RBBB causes ST Depression, T Wave Inversion, ANTERIOR Leads (V1 - V4).
Wide QRS present: (QRSd > 120ms)

• When RIGHT Bundle Branch Block pattern is present:
  – Precordial Leads typically demonstrate ST Depression and T wave Inversion
  – DOES NOT MASK STEMI; when ST Elevation is noted, CONSIDER STEMI !!!
Right bundle branch block

Sinus tachycardia with Premature supraventricular complexes and Fusion complexes

ST elevation consider anterior injury or acute infarct

Abnormal ECG...

DIAGNOSIS: STEMI, ANTERIOR - SEPTAL WALL
CATH LAB FINDINGS: TOTAL OCCLUSION of
mid - LEFT ANTERIOR DESCENDING ARTERY.
**DIAGNOSIS:** STEMI - INFERIOR-POSTERIOR WALL

**CATH LAB FINDINGS:** TOTAL OCCLUSION of DOMINANT RIGHT CORONARY ARTERY
RBBB with CHEST PAIN - CASE 3: ST ELEVATION V3 - V6, II, III, aVF

75 yr Male Caucasian
Room: CS-19
Loc: 6 Option: 41

Vent. rate 110 BPM
PR interval 170 ms
QRS duration 148 ms
QT/QTc 366/495 ms
P-R-T axes 57 19 69

Sinus tachycardia
Right bundle branch block
Lateral infarct, possibly acute
Inferior infarct, possibly acute
Anterior injury pattern
Abnormal ECG

ACUTE LATERAL - INFERIOR - ANTERIOR AMI
CATH LAB FINDINGS: OCCLUDED VEIN GRAFT TO THE CIRCUMFLEX DISTRIBUTION (DOMINANT CIRCUMFLEX)
Wide QRS present: (QRSd > 120ms)

- When LBBB QRS pattern is present:
Wide QRS present: 
(QRSd > 120ms)

- When LBBB QRS pattern is present:
  - ST-Segment Elevation is typically noted in Precordial Leads
Wide QRS present: 
(QRSd > 120ms)

• When LBBB QRS pattern is present:
  – ST-Segment Elevation is typically noted in Precordial Leads
  – Can cause up to 5mm of J Point Elevation in normally calibrated ECG (1mm=10mv)
Wide QRS present: (QRSd > 120ms)

- When LBBB QRS pattern is present:
  - ST-Segment Elevation is typically noted in Precordial Leads
  - Can cause up to 5mm of J Point Elevation in normally calibrated ECG (1mm=10mv)
  - Does NOT typically cause ST elevation in INFERIOR Leads (II, III and AVF).
Diagnosis of STEMI with LBBB pattern:

2013 ACC/AHA Guideline for Management of STEMI

- ST Elevation of 0.1mv (1mm) or more in leads with Positive Deflection QRS complexes
Diagnosis of STEMI with LBBB pattern:

2013 ACC/AHA Guideline for Management of STEMI

• *ST Elevation of 0.1mv (1mm) or more in leads with Positive Deflection QRS complexes*
• *ST Elevation of 0.5mv (5mm) or more in leads with Negative Deflection QRS complexes*
Diagnosis of STEMI with LBBB pattern:

2013 ACC/AHA Guideline for Management of STEMI

• *ST Elevation of 0.1mv (1mm) or more in leads with Positive Deflection QRS complexes*
• *ST Elevation of 0.5mv (5mm) or more in leads with Negative Deflection QRS complexes*
• *ST Segment Changes as compared with those of older ECGs with LBBB*
Diagnosis of STEMI with LBBB pattern:

**2013 ACC/AHA Guideline for Management of STEMI**

- **ST Elevation of 0.1mv (1mm) or more in leads with Positive Deflection QRS complexes**
- **ST Elevation of 0.5mv (5mm) or more in leads with Negative Deflection QRS complexes**
- **ST Segment Changes as compared with those of older ECGs with LBBB**
- **Convex ST Segment**
A.H.A. ACLS GUIDELINES

1. If patient has a CONFIRMED HISTORY of LBBB, rely on:
   - CARDIAC MARKERS
   - SYMPTOMS
   - RISK FACTOR PROFILE
   - HIGH INDEX OF SUSPICION

   for diagnosis of STEMI

2. If patient has:
   
   a) previously NORMAL ECGs (no LBBB) -- or --
   b) no old ECGs available for comparison

   consider diagnosis as STEMI until proven otherwise.
QRS duration: 160 ms
Left bundle branch block

- Normal arteries
- Normal LV Function
- No hypertrophy
HELPFUL INDICATORS FOR ECG DIAGNOSIS OF STEMI in the presence of LBBB:

- ST ELEVATION > 5 mm
- COMPARE J POINT, ST SEGMENTS and T WAVES of previous ECG with LBBB to NEW ECG.
- CONVEX ST SEGMENT = poss. MI
- CONCAVE ST SEGMENT = normal
- CONCORDANT ST changes (1 mm or > ST DEPRESSION V1 - V3 or ST ELEVATION LEADS II, III, AVF)
- ST ELEVATION in LEADS II, III, and/or AVF
Be advised that in patients with Left Bundle Branch Block Combined with Ventricular Hypertrophy, the J Point elevation can exceed 0.5 mv (5mm) above the iso-electric line in patients without ACS.
LBBB with CHEST PAIN - CASE 1: PRESENTING EKG

58 yr Female
Vent. rate 77 BPM
PR interval 128 ms
QRS duration 158 ms
QT/QTc 454/513 ms
P-R-T axes 43 -11 150

Normal sinus rhythm
Left bundle branch block
Abnormal ECG

DIAGNOSIS: STEMI - INFERIOR-POSTERIOR WALL
CATH LAB FINDINGS: TOTAL OCCLUSION DISTAL RCA (PDA / PLV)
DIAGNOSIS: STEMI - INFERIOR-POSTERIOR WALL
CATH LAB FINDINGS: TOTAL OCCLUSION DISTAL RCA (PDA/PLV)

OLD ECG
NEW ECG

V3
2 mm ST elev.
1.5 mm ST depr.

2 + 1.5 = 3.5mm CHANGE
LBBB with CHEST PAIN - CASE 2: NEW ONSET of LBBB

- Normal sinus rhythm
- Left bundle branch block
- Abnormal ECG

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Vent. rate</td>
<td>77 BPM</td>
</tr>
<tr>
<td>PR interval</td>
<td>172 ms</td>
</tr>
<tr>
<td>QRS duration</td>
<td>142 ms</td>
</tr>
<tr>
<td>QT/QTc</td>
<td>446/504 ms</td>
</tr>
<tr>
<td>P-R-T axes</td>
<td>38 0 92</td>
</tr>
</tbody>
</table>

Room: ER  Loc: 3  Option: 23

DIAGNOSIS: STEMI - ANTERIOR-SEPTAL WALL
CATH LAB FINDINGS: TOTAL OCCLUSION of PROXIMAL LEFT ANTERIOR DESCENDING
Evaluating the ECG for ACS:

**STEP 1 - EVALUATE WIDTH OF QRS:**

- **NORMAL** (≤ 120 ms)
  - Evaluate for ST DEPRESSION in usual manner
- **WIDE** (> 120 ms)
  - Determine QRS morphology:
    - **RIGHT BUNDLE BRANCH BLOCK PATTERN**
      - Evaluate for ST ELEVATION in usual manner
  - **LEFT BUNDLE BRANCH BLOCK PATTERN**
    - Do not rely on ST DEPRESSION as a marker of ACS. Wide QRS complex rhythms (both L and R BBB patterns) often cause depression of J points, ST segments, & inversion of T waves.

**Use caution -- ST ELEVATION is routinely seen in wide QRS complex rhythms with LBBB pattern. Follow AHA criteria (page 109) for diagnosis of STEMI in presence of LBBB.**
Evaluating the ECG for ACS:

**Patients with Normal Width QRS**  
(QRSd < 120ms)

---

**STEP 2 - EVALUATE the EKG for ACS**

The EKG markers used for determining the presence of Acute Coronary Syndrome include:

- J Points
- ST Segments
- T Waves

Carefully scrutinize these markers in every lead of the 12 lead EKG, to determine if they are *Normal* or *Abnormal*. 
Defining NORMAL – QRS <120ms:
When QRS duration is NORMAL ( < 120 ms):

NORMAL ST - T WAVES

- WHEN QRS WIDTH IS NORMAL ( < 120 ms )

ASSESS:

- J POINT: ISOELECTRIC ( or < 1 mm dev. )
- ST SEG: SLIGHT, POSITIVE INCLINATION
- T WAVE: UPRIGHT, POSITIVE

in EVERY LEAD EXCEPT aVR !!
THE J POINT SHOULD BE...

WITHIN 1 mm ABOVE OR BELOW the ISOELECTRIC LINE
...the “flat line” between ECG complexes, when there is no detectable electrical activity...
The Isoelectric Line - 
*it’s not always isoelectric!*

**THE ISOELECTRIC LINE**

EKG from 13 y/o girl in ACCELERATED JUNCTIONAL RHYTHM.
note: upsloping T-P interval, and P buried in T waves.
THE P-Q JUNCTION

... is the POINT where the P-R SEGMENT ends and the QRS COMPLEX BEGINS.

Used for POINT OF REFERENCE for measurement of the J-POINT and the S-T SEGMENT –

--- as per the A.H.A., A.C.C., and WANG, ASINGER, and MARRIOTT, N.E.J.M. vol. 349:2128-2135 Nov. 27, 2003
Use the P-Q junction as a reference point for measuring the J Point and ST-Segment when "iso-electric line is not iso-electric!"

---

**THE P-Q JUNCTION**

... is the POINT where the P-R SEGMENT ends and the QRS COMPLEX BEGINS. Used for POINT OF REFERENCE for measurement of the J-POINT and the S-T SEGMENT. — as per the A.H.A., A.C.C., and WANG, ASINGER, and MARRIOTT, N.E.J.M. vol. 349:2128-2135 Nov. 27, 2003
Defining NORMAL:

THE J POINT SHOULD BE...

WITHIN 1 mm ABOVE OR BELOW THE P-Q JUNCTION
THE S-T SEGMENT

BEGINNS AT J POINT

ENDS AT BEGINNING OF T WAVE

J POINT
THE S-T SEGMENT

SHOULD HAVE A "SLIGHT POSITIVE" INCLINATION
THE S-T SEGMENT

SHOULD BE "CONCAVE" IN SHAPE . . .
THE S-T SEGMENT

AS OPPOSED TO "CONVEX" IN SHAPE

SHOULD BE "CONCAVE" IN SHAPE . . .
THE T WAVE

- SHOULD BE A "NICE," ROUNDED, CONVEX SHAPE

- SHOULD BE SYMMETRICAL
THE T WAVE

- SHOULD BE A "NICE,"
  ROUNDED,
  CONVEX SHAPE

- SHOULD BE SYMMETRICAL

- SHOULD BE UPRIGHT IN ALL LEADS, EXCEPT AVR
THE T WAVE

LEAD AVR

- REMEMBER, IN LEAD AVR EVERYTHING IS "UPSIDE-DOWN"
Normal Variants:
T Wave Inversion

Leads where the T WAVE may be INVERTED:
THE T WAVE

AMPLITUDE GUIDELINES:

- IN THE LIMP LEADS, SHOULD BE LESS THAN 1.0 mv (10 mm)
- IN THE PRECORDIAL LEADS, SHOULD BE LESS THAN 0.5 mv (5 mm)
- SHOULD NOT BE TALLER THAN R WAVE IN 2 OR MORE LEADS.
When QRS duration is NORMAL (< 120 ms):

**NORMAL ST - T WAVES**

- WHEN QRS WIDTH IS NORMAL (< 120 ms)

**ASSESS:**

- **J POINT:** ISOELECTRIC (or < 1 mm dev.)
- **ST SEG:** SLIGHT, POSITIVE INCLINATION
- **T WAVE:** UPRIGHT, POSITIVE

*in EVERY LEAD EXCEPT aVR!!*
ECG Indicators of ACS in Patients with Normal Width QRS Complexes (QRS duration < 120 ms)
Multiple patterns of ABNORMAL:
- J Point
- ST-Segment
- T Wave configurations may indicate ACS.

Remember, “IF IT’S NOT NORMAL, it’s ABNORMAL!”
## Patterns of ACS & Ischemia

--- J POINT, ST SEGMENT, and T WAVE ABNORMALITIES ---

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLAT or CONVEX J-T APEX SEGMENT</strong></td>
<td>ACUTE MI EARLY PHASE</td>
</tr>
<tr>
<td><strong>HYPER-ACUTE T WAVE</strong></td>
<td>ACUTE MI EARLY PHASE</td>
</tr>
<tr>
<td><strong>S-T SEGMENT ELEVATION at J POINT</strong></td>
<td>ACUTE MI</td>
</tr>
<tr>
<td><strong>DEPRESSED J pt. DOWNSLOPING ST and INVERTED T</strong></td>
<td>- ACUTE (NON-Q WAVE) MI</td>
</tr>
<tr>
<td>Condition</td>
<td>Description</td>
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<td>-----------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td>- ACUTE MI (RECIProCAL CHANGES)</td>
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<td></td>
<td>- ISCHEMIA</td>
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</table>
ECG Patterns associated with “EARLY PHASE MI:”

• J-T Apex abnormalities
• Hyper-Acute T Waves
• ST-T Wave Changes
J-T Apex Segment

ST-Segment

T wave: origin to apex
J-T APEX SEGMENT VARIATIONS

ABNORMAL - CONVEX

ABNORMAL - FLAT

NORMAL - CONCAVE

PATTERNS of EARLY INFARCTION
-- FLAT and CONVEX J-T APEX SEGMENTS
WHEN EVALUATING for ST SEGMENT ELEVATION.

From:
AMERICAN HEART ASSOCIATION
ACLS 2005 REVISIONS

During NORMAL STATES of PERFUSION, the J POINT is ISOELECTRIC and the ST SEGMENT has a CONCAVE appearance. When measured 40 ms beyond the J POINT (noted by the RED DOT), the ST SEGMENT elevation is less than 1 mm.

Both figures were recorded from a 54 year old male while resting (figure A), and during PTCA of the Left Anterior Descending artery (figure B).

During a 20 second BALLOON OCCLUSION of the patient's LAD during routine PTCA, the ST segment assumes a CONVEX shape. When measured 40 ms beyond the J POINT, the ST segment is elevated > 1 mm. This phenomenon is seen routinely in the cath lab prior to the occurrence of ST ELEVATION at the J POINT during PTCA and STENTING.
ABNORMAL J-T APEX SEGMENT

- J POINT
- END of ST SEGMENT
- T WAVE APEX

FLAT J-T APEX SEGMENT

☞ CONSIDER EARLY PHASE of ACUTE MI

---

LEAD II

41 y/o FEMALE
In ER C/O CHEST PAIN
x 30 minutes.
- FLAT J-T APEX SEGMENT
- NO ST ELEVATION at J POINT!

1839 hrs

STEMI - INFERIOR WALL
11 MINUTES LATER, S-T ELEVATION at the J POINT IS NOTED.
- CATH LAB FINDINGS: TOTAL OCCLUSION of the RIGHT CORONARY ARTERY

1850 hrs
ABNORMAL J-T APEX SEGMENT

CONVEX J-T APEX SEGMENT

CONSIDER EARLY PHASE of ACUTE MI!

LEAD I

53 y/o MALE

1 yr. PRIOR TO MI
NORMAL EKG
CONCAVE J-T APEX SEGMENT

STEMI LATERAL WALL
- CONVEX J-T APEX SEGMENT
- MINIMAL ST ELEVATION at J POINT

0732 hrs

15 MINUTES LATER, S-T ELEVATION at the J POINT IS NOTED.
- CATH LAB FINDINGS: TOTAL OCCLUSION OF CIRCUMFLEX ARTERY

0747 hrs
CASE STUDY: ABNORMAL J-T APEX SEGMENTS

CHIEF COMPLAINT and SIGNIFICANT HISTORY:

56 y/o MALE presents to ED with complaint of "INTERMITTENT SUBSTERNAL & SUB-EPIGASTRIC PRESSURE" x 3 HOURS. PMHx of ESOPHAGEAL REFLUX. NO other significant past medical history.

RISK FACTOR PROFILE:

🔥 FAMILY HISTORY - father died of MI at age 62
✅ PREVIOUS CIGARETTE SMOKER - quit 15 years ago.
✅ CHOLESTEROL - DOES NOT KNOW; "never had it checked."
✅ OBESITY

PHYSICAL EXAM: Patient supine on exam table, mildly anxious, currently complaining of "mild indigestion," skin is warm, pale, dry; REST OF EXAM is UNREMARKABLE.

VITAL SIGNS: BP 142/94, P 80, R 20, SAO2 98%

LABS: JUST OBTAINED, RESULTS NOT AVAILABLE YET.
ECG COMPUTER DOES NOT NOTICE THE CONVEX J-T APEX SEGMENTS!
measurement of S-T elevation

S-T elevation at J point = 0.5 mm

ACUTE MI = S-T elev. > 1.0 mm
measurement of S-T elevation by "J point + .04" method

S-T elevation at J point = 0.5 mm
S-T elevation at J + .04 = 2.0 mm

ACUTE MI = S-T elev. > 1.0 mm
CASE STUDY: 56 y/o male with INTERMITTENT "CHEST HEAVINESS"

TREATMENT PLAN: EMERGENCY CORONARY ARTERY BYPASS SURGERY (4 VESSEL)
J-T Apex Abnormality – Case 2:
44 y/o male with substernal CP x 30 min . . .

A special “thanks!” to Chelsie Carter, RN, BSN, Cardiovascular Coordinator Mountainview Regional Medical Center, Las Cruces, New Mexico
Flattening of J-T Apex segment . . . .
ST-Segment Depression, Inferior Leads II, III and AVF.

Consistent with “Reciprocal ST Depression” from STEMI (on opposite side of myocardium)
Proximal Total Occlusion of LAD Artery
Post-PCI / Stent, Proximal LAD lesion, 44 y/o male:
PATTERNS of ACS & ISCHEMIA

- J POINT, ST SEGMENT, and T WAVE ABNORMALITIES -

FLAT or CONVEX J-T APEX SEGMENT

HYPER-ACUTE T WAVE

S-T SEGMENT ELEVATION at J POINT

DEPRESSED J pt. DOWNSLOPING ST and INVERTED T

ACUTE MI EARLY PHASE

ACUTE MI EARLY PHASE

ACUTE MI

- ACUTE (NON-Q WAVE) MI
- ACUTE MI - (RECIPIROCAL CHANGES)
- ISCHEMIA
T waves should not be HYPERACUTE
HYPERACUTE T Waves may indicate:

- Early phase Acute MI
- Transmural ischemia (usually seen in one region of the ECG)
- Hyperkalemia (seen globally across ECG)
- Hypertrophy
HYPERACUTE T WAVES

SUB-TOTAL OCCLUSION OF PROXIMAL LAD

BOOK PAGE: 88
Helpful Clue: Hyper-Acute T Waves

- **GLOBAL** Hyper-acute T Waves (in leads viewing multiple myocardial regions / arterial distributions) favors HYPERKALEMIA
Regional Medical Center

ID: 23-Nov-

55 Years Female Caucasian

- Vent. rate: 57 bpm
- PR interval: 150 ms
- QRS duration: 102 ms
- QT/QTc: 472/459 ms
- P-R-T axes: 76 70 58

Sinus bradycardia
Possible left atrial enlargement
Borderline ECG

ER attending review
No STEMI
Time: 15

K+ = 6.7

Test ind:

Location:

Referred by:
Unconfirmed
Helpful Clue: Hyper-Acute T Waves

• **GLOBAL** Hyper-acute T Waves (in leads viewing multiple myocardial regions / arterial distributions) **favors HYPERKALEMIA**

• **Hyper-acute T Wave noted in ONE ARTERIAL DISTRIBUTION** (Anterior / Lateral / Inferior) **favors TRANSMURAL ISCHEMIA / Early Phase Acute MI**
CASE STUDY: HYPERACUTE T WAVES

CHIEF COMPLAINT and SIGNIFICANT HISTORY:

30 y/o male presents to ER via EMS, c/o sudden onset of dull chest pain x 40 min. Pain level varies, not effected by position, movement or deep inspiration. No associated symptoms.

RISK FACTOR PROFILE: NONE. CHOLESTEROL UNKNOWN.

PHYSICAL EXAM: Patient is supine on exam table, CAO x 4, anxious, restless, skin pale, cool, dry. Patient c/o chest pressure, "7" on 1 - 10 scale, uneffected by position, movement, deep inspiration. Lungs clear. HS: NL S1, S2, no rubs, murmurs, gallops

VITAL SIGNS: BP 136/88  P 90  R 20  SAO2 98%

DIAGNOSTIC TESTING: 1st TROPONIN I - ultra: <0.07
30 yr Male Black
Vent. rate 88 BPM
PR interval 164 ms
QRS duration 90 ms
QT/QTc 370/447 ms
P–R–T axes 61 62 53

Normal sinus rhythm
Normal ECG
No previous ECGs available

NOTE COMPUTER INTERPRETATION
30 yr Male Black
Room: ER Loc: Option:
Vent. rate 88 BPM
PR interval 164 ms
QRS duration 90 ms
QT/QTc 370/447 ms
P–R–T axes 61 62 53

Normal sinus rhythm Normal ECG
No previous ECGs available

CORONARY ARTERIAL DISTRIBUTIONS:
V1 - V4 = LEFT ANTERIOR DESCENDING (LAD)
I, AVL = DIAGONAL (DIAG) off the LAD or
OBTUSE MARGINAL (OM) off CIRCUMFLEX (CX)
V5, V6 = CIRCUMFLEX
II, III, AVF = RIGHT CORONARY ARTERY or CX

HIGHLIGHTED AREAS = HYPERACUTE T WAVES
Cath Lab findings:

TOTAL OCCLUSION of LEFT ANTERIOR DESCENDING ARTERY

LAD OPEN, POST PTCA / STENT
Dynamic ST-T Wave Changes:

• Other than HEART RATE related variations (which affect intervals), *J Points, ST-Segments and T Waves SHOULD NOT CHANGE.*
Dynamic ST-T Wave Changes:

• Other than HEART RATE related variations (which affect intervals), *J Points, ST-Segments and T Waves SHOULD NOT CHANGE.*

• When changes to *J Points, ST-Segments and/or T waves* are NOTED, consider EVOLVING MYOCARDIAL ISCHEMIA and/or EARLY PHASE MI, until proven otherwise.
46 year old male

- Exertional dyspnea X “several weeks”
- Intermittent chest pressure X last 3 hours. Currently pain free.
46 year old male: ECG 1

- Chest pressure has returned, “5” on 1-10 scale. 2nd ECG obtained due to “change in symptoms”:
ECG #1
7:59 am

ST-segments have dropped in Lead II

ECG #2
8:08 am

T waves have gained amplitude in Leads V1-V5
7:59 am

8:08 am

↑ 2.5 mm

↑ 3.0 mm

↑ 4.0 mm
ST-Segment Depression

7:59 am        8:08 am
Cath Lab Angiography:

Proximal sub-totally occluded Left Anterior Descending Artery (LAD)
ISCHEMIA

BI-PHASIC T WAVE

- SUB-TOTAL OCCLUSION of LEFT ANTERIOR DESCENDING ARTERY (when noted in V1-V4)
- LEFT VENTRICULAR HYPERTROPHY
- COCAINE INDUCED VASOSPASM
BI-PHASIC T WAVES

58 y/o MALE WITH SUB-TOTAL OCCLUSIONS OF THE LEFT ANTERIOR DESCENDING ARTERY
58 y/o MALE WITH "WELLEN'S WARNING." PT HAS SUB-TOTALLY OCCLUDED LAD X 2
Classic “Wellen’s Syndrome:”

- Characteristic T wave changes
  - Biphasic T waves
  - Inverted T waves
- History of anginal chest pain
- Normal or minimally elevated cardiac markers
- ECG without Q waves, without significant ST-segment elevation, and with normal precordial R-wave progression
Wellen’s Syndrome ETIOLOGY:

- Critical Lesion, Proximal LAD
- Coronary Artery Vasospasm
- Cocaine use (vasospasm)
- Increased myocardial oxygen demand
- Generalized Hypoxia / anemia / low H&H
Wellen’s Syndrome EPIDEMIOLOGY & PROGNOSIS:

- Present in 14-18% of patients admitted with unstable angina
- 75% patients not treated developed extensive Anterior MI within 3 weeks.
- *Median Average time from presentation to Acute Myocardial Infarction – 8 days*

Sources: H Wellens et. Al, Am Heart J 1982; v103(4) 730-736
Wellen’s Syndrome Case Study

• 33 y/o male
• Chief complaint “sharp, pleuritic quality chest pain, intermittent, recent history lower respiratory infection with productive cough.”
• ED physician attributed the ST elevation in precordial leads to “early repolarization,” due to patient age, gender, race (African American) and concave nature of ST-segments.
Wellen’s Syndrome Case Study

SERIAL EKG CASE STUDY 1 - EKG # 1 @ 06:22 HOURS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vent. rate</td>
<td>89 BPM</td>
</tr>
<tr>
<td>PR interval</td>
<td>158 ms</td>
</tr>
<tr>
<td>QRS duration</td>
<td>80 ms</td>
</tr>
<tr>
<td>QT/QTc</td>
<td>366/445 ms</td>
</tr>
<tr>
<td>P–R–T axes</td>
<td>60–5 65</td>
</tr>
</tbody>
</table>

Normal sinus rhythm
Possible Left atrial enlargement
Borderline ECG
No previous ECGs available
**Wellen’s Syndrome Case Study**

**ERIAL EKG CASE STUDY 1 - EKG # 2 @ 09:42 HOURS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Vent. rate</td>
<td>67 BPM</td>
</tr>
<tr>
<td>PR interval</td>
<td>160 ms</td>
</tr>
<tr>
<td>QRS duration</td>
<td>82 ms</td>
</tr>
<tr>
<td>QT/QTc</td>
<td>512/541 ms</td>
</tr>
<tr>
<td>P–R–T axes</td>
<td>44 0 54</td>
</tr>
</tbody>
</table>

"**UNEDITED COPY: REPORT IS COMPUTER GENERATED ONLY, WITHOUT PHYSICAL INTERPRETATION**".

- Normal sinus rhythm
- T wave abnormality, consider anterolateral ischemia
- Prolonged QT
- Abnormal ECG
DYNAMIC ST-T Wave Changes ARE PRESENT !!

NOW

is the time for the STAT CALL to the CARDIOLOGIST !!!!
Wellen’s Syndrome Case Study

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vent. rate (BPM)</td>
<td>64</td>
<td>Normal sinus rhythm</td>
</tr>
<tr>
<td>PR interval (ms)</td>
<td>160</td>
<td>Marked T wave abnormality, consider anterolateral ischemia</td>
</tr>
<tr>
<td>QRS duration (ms)</td>
<td>84</td>
<td>Prolonged QT</td>
</tr>
<tr>
<td>QT/QTc</td>
<td>514/530 ms</td>
<td>Abnormal ECG</td>
</tr>
<tr>
<td>P–R–T axes</td>
<td>45 3 91</td>
<td>When compared with ECG of 05–NOV–2008 05:12.</td>
</tr>
</tbody>
</table>
Wellen’s Syndrome Case Study
Wellen’s Syndrome Case Study

SUB-TOTAL OCCLUSION OF LEFT ANTERIOR DESCENDING ARTERY

STENT DEPLOYMENT, LEFT ANTERIOR DESCENDING ARTERY, 33 y/o male
Wellen’s Syndrome Case Study

SUB-TOTAL OCCLUSION OF LEFT ANTERIOR DESCENDING ARTERY

POST PCI - LAD
Additional Resources:

• Wellen’s Syndrome, NEJM case study
<table>
<thead>
<tr>
<th>Pattern</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLAT or CONVEX J-T APEX SEGMENT</strong></td>
<td><strong>ACUTE MI EARLY PHASE</strong></td>
</tr>
<tr>
<td><strong>HYPER-ACUTE T WAVE</strong></td>
<td><strong>ACUTE MI EARLY PHASE</strong></td>
</tr>
<tr>
<td><strong>S-T SEGMENT ELEVATION at J POINT</strong></td>
<td><strong>ACUTE MI</strong></td>
</tr>
<tr>
<td><strong>DEPRESSED J pt. DOWNSLOPING ST and INVERTED T</strong></td>
<td><strong>ACUTE (NON-Q WAVE) MI</strong> - <strong>ACUTE MI</strong> - (RECPROCAL CHANGES) - <strong>ISCHEMIA</strong></td>
</tr>
</tbody>
</table>
Abnormal ST Elevation Criteria: ACC/AHA 2009 “Standardization and Interpretation of the ECG, Part VI
Acute Ischemia and Infarction,” Galen Wagner, et al

**Recommendations**

1. For men 40 years of age and older, the threshold value for abnormal J-point elevation should be 0.2 mV (2 mm) in leads $V_2$ and $V_3$ and 0.1 mV (1 mm) in all other leads.
2. For men less than 40 years of age, the threshold values for abnormal J-point elevation in leads $V_2$ and $V_3$ should be 0.25 mV (2.5 mm).
3. For women, the threshold value for abnormal J-point elevation should be 0.15 mV (1.5 mm) in leads $V_2$ and $V_3$ and greater than 0.1 mV (1 mm) in all other leads.
4. For men and women, the threshold for abnormal J-point elevation in $V_3R$ and $V_4R$ should be 0.05 mV (0.5 mm), except for males less than 30 years of age, for whom 0.1 mV (1 mm) is more appropriate.
5. For men and women, the threshold value for abnormal J-point elevation in $V_7$ through $V_9$ should be 0.05 mV (0.5 mm).
6. For men and women of all ages, the threshold value for abnormal J-point depression should be $-0.05$ mV ($-0.5$ mm) in leads $V_2$ and $V_3$ and $-0.1$ mV ($-1$ mm) in all other leads.
ST SEGMENT ELEVATION:

S-T SEGMENTS ELEVATE WITHIN SECONDS OF CORONARY ARTERY OCCLUSION:

IN THIS CASE, a normal response to balloon occlusion of the RIGHT CORONARY ARTERY during PTCA in the CARDIAC CATH LAB

3 COMMON PATTERNS of ST SEGMENT ELEVATION From ACUTE MI:

- DOWNSLOPING S-T SEGMENT
- FLAT S-T SEGMENT
- UPSLOPING S-T SEGMENT
ST SEGMENT ELEVATION in ACUTE MI:

The following samples are from patients with ACUTE MI, as confirmed by discovery of total arterial occlusion in the Cardiac Cath Lab:

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="V5 - ANTERIOR LATERAL MI" /></td>
<td>V5 - ANTERIOR LATERAL MI</td>
</tr>
<tr>
<td><img src="image2" alt="V4 - ANTERIOR LATERAL MI" /></td>
<td>V4 - ANTERIOR LATERAL MI</td>
</tr>
<tr>
<td><img src="image3" alt="aVL - ANTERIOR LATERAL MI" /></td>
<td>aVL - ANTERIOR LATERAL MI</td>
</tr>
<tr>
<td><img src="image4" alt="V2 - ANTERIOR LATERAL MI" /></td>
<td>V2 - ANTERIOR LATERAL MI</td>
</tr>
<tr>
<td><img src="image5" alt="V3 - ANTERIOR LATERAL MI" /></td>
<td>V3 - ANTERIOR LATERAL MI</td>
</tr>
<tr>
<td><img src="image6" alt="V4 - ANTERIOR LATERAL MI" /></td>
<td>&quot;TOOMBSTONE&quot; PATTERN</td>
</tr>
<tr>
<td><img src="image7" alt="V5 - ANTERIOR LATERAL MI" /></td>
<td>&quot;TOOMBSTONE&quot; PATTERN</td>
</tr>
<tr>
<td><img src="image8" alt="V5-ANTERIOR LATERAL MI" /></td>
<td>&quot;TOOMBSTONE&quot; PATTERN</td>
</tr>
<tr>
<td><img src="image9" alt="II - INFERIOR POSTERIOR MI" /></td>
<td>II - INFERIOR POSTERIOR MI</td>
</tr>
<tr>
<td><img src="image10" alt="aVF - INFERIOR POSTERIOR MI" /></td>
<td>&quot;FIREMAN'S HAT&quot; PATTERN</td>
</tr>
<tr>
<td><img src="image11" alt="III-INFERIOR MI" /></td>
<td>III-INFERIOR MI</td>
</tr>
<tr>
<td><img src="image12" alt="III-INFERIOR POSTERIOR MI" /></td>
<td>III-INFERIOR POSTERIOR MI</td>
</tr>
<tr>
<td><img src="image13" alt="III-INFERIOR MI" /></td>
<td>III-INFERIOR MI</td>
</tr>
<tr>
<td><img src="image14" alt="III-INFERIOR MI" /></td>
<td>III-INFERIOR MI</td>
</tr>
<tr>
<td><img src="image15" alt="II - INFERIOR POSTERIOR MI" /></td>
<td>II - INFERIOR POSTERIOR MI</td>
</tr>
</tbody>
</table>
Reciprocal S-T Segment Depression *may* or *may not* be present during STEMI.
Reciprocal S-T Segment Depression *may* or *may not* be present during STEMI.

The presence of S-T Depression on an EKG which exhibits significant S-T elevation is a fairly reliable indicator that STEMI is the diagnosis.
Reciprocal S-T Segment Depression *may* or *may not* be present during STEMI.

The presence of S-T Depression on an EKG which exhibits significant S-T elevation is a fairly reliable indicator that STEMI is the diagnosis.

However the *lack of Reciprocal S-T Depression* DOES NOT rule out STEMI.
ACUTE MI

COMPLICATIONS TO ANTICIPATE FOR ALL MI PATIENTS:

- LETHAL DYSRHYTHMIAS
- CARDIAC ARREST
- FAILURE OF STRUCTURE(S) SERVED BY THE BLOCKED ARTERY
STEMI

- Correlation of ECG Leads with Coronary Arterial Anatomy and the STRUCTURES SERVED by the OCCLUDED ARTERY . . . .
• Correlation of ECG Leads with Coronary Arterial Anatomy and the STRUCTURES SERVED by the OCCLUDED ARTERY . . . .

. . . . . Will serve as a “crystal ball,” allowing you to ANTICIPATE complications of STEMI . . . .
STEMI

• Correlation of ECG Leads with Coronary Arterial Anatomy and the STRUCTURES SERVED by the OCCLUDED ARTERY . . . . .

. . . . . Will serve as a “crystal ball,” allowing you to ANTICIPATE complications of STEMI . . . . .

. . . . . . BEFORE they occur !!
"Having knowledge of common coronary artery anatomy is the . . . .

to understanding the PHYSIOLOGICAL CHANGES that occur during ACUTE MI."

“an INVALUABLE ASSET for ALL MEDICAL PROFESSIONALS who provide direct care to STEMI patients !"
INTERPRET THE EKG, THEN:

1. IDENTIFY THE AREA OF THE HEART WITH A PROBLEM . . .
2. RECALL THE ARTERY WHICH SERVES THAT REGION . . .
3. RECALL OTHER STRUCTURES SERVED BY THAT ARTERY . . .
4. ANTICIPATE FAILURE OF THOSE STRUCTURES . . .
5. **INTERVENTE APPROPRIATELY!**
3 STEMI Case Studies, excerpts from “12 Lead ECG Interpretation in ACS with Case Studies from the Cardiac Cath Lab.”
CASE STUDY 1 - STEMI

CHIEF COMPLAINT and SIGNIFICANT HISTORY:
72 y/o male, c/o CHEST "HEAVINESS," started 20 minutes before calling 911. Pain is "8" on 1-10 scale, also c/o mild shortness of breath. Has had same pain "intermittently" x 2 weeks.

RISK FACTOR PROFILE:
- FAMILY HISTORY - father died of MI at age 77
- FORMER CIGARETTE SMOKER - smoked for 30 year - quit 27 years ago
- DIABETES - oral meds and diet controlled
- HIGH CHOLESTEROL - controlled with STATIN meds
- AGE: OVER 65

PHYSICAL EXAM: Patient calm, alert, oriented X 4, skin cool, dry, pale. No JVD, Lungs clear bilaterally. Heart sounds normal S1, S2. No peripheral edema.

VITAL SIGNS: BP: 100/64, P: 75, R: 20, SAO2: 94%

LABS: FIRST TROPONIN: 6.4
72 yr Male Caucasian
Vent. rate 75 BPM
PR interval 162 ms
QRS duration 98 ms
QT/QTc 382/426 ms
P–R–T axes 72 13 83

EVALUATE EKG for indicators of ACS:
- ST SEGMENT ELEVATION / DEPRESSION
- HYPERACUTE T WAVES
- CONVEX ST SEGMENTS
- OTHER ST SEGMENT / T WAVE ABNORMALITIES
Normal sinus rhythm

Anteroseptal infarct, possibly acute
************************ ACUTE MI ********
Abnormal ECG

ST SEGMENT ELEVATION

LATERAL - ANTERIOR

DIAG. (LAD) or OM (CIRC).

BASILAR SEPTUM

ANTERIOR - SEPTAL

LAD

ANTERIOR

LAD

INFERIOR

DOMINANT RCA or CIRC.

LATERAL - ANTERIOR

DIAG. (LAD) or OM (CIRC).

ANTERIOR - SEPTAL

LAD

LATERAL

CIRC. or LAD

INFERIOR

DOMINANT RCA or CIRC.

INFERIOR

DOMINANT RCA or CIRC.

ANTERIOR

LAD

LATERAL

CIRC. or LAD
Note: There is NO Reciprocal ST Depression on this STEMI ECG!
Male
Caucasian
PR interval 166 ms
QRS duration 98 ms
QT/QTc: 382/426 ms
P–R–T axes 72 13 83
Normal sinus rhythm
Anteroseptal infarct, possibly acute
** **** * ACUTE MI ** *** ***
Abnormal ECG

ST SEGMENT ELEVATION

V1 - V4 VIEW THE ANTERIOR-SEPTAL WALL
of the LEFT VENTRICLE

V1, V2 - ANTERIOR / SEPTAL
V3, V4 - ANTERIOR
Normal sinus rhythm

Arteroseptal infarct, possibly acute

* * * * * * * * ACUTE MI * * * * * *

Abnormal ECG

**ST SEGMENT ELEVATION**

**V1 - V4 VIEW THE ANTERIOR-SEPTAL WALL of the LEFT VENTRICLE**

V1, V2 - ANTERIOR / SEPTAL
V3, V4 - ANTERIOR

**OCCLUSION of MID-LEFT ANTERIOR DESCENDING ARTERY**

LEFT MAIN CORONARY ARTERY
AV NODE
CIRCUMFLEX ARTERY
LEFT ANTERIOR DESCENDING ARTERY
LV
RBB
LBB
AREA OF INFARCT

ANTERIOR VIEW
OCCLUSION of MID-LEFT ANTERIOR DESCENDING ARTERY

LEFT MAIN CORONARY ARTERY

AV NODE

LBB

LV

CIRCUMFLEX ARTERY

LEFT ANTERIOR DESCENDING ARTERY

AREA OF INFARCT

RV

ANTERIOR VIEW
A blockage of the LAD can result in LV pump failure -- cardiogenic shock, pulmonary edema.
LEFT ANTERIOR DESCENDING ARTERY (LAD)

- ANTERIOR WALL OF LEFT VENTRICLE
  - 35 - 45% OF LEFT VENTRICLE MUSCLE MASS
- SEPTUM, ANTERIOR 2/3
  - BUNDLE BRANCHES
- ANTERIOR-MEDIAL PAPILLARY MUSCLE
<table>
<thead>
<tr>
<th>Complication</th>
<th>Possible Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Arrest</td>
<td>BCLS / ACLS</td>
</tr>
<tr>
<td>Cardiac Dysrhythmias (VT / VF)</td>
<td>ACLS (antiarrhythmics)</td>
</tr>
</tbody>
</table>
| Pump Failure with Cardiogenic Shock | Inotrope Therapy:  
- Dopamine / Dobutamine / Levophed  
- Intra-Aortic Balloon Pump  
(use caution with fluid challenges due to Pulmonary Edema) |
| Pulmonary Edema | CPAP  
| ET Intubation  
(use caution with diuretics due to pump failure and hypotension) |
| 3rd Degree Heart Block - Not Responsive to Atropine | Transcutaneous or Transvenous Pacing |
CASE STUDY 3: STEMI

CHIEF COMPLAINT and SIGNIFICANT HISTORY:
29 y/o male presents to the ER c/o "HEAVY CHEST PRESSURE" x 30 minutes. The patient states he was playing football with friends after eating a large meal. Pt. also c/o nausea. Denies DIB.

RISK FACTOR PROFILE:
- FAMILY HISTORY - father died of MI age 46
- CURRENT CIGARETTE SMOKER
- "MILD" HYPERTENSION - untreated
- CHOLESTEROL - unknown - "never had it checked."

PHYSICAL EXAM: Patient alert, oriented X 4, skin cool, dry, pale. Patient restless. No JVD, Lungs clear bilaterally. Heart sounds normal S1, S2. No peripheral edema.

VITAL SIGNS: BP: 104/78, P: 76, R: 20, SAO2: 96%

LABS: INITIAL CARDIAC MARKERS - NEGATIVE
EVALUATE the EKG for signs of ACS:
- ST SEGMENT ELEVATION / DEPRESSION
- HYPERACUTE T WAVES
- CONVEX / FLAT ST SEGMENTS
- OTHER ST - T WAVE ABNORMALITIES
29 yr
Male
Caucasian

Vent. rate 75 BPM
PR interval 176 ms
QRS duration 90 ms
QT/QTc 362/404 ms
P–R–T axes 70 50 −11

Normal sinus rhythm
Septal infarct, possibly acute
Anterolateral injury pattern
*** *** *** ACUTE MI *** *** ***
Abnormal ECG
- Reciprocal ST Depression is NOW PRESENT
- Additional ST Elevation is present in Leads I, AVL
OCCLUSION of PROXIMAL LEFT ANTERIOR DESCENDING ARTERY

- LEFT MAIN CORONARY ARTERY
- AV NODE
- CIRCUMFLEX ARTERY
- LEFT ANTERIOR DESCENDING ARTERY
- AREA OF INFARCT
- LBB
- RV
- LV
- RBB

ANTERIOR VIEW
ANTICIPATED COMPLICATIONS of ANTERIOR-SEPTAL WALL STEMI & POSSIBLE INDICATED INTERVENTIONS:

<table>
<thead>
<tr>
<th>Complication</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARDIAC ARREST</td>
<td>BCLS / ACLS</td>
</tr>
<tr>
<td>CARDIAC DYSRHYTHMIAS (VT / VF)</td>
<td>ACLS (antiarrhythmics)</td>
</tr>
<tr>
<td>PUMP FAILURE with CARDIOGENIC SHOCK</td>
<td>INOTROPE THERAPY:</td>
</tr>
<tr>
<td></td>
<td>- DOPAMINE / DOBUTAMINE / LEVOPHED</td>
</tr>
<tr>
<td></td>
<td>- INTRA-AORTIC BALLOON PUMP</td>
</tr>
<tr>
<td></td>
<td>(use caution with fluid challenges due to PULMONARY EDEMA)</td>
</tr>
<tr>
<td>PULMONARY EDEMA</td>
<td>CPAP</td>
</tr>
<tr>
<td></td>
<td>ET INTUBATION</td>
</tr>
<tr>
<td></td>
<td>(use caution with diuretics due to pump failure and hypotension)</td>
</tr>
<tr>
<td>3rd DEGREE HEART BLOCK - NOT RESPONSIVE TO ATROPINE</td>
<td>TRANSCUTANEOUS or TRANSVENOUS PACING</td>
</tr>
</tbody>
</table>
PROXIMAL OCCLUSION of the LEFT ANTERIOR DESCENDING Artery

POST PTCA and STENT to the PROXIMAL LAD
CASE STUDY 7 - STEMI

CHIEF COMPLAINT and SIGNIFICANT HISTORY:
46 yr. old MALE arrives in ER, C/O SUDDEN ONSET OF CHEST PRESSURE 45 MINUTES AGO. PAIN IS CONSTANT, PRESSURE-LIKE, AND NOT EFFECTED BY POSITION, MOVEMENT or DEEP INSPIRATION. ALSO C/O D.I.B.

RISK FACTOR PROFILE:
-yellow CURRENT CIGARETTE SMOKER x 18 YEARS
-yellow HYPERTENSION
-yellow HIGH LDL CHOLESTEROL

PHYSICAL EXAM: Patient is alert & oriented x 4, skin warm, dry, color normal. Non-anxious Lungs clear, normal S1, S2. No JVD, No ankle edema.

VITAL SIGNS: BP: 136/88  P: 88  R: 20  SAO2: 100% on 4 LPM O2

LABS: TROPONIN: < .04
EVALUATE EKG for indicators of ACS:
- ST SEGMENT ELEVATION / DEPRESSION
- HYPERACUTE T WAVES
- CONVEX ST SEGMENTS
- OTHER ST SEGMENT / T WAVE ABNORMALITIES
46 yr Male Caucasian

- Vent. rate: 82 BPM
- PR interval: 168 ms
- QRS duration: 96 ms
- QT/QTc: 384/448 ms
- P-R-T axes: 76 81 88

**Normal sinus rhythm**

- ST elevation consider inferior injury or acute infarct
- ******* ACUTE MI *******
- Abnormal ECG

**ST SEGMENT ELEVATION**

**ST SEGMENT DEPRESSION**
正常窦性心律

ST段抬高考虑下壁损伤或急性梗死

突起ST段的急性心肌梗死

异常ECG

图中显示了心脏的不同区域和相应的ECG波形，包括前壁、基底、及下壁。

前壁心肌梗死：对应EKG I、II、aVF

基底心肌梗死：对应EKG II、III、aVF

下壁心肌梗死：对应EKG II、III、aVF

图中还指出了右冠状动脉（RCA）的流通情况（75-80%的流通率）或周缘前向分支（10-15%的流通率）。

图例中还有一些参数，如心率、PR间期、QT/QTc间期等。
RIGHT DOMINANT

75 - 80% POPULATION

LV

RV

POSTERIOR VIEW
HELPFUL HINT... MEMORIZE THIS!

RIGHT CORONARY ARTERY (RCA)  

- RIGHT ATRIUM
- SINUS NODE (55% of the population)
- RIGHT VENTRICLE - 100% of muscle mass
- LEFT VENTRICLE: 15-25% of muscle mass
  - INFERIOR WALL
  - approx. 1/2 of POSTERIOR WALL
- AV NODE
<table>
<thead>
<tr>
<th>Complication</th>
<th>Intervention/Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CARDIAC ARREST</strong></td>
<td>BCLS / ACLS</td>
</tr>
<tr>
<td><strong>CARDIAC DYSRHYTHMIAS (VT / VF)</strong></td>
<td>ACLS (antiarrhythmics)</td>
</tr>
<tr>
<td><strong>SINUS BRADYCARDIA</strong></td>
<td>ATROPINE 0.5mg, REPEAT as needed UP TO 3mg. (follow ACLS and/or UNIT protocols)</td>
</tr>
<tr>
<td><strong>HEART BLOCKS (1st, 2nd &amp; 3rd Degree HB)</strong></td>
<td>ATROPINE 0.5mg, REPEAT as needed UP TO 3mg, Transcutaneous Pacing, (follow ACLS and/or UNIT protocols)</td>
</tr>
</tbody>
</table>
| **RIGHT VENTRICULAR MYOCARDIAL INFARCTION** | - The standard 12 Lead ECG does NOT view the Right Ventricle.  
- You must do a RIGHT-SIDED ECG to see if RV MI is present.  
- Do NOT give any Inferior Wall STEMI patient NITRATES or DIURETICS until RV MI has been RULED OUT. |
| **POSTERIOR WALL INFARCTION**        | - POSTERIOR WALL MI presents on the 12 Lead ECG as ST DEPRESSION in Leads V1 - V3.  
- POSTERIOR WALL MI is NOT PRESENT ON THIS ECG. |
A standard 12 LEAD EKG Does NOT show the RIGHT VENTRICLE
To see the right ventricle...

...such as in cases of inferior wall M.I.

☞ You must do a right-sided EKG!!
V4R - V6R VIEW THE RIGHT VENTRICLE

RV
LV
SPINE
ANTERIOR CHEST WALL

38 Yrs MALE
VENT. RATE: 68
P-R INT.: 160 ms
QRS: 100 ms
NORMAL SINUS RHYTHM
Normal EKG
Very Healthy Athletic EKG!

RUPPERT, WAYNE
ID: 7445683659
05-OCT-2006
JOHNS-HOPKINS UNIV.
Right Ventricular Infarct

V LEADS R SIDE

**INDICATOR**  
1. S-T DEPRESSION IN THE V-LEADS (PREDOMINANTLY V1 - V3)  → POSTERIOR WALL MI  
2. S-T ELEVATION IN LEADS V5, V6, LEAD I, AND AVL  → LATERAL WALL MI  
3. S-T ELEVATION IN LEADS V3r - V6r  → R. VENTRICULAR MI
ANTICIPATED COMPLICATIONS of INFERIOR - RIGHT VENTRICULAR WALL STEMI secondary to PROXIMAL RCA Occlusion & POSSIBLE INDICATED INTERVENTIONS:

<table>
<thead>
<tr>
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<th>Intervention</th>
</tr>
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<tr>
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<td>ATROPINE 0.5mg, REPEAT as needed UP TO 3mg,</td>
</tr>
<tr>
<td></td>
<td>Transcutaneous Pacing, (follow ACLS and/or UNIT</td>
</tr>
<tr>
<td></td>
<td>protocols)</td>
</tr>
<tr>
<td>RIGHT VENTRICULAR MYOCARDIAL INFARCTION</td>
<td>- NITRATES and DIURETICS are CONTRA-INDBLED.</td>
</tr>
<tr>
<td></td>
<td>- TREAT HYPOTENSION WITH FLUIDS. (It is</td>
</tr>
<tr>
<td></td>
<td>Not uncommon to give 500-2000ml of NORMAL</td>
</tr>
<tr>
<td></td>
<td>SALINE to stabilize BP.</td>
</tr>
<tr>
<td>POSTERIOR WALL INFARCTION</td>
<td>- POSTERIOR WALL MI presents on the 12</td>
</tr>
<tr>
<td></td>
<td>Lead ECG as ST DEPRESSION in Leads V1 - V3.</td>
</tr>
<tr>
<td></td>
<td>- POSTERIOR WALL MI is NOT PRESENT ON THIS ECG.</td>
</tr>
</tbody>
</table>
If this patient becomes HYPOTENSIVE . . . . . .
MI with HYPOTENSION ?

WET LUNG SOUNDS ??

NO

RIGHT VENTRICULAR MI ?

YES

POSTERIOR / LATERAL INVOLVEMENT ?

NO

IV FLUIDS !

YES

- INOTROPES
- CONSIDER ET INTUBATION
- CONSIDER I.A.B.P.

- FLUID CHALLENGE
- INOTROPES
- CONSIDER I.A.B.P.
PROXIMAL OCCLUSION of the RIGHT CORONARY ARTERY.
Helpful STEMI ECG Resources


Abnormal ST Elevation Criteria: ACC/AHA 2009
“Standardization and Interpretation of the ECG, Part VI Acute Ischemia and Infarction,” Galen Wagner, et al

ECG in STEMI – excellent powerpoint – quick reference, in-depth material
Helpful STEMI ECG Resources

Download Non-ED STEMI Protocol - example

Download STEMI Alert ED Physicians Order Set
<table>
<thead>
<tr>
<th>ECG Leads:</th>
<th>Associated Region:</th>
<th>Coronary Artery:</th>
<th>Structures at Risk:</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Patients</td>
<td>V1 - V4</td>
<td>Anterior and Septal walls of LV</td>
<td>- 35 - 45% of LV muscle mass</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Bundle of HIS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Bundle Branches</td>
</tr>
<tr>
<td>RCA Dominant</td>
<td>V5 - V6</td>
<td>Lateral wall LV, approx. 50% Posterior wall</td>
<td>- 20 - 30% LV muscle mass</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Sinus Node (rare)</td>
</tr>
<tr>
<td></td>
<td>II, III, AVF</td>
<td>Inferior Wall, approx. 50% Posterior wall</td>
<td>- SA Node</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Right Ventricle</td>
</tr>
<tr>
<td></td>
<td>V5 - V6 + II, III, AVF</td>
<td>Lateral wall of LV Posterior Wall (all)</td>
<td>- AV Node</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inferior Wall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cx Dominant</td>
<td></td>
<td></td>
<td>- 45-55% LV muscle mass</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- SA Node (rare)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- AV Node</td>
</tr>
</tbody>
</table>
Evolving STEMI:
- ST segments drop
- Q waves form
- R wave progression changes

In precordial leads.

Q Wave Rules - Summary:
- Q waves should be less than 0.40 wide (1 mm)
- Q waves should be less than 1/3 the height of the R wave
- Q waves can be any size in leads III and AVR
- There should be no Q waves in leads V1, V2, or V3
The NORMAL ECG

ASSESSING AXIS ROTATION

NORMAL

R - WAVE PROGRESSION

V1  V2  V3  V4  V5  V6

R wave amplitude (size) gradually increases from V1 through V6 . . . .
In V3 or V4, the QRS complex becomes Biphasic.
Anterior Wall necrosis ("old MI") is a common cause of "Poor R Wave Progression".

<table>
<thead>
<tr>
<th>LATE TRANSITION - COMMON CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIGHT</td>
</tr>
<tr>
<td>V1</td>
</tr>
<tr>
<td>V5</td>
</tr>
</tbody>
</table>

- LEFT BUNDLE BRANCH BLOCK
- OLD ANTERIOR WALL M.I.
- LEFT VENTRICULAR HYPERTROPHY
- WOLFF-PARKINSON-WHITE SYNDROME
  (R. ATRIUM - R. VENTRICLE BYPASS TRACT)
2. OLD ANTERIOR WALL M.I.
- Q waves in V1, V2, V3 and/or V4
- other causes of LATE TRANSITION ruled out
ACUTE ANTERIOR WALL STEMI

EKG #1 UPON ARRIVAL IN E.D. - CHEST PAIN x 40 MINUTES

April 6, 2009 01:14 HOURS

49 yr Male Caucasian
Vent. rate 91 BPM
PR interval 172 ms
QRS duration 86 ms
QT/QTc 350/430 ms
P–R–T axes 41 17 −15

Normal sinus rhythm
Left atrial enlargement
Cannot rule out Inferior infarct, new
Anterior injury pattern

***** Acute MI *****

NOTE:
1. NO Q WAVES IN V1 - V4
2. TRANSITION IS BETWEEN V2 AND V3

EKG TAKEN UPON ARRIVAL IN EMERGENCY DEPARTMENT.
- CHEST PAIN x 40 MINUTES
- ST ELEVATION V1 - V4

TRANSITION BETWEEN V2 - V3
EKG #4 APPROXIMATELY 19 HOURS FROM ONSET OF SYMPTOMS APRIL 6, 2009 19:36 HOURS

49 yr Male Caucasian
Vent. rate PR interval QRS duration QT/QTc P-R-T axes
86 BPM 174 ms 78 ms 360/430 ms

Normal sinus rhythm
Anterior infarct, possibly acute
Lateral injury pattern

** **** ** ACUTE MI **** **

NOTE: 1. Q WAVES IN LEADS V2 - V5
2. ST ELEVATION NOW IN V5
3. TRANSITION HAS SHIFTED TO V6
4. ST ELEVATION IN ANTERIOR LEADS RESOLVING

TRANSITION V6
**FULLY EVOLVED ANTERIOR WALL MI**

### POST - INFARCTION EKG

<table>
<thead>
<tr>
<th>50 yr</th>
<th>Vent. rate</th>
<th>57 BPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>PR interval</td>
<td>216 ms</td>
</tr>
<tr>
<td>Caucasian</td>
<td>QRS duration</td>
<td>96 ms</td>
</tr>
<tr>
<td>Room:</td>
<td>QT/QTc</td>
<td>392/381 ms</td>
</tr>
<tr>
<td>Loc:</td>
<td>P–R–T axes</td>
<td>40 58 –120</td>
</tr>
</tbody>
</table>

- Sinus bradycardia with 1st degree A–V block
- Anterolateral infarct
- T wave abnormality, consider inferior ischemia
- Abnormal ECG

**NOTE:**
1. QS COMPLEXES NOW SEEN IN V1 - V4
2. TRANSITION NOW BETWEEN V5 and V6
3. ST ELEVATION RESOLVED

**DIAGRAM:**

- Leads I, aVR, V1, V4
- Leads II, aVL, V2, V5
- Leads III, aVF, V3, V6

**TRANSITION BETWEEN V5 - V6**
ISCHEMIA

HELPFUL PATTERNS . . .

J POINT DEPRESSION
( > 1 mm )

INVERTED T WAVES

J POINT DEPRESSION
+ INVERTED T WAVES
<table>
<thead>
<tr>
<th>Condition</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverted T Wave</td>
<td>- Myocarditis</td>
</tr>
<tr>
<td></td>
<td>- Electrolyte Imbalance</td>
</tr>
<tr>
<td></td>
<td>- Ischemia</td>
</tr>
<tr>
<td>Sharp S-T Angle</td>
<td>- Acute MI (Not Common)</td>
</tr>
<tr>
<td></td>
<td>- Ischemia</td>
</tr>
<tr>
<td>Bi-Phasic T Wave (Wellen's)</td>
<td>- Sub-Total LAD Lesion</td>
</tr>
<tr>
<td></td>
<td>- Vasospasm</td>
</tr>
<tr>
<td></td>
<td>- Hypertrophy</td>
</tr>
<tr>
<td>Depressed J Point with Upsloping ST</td>
<td>- Ischemia</td>
</tr>
<tr>
<td>Downsloping S-T Segment</td>
<td>- Ischemia</td>
</tr>
</tbody>
</table>
Some less common, less reliable possible indicators of ACS:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat S-T Segment &gt; 120 ms</td>
<td>ISCHEMIA</td>
</tr>
<tr>
<td>Low Voltage T Wave With Normal QRS</td>
<td>ISCHEMIA</td>
</tr>
<tr>
<td>U Wave Polarity Opposite That of T Wave</td>
<td>ISCHEMIA</td>
</tr>
</tbody>
</table>
1. ECG abnormality(ies)?
2. Possible diagnosis?
3. Action / Intervention?
1. ECG abnormality(ies)? ST Elevation Leads I, AVR AVL, V1, V2, V3, V4, V5 & V6. ST Depression II, III and AVF

2. Possible diagnosis? Acute Anterolateral Wall STEMI secondary to Left Main Coronary Artery occlusion (widow-maker MI).

3. Action / Intervention? STAT CATH LAB vs STAT Thrombolytics. Prepare for Cardiac Arrest
1. ECG abnormality(ies)?
2. Possible diagnosis?
3. Action / Intervention?
1. ECG abnormality(ies)?  ST Depression V1-V4
2. Possible diagnosis?  Anterior ischemia vs. Posterior wall STEMI
3. Action / Intervention?  Posterior ECG (V7-V9)
1. ECG abnormality(ies)?
2. Possible diagnosis?
3. Action / Intervention?

- ST SEGMENT ELEVATION / DEPRESSION
- HYPERACUTE T WAVES
- CONVEX ST SEGMENTS
- OTHER ST SEGMENT / T WAVE ABNORMALITIES
1. ECG abnormality(ies)? ST Elevation, Leads II, III & AVF
2. Possible diagnosis? Inferior Wall STEMI
3. Action / Intervention? 1. Do R-sided ECG, prepare for Atropine administration, external pacing, cardiac arrest, STAT cath lab visit!
What leads show signs of possible ACS?
12 Lead ECG shows ISCHEMIC CHANGES Lateral Wall:
1. ECG abnormality(ies)?
2. Possible diagnosis?
3. Action / Intervention?
1. ECG abnormality(ies)? ST Elevation Lead AVR, Global ST Depression (I, II, III, AVL, AVF, V2, V3, V4, V5, V6)
2. Possible diagnosis? possible LMCA or 3x vessel disease.
3. Action / Intervention? Troponins, Continuous ST monitoring, cath lab visit STAT or ASAP (based on sympt.)
1. ECG abnormality(ies)?
2. Possible diagnosis?
3. Action / Intervention?
1. ECG abnormality(ies)? Inferior (II, III, AVF) ST Depr (ischemia?), I & AVL T wave inversion, V5 ST Depr
2. Possible diagnosis? Inferior / Lateral ischemia
3. Action / Intervention? Serial ECGs / Troponins, additional diagnostic testing, cath lab
Once an appropriate testing method is developed to validate ECG interpretation competency, it may be possible that this course, or others that are similar, can be a route to credential nurses to “interpret” Serial ECGs.
Your thoughts, ideas, comments and feedback are welcome . . .
Author’s correspondence information:

Wayne W Ruppert
Wayneruppert@bayfronthealth.com
Office: 352-521-1544
“NOWHERE”, NEW MEXICO, 1994