ECG Ischemic Changes

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ECG Ischemic Changes

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• Old MI
• Ischemia with
  – Bundle branch block
  – Paced rhythm
  – Lt ventricular hypertrophy
ECG Ischemic Changes

Introduction
The three major coronary arteries that supply blood to the heart.

**Location of MI**
Location of MI
Localizing myocardial ischemia, injury or infarction using the 12-lead ECG.
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<td>$V_1$ to $V_4$</td>
<td>$I$, $aVL$, $II$, $III$, $aVF$</td>
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<td>Septal</td>
<td>$V_1$, $V_2$</td>
<td>$I$, $aVL$</td>
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<td>Inferior</td>
<td>$II$, $III$, $aVF$</td>
<td>$I$, $aVL$, $V_1$ to $V_4$</td>
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<td>Posterior</td>
<td>None</td>
<td>$V_1$ to $V_4$</td>
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<td>Lateral</td>
<td>$I$, $aVL$, $V_5$, $V_6$</td>
<td>$II$, $III$, $aVF$, $V_1$, $V_2$</td>
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<tr>
<td>RV</td>
<td>$V_3$ R to $V_6$R</td>
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Right Leads

V1R is same as standard V2,
V2R is the same as standard V1,
V3R is halfway between V2R
V4R, V4R is fifth intercostals space at right midclavicular line,
V5R is same level as V4R in right anterior axillary line
V6R is same level in right midaxillary line
Posterior Leads

V7, posterior axillary line;

V8, posterior scapular line;

V9, left border of spine.

All in the same horizontal plane of V4 to V6
ECG Ischemic Changes

STEMI
Zones of ischemia

Indicative changes of ischemia, injury, and necrosis seen in leads facing the injured area.

Reciprocal changes often seen in leads not directly facing the involved area.
ST segment shape

dome shaped

plateau shaped

obliquely elevated.

dome shaped
ECG patterns associated with acute myocardial injury

- ST elevation 1 mm or more
- ST segment pulled up to peak of T wave
- Tall, peaked T waves
- Symmetrical T inversion

Straightening of the ST segment that slopes up to the peak of the T wave without spending any time on the baseline
Evolution of STEMI

Normal

lead III
Evolution of ST segment elevation

0713: normal concave upward
0726: straight
0739: convex
0756: more ST elevation, confirming
Evolution of STEMI

earliest phase, tall positive (hyperacute) T waves are seen in leads V2 to V5. Hours later, marked ST elevation & abnormal Q is present in the same leads.
Evolution of T-wave inversion

- **A** Terminal T-wave inversion
  - Pattern A

- **B** Later Terminal T-wave inversion
  - Pattern A

- **C** Later still

- **D** Later: Symmetric T-wave inversion
  - Pattern B
Pseudonormalization of inverted T waves.
Evolution of STEMI

Acute phase ST elevations and new Q waves

Evolving phase: deep T wave inversions

Resolving phase: partial or complete regression of ST-T changes

Reciprocal ST-T changes in the inferior leads (II, III, and aVF).
Four examples of hyperacute T waves

- **A**
  - T wave is very large compared with QRS

- **B**
  - depressed ST segment take-off and straightening of the ST segment

- **C**
  - wide and bulky, much larger than QRS.

- **D**
  - This less common form is very peaked and tented T wave
Anterior STE with QS waves and terminal T-wave inversion. QS waves suggest prolonged occlusion and deep T-wave inversion suggests (late)
Hyperacute T waves & ST elevation
Proximal LAD occlusion
STE (inferior, anterior, lateral)
Wellens syndrome

This patient's chest pain had resolved recently and he now has subtle biphasic terminal T-wave inversion in lead V2.
Early (LAD) occlusion.
• diffuse STD in inferior and lateral leads
• STE in V1.
• straightening of ST segments in leads V2 and V3, with slightly large T waves.
High STE in V1–V4 with upwardly concave ST segments, but also STE in lead aVL with reciprocal depression in inferior leads.
LAD occlusion manifesting as tall T waves that tower over a tiny R wave (V3)
STEMI

- (hyperacute) T waves
- slight ST segment elevations
- reciprocal ST depression in leads II, III, and aVF.
34-year-old male. What's going on here

ECG shows classic findings of acute/hyperacute anterior MI with reciprocal inferior ST depressions.
STE MI

ST Acute ST elevation inferior wall infarction
Hyperacute T & ST elevations localized in the anterior leads.
ECG Ischemic Changes

Ischemia & Rt or Lt bundle Branch Block (RBBB & LBBB)
BBB & Ischemia
• The ECG shows a prolonged PR with (RBBB).
• The wide notched R waves (RSR' equivalent) in V1-V3 are due to the RBBB.
• The rather prominent initial R wave in V2-V3 due to posterior MI on the RBBB.
Q waves and ST elevations in I and aVL

reciprocal ST depressions in II, III, and aVF.
Prominent Q in the Lt chest leads as part of QR complexes

ST elevations in the left chest leads or in other leads with prominent R waves as in lead V5

ST segment depressions in the rt leads

T wave inversions in leads V1 to V3 as in previous slide
Elderly female presented to the emergency ward with shortness of breath

Sinus bradycardia, inverted T waves suggesting that a "primary" or ischemic process is evolving in the inferior distribution + LBBB
RBBB with AMI

STE (leads V2–V6, I, and aVL)
reciprocal STD(leads II, III, and aVF)
Concordant STE and upright T waves in leads I, aVL, V5, and V6. Concordant reciprocal STD in the inferior leads II, III, and aVF.
T wave inversions in leads V1 to V3

STEMI & LBBB

LBBB + ischemia
58-year-old man with chest pain

Acute anteroseptal MI & RBBB.
AMI and LBBB
concordant ST-segment elevation in leads V3, V4, V5, and aVf.
Excessive discordant ST-segment elevation in lead III
AMI and LBBB pattern
excessive discordant ST-segment elevation in leads V2, V3, V4
concordant ST-segment elevation in Lead V5
Lateral Myocardial Infarction

- circumflex artery occlusion
- indicative changes in leads I, aVL, and sometimes V5–6
- reciprocal changes in inferior or anterior leads.
- Lateral wall MI does not often occur alone but commonly accompanies anterior MI
Lateral Myocardial Infarction

STE is 0.5 mm in leads I and aVL
STE is 0.5 mm in leads I and aVL    STD in leads II, III, and aVF
There is left anterior fascicular block
Acute anterolateral wall MI.
ST elevation is present in I, aVL, and V2–V6.
Reciprocal ST depression is present in III, aVF, and aVR.
Inferior MI

• is usually due to occlusion of the right coronary artery and is diagnosed by indicative changes in leads II, III, and aVF.

• Reciprocal changes are often seen in leads I, aVL, or the V leads.

• In people with left dominant coronary circulation, the circumflex artery supplies the inferior surface of the heart and circumflex occlusion is the cause of inferior MI.

• Lead III can have a Q wave normally

• Approximately 40% of inferior MIs involve the right ventricle
Elderly female presented to the emergency ward with shortness of breath

Sinus bradycardia, inverted T waves suggesting that a "primary" or ischemic process is evolving in the inferior distribution + LBBB
Acute right ventricular MI. ST elevation is present in II, III, aVF, and V1; reciprocal ST depression in all other leads
Posterior MI

due to right coronary artery occlusion or to circumflex occlusion in left-dominant circulation and usually occurs in conjunction with inferior MI.

12-lead ECG there are no leads that face the posterior wall, and, therefore, no indicative changes are recorded.

reciprocal changes in the anterior leads, especially V1 and V2, but often all the way to V4.

taller R wave than normal V1 and V2

ST-segment depression

upright, tall T waves

confirmed by recording posterior leads and observing ST elevation
STD in V2 and V3 diagnostic of posterior STEMI
STE in lead III is >STE in lead II
Acute posterior wall MI.
• first degree AV block, RBBB, inferior and possibly posterior (MI).
• The prominent initial R waves in V2 and V3 in this due to associated posterior MI and/or the RBBB alone.
• T waves are upright in leads V2 and V3, whereas uncomplicated RBBB should produce secondary T wave inversions in leads.
Posterior Leads

V7, posterior axillary line;

V8, posterior scapular line;

V9, left border of spine.

All in the same horizontal plane of V4 to V6
Posterior wall MI.

Large R waves and ST depression in V1 and V2.
Notice the tall R waves
Right ventricular MI (RVMI) occurs in up to 45% of inferior MI.

- ST-segment elevation in V1 as well, because V1 is the chest lead that is closest to the right ventricle.
- ST-segment elevation in V1 together with ST-segment elevation in the inferior leads is suspect for RVMI.
- Another clue is discordance between the ST segment in V1 and the ST segment in V2.
- Discordance means that the ST segments do not point in the same direction—V1 shows ST-segment elevation, whereas V2 is either normal or shows ST-segment depression.
- Leads V3R through V6R develop ST-segment elevation when acute RVMI is present.
- Lead V4R is the most sensitive and specific lead for recognition of RVMI.
Right Leads

V1R is same as standard V2,

V2R is the same as standard V1,

V3R is halfway between V2R and V4R,

V4R, V4R is fifth intercostal space at right midclavicular line,

V5R is same level as V4R in right anterior axillary line,

V6R is same level in right midaxillary line.
Right-sided chest leads in a patient with acute RVMI.

- ST elevation in leads V3R–6R.
- Standard V1 shows ST elevation while
- Standard V2 shows a normal ST segment (a form of “discordance”)

Right Ventricular MI
Acute right ventricular MI.

ST elevation is present in II, III, aVF, and V1; reciprocal ST depression in all other leads.
Right-sided leads reflecting RV involvement.
STE in the inferior leads (lead III > lead II),
Inferior & RV MI

- Inferior STE & reciprocal STD
- STE in lead V1 is typical for RV AMI
- Widespread STE
Acute infero-postero-lateral myocardial infarction
70-yr-old man presents with severe chest pain, nausea, vomiting and diaphoresis. Right-sided chest leads are shown (i.e., V1R to V6R).

- A. fib with subtle signs of acute inferior (MI) with ST elevations intermittently apparent in leads II, II and aVF.
- The right-sided chest leads show evidence of concomitant (RV) MI with slight ST elevations in leads V4R to V6R.
Tall R waves in V1-V2 in a 48-year-old man. These were due to...

Inferior-posterior myocardial infarction (MI).
Subendocardial ischemia

• The subendocardium is particularly vulnerable to ischemia because it is most distant from the coronary blood supply and closest to the high pressure of the ventricular cavity.
• ST segment depression is the most common ECG change
Familiar pattern of ischemia:

- T-wave inversion
- ST-segment depression of 0.5 mm or more
- ST segment that remains on the baseline longer than 0.12 second
- ST segment that forms a sharp angle with the upright T wave
- tall, wide-based T waves
- inverted U waves
subendocardial ischemia

ECG shows ST segment depression (except in lead aVR, which typically shows ST elevation).
NSTEMI

ST segment depression. Leads V1–V6 only.
ANGINA PECTORIS

ST depressions seen during an attack. When the pain disappears, the ST segments generally return to the baseline.
Subendocardial ischemia.

Marked, diffuse ST depressions in leads I, II, III, aV_L, aV_F, and V_2 to V_6.
ST elevation in lead aV_R.
NSTEMI
Prinzmetal's angina

• ST segment elevations are transient. After the episode of chest pain,
• ST segments usually return to the baseline, without the characteristic evolving pattern of Q waves and T wave inversions.
• it is a marker of coronary artery *spasm* that causes transient transmural ischemia.
The baseline resting ECG shows nonspecific inferior ST-T changes. With chest pain, marked ST segment elevations occur in leads II, III, and aVF, and reciprocal changes. The ST segments return to baseline after the patient is given nitroglycerin. Cardiac catheterization showed severe RCA obstruction with intermittent spasm producing total occlusion and transient ST elevations.

Prinzmetal's angina
ECG Ischemic Changes

Ventricular Paced Rhythm
Right VPR with AMI.

Excessive, discordant ST-segment elevation.

Concordant ST-segment depression in lead V1, V2, or V3.
Right VPR with appropriate ST-segment and T-wave locations and configurations.
Right VPR with AMI.
concordant ST-elevation in leads II, III, and aVf
excessive, discordant ST elevation leads V3 and V4
A 68-year-old man with dyspnea. What does the ECG show?

Ventricular paced rhythm with underlying complete heart block (P waves march through).

Hyperacute ST-T changes inferiorly and laterally with reciprocal change V1-V3 consistent with acute infero-postero-lateral MI
>5 mm ST segment elevation in right precordial or inferior leads, and especially ST depressions/T wave inversions in leads with QS or rS complexes, are highly suggestive of ischemia.

Why is this patient with a dual chamber pacemaker & presyncopal inferior (MI). elevated J point and convex ST segment elevations inferiorly, with reciprocal changes in I, aVL, and V2.
ECG Ischemic Changes

Left Ventricular Hypertrophy pattern & Ischemia
ECG in LVH

absence of ST-segment and T-wave changes

Predominantly positive QRS complexes with ST-depression and T-wave inversion

Predominantly negative QRS complexes with ST-segment elevation and upright T wave.
Ischemia & LVH

LVH pattern with progressive abnormality demonstrating increasing ST-segment elevation and changing morphology of elevated ST segment
12-lead ECG with left ventricular hypertrophy pattern. Note absence of ST-segment and T-wave changes.
ST-segment elevation in leads V2 and V3 with obliquely straight form of ST segment, anterior AMI.

12-lead ECG with left ventricular hypertrophy pattern
ECG Ischemic Changes

Old Ischemia
Q waves

• Not all Q waves are indicators of MI.
• Q wave is normally seen in lead aVR.
• Small “septal” q waves are normally seen in the left chest leads (V4 to V6) and in one or more of leads I, aVL, II, III, and aVF.
Q waves

Q wave is generally abnormal if its duration is 0.04 second or more in

- lead I
- all three inferior leads (II, III, aVF)
- leads V3 to V6.

- Lead V2: any Q wave
- Lead V3: almost any Q wave

- A Q wave of depth >25% of R wave height is often quoted as diagnostic, but width is more important than depth
Early acute anterior wall MI. R wave progression in V1–3

ST elevation with tall wide-based T waves in V2–4.
Early acute inferior wall MI
Old Lateral wall infarction & RBBB.
Thank You