ECG Recognition of Myocardial Ischemia & Infarction

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Objectives

- To detect myocardial ischemia & infarction on an electrocardiogram
- To define the areas of the heart to which the twelve standard ECG leads correspond
- To correlate coronary anatomy with areas of ischemia & infarction
Acute Myocardial Injury
Acute Myocardial Injury
Acute Myocardial Injury

NORMAL

FIXED CORONARY OBSTRUCTION
(Typical angina)

Platelet aggregate

Healing

PLAQUE DISRUPTION

SEVERE FIXED CORONARY OBSTRUCTION
(Chronic ischemic heart disease)

Thrombus

MURAL THROMBUS WITH VARIABLE OBSTRUCTION / ? EMBOLI
(Unstable angina or acute subendocardial myocardial infarction or sudden death)

OCCLUSIVE THROMBUS
(Acute transmural myocardial infarction or sudden death)

ACUTE CORONARY SYNDROMES
EKG Basics

The electrocardiogram (ECG): the *electrical activity* of the heart recorded at the body surface.
ECG Basics

Anatomy of the heart: positioning in chest

- Superior vena cava
- SA node
- Interatrial septum
- AV node
- Common bundle (His)
- Tricuspid valve
- Mitral valve (bicuspid)
- Purkinje fibers
- Bundle branches
- Interventricular septum
Coronary Anatomy
There are *two* coronary arteries which supply the heart with blood.
Coronary Anatomy
LCA

Figure 4: Schematic diagram of the left coronary artery viewed from a right anterior oblique orientation.

Figure 5: Schematic diagram of the left coronary artery viewed from a left anterior oblique orientation.
Coronary Anatomy

The *LEFT* coronary artery has 2 major branches:

- **Left Anterior Descending (LAD)** - supplies *Anterior wall* of the ventricles & septum
- **Circumflex branch** - supplies *Lateral wall* of the left ventricle & atrium
Coronary Anatomy

RCA

Figure 6: Schematic diagram of the right coronary artery viewed from a right anterior oblique orientation.

Figure 7: Schematic diagram of the right coronary artery viewed from a left anterior oblique orientation.
Coronary Anatomy
RIGHT coronary artery (RCA)

The RCA supplies:

- Right atrium
- SA & AV nodes
- Posterior regions of ventricles
Coronary Anatomy

RCA

- Sinoatrial node
- Right coronary artery
- Right ventricular
- Acute marginal
- Posterior descending
- Posterior lateral
- 1st septal
- Left main
- Left circumflex
- Intermediate (ramus intermedius)
- Obtuse marginal
- Left anterior descending
EKG Basics

- The EKG – essentially a voltmeter.
- Measures voltage - electrical potential - between two points.
- Records this voltage over time.
EKG Basics

- The EKG – 12 voltmeters.
- Upward deflections move towards the (+) electrode.
- Downward deflections move toward the (-) electrode.
EKG Basics

- Chest Leads
- Exploring leads (V1 – V6) are (+)
- Reference lead (-) is Wilson’s Central Terminus
EKG Basics

- The EKG: electrical activity of atria and ventricles
- Depolarization and repolarization
EKG Basics

The EKG: Standardized grid
- small box
  - 40 mSec
  - 100 uV
- Large box
  - 200 mSec
  - 500 uV

The time intervals indicated for the thick and thin vertical grid lines on the ECG.
**EKG - Leads and Electrode Positioning**

The standard EKG is composed of 12 Leads

Six *limb* leads: I, II, III, aVR, aVL, aVF

Six *chest* leads: V1, V2, V3, V4, V5, V6
EKG - Leads and Electrode Positioning

For a STANDARD RESTING 12 LEAD
Extremity leads placed:
Beyond the tip of the clavicles (arm leads)
Beyond the inguinal ligament (leg leads)

Monitoring lead placement – more centrally on torso (Mason- Likar lead positions)
EKG - Leads and Electrode Positioning

Chest Leads: V1 – V6

Palpate chest to locate landmarks

Small lead position changes can lead to changes in interpretation.
EKG - Leads and Electrode Positioning

Chest Leads: V1 – V6

V1 – 4\(^{th}\) IC space, R of sternum
V2 – 4\(^{th}\) IC space, L of sternum
V3 – between V2 and V4
V4 – 5\(^{th}\) IC space, Mid clav line
V5 - Lat to V4, Anterior Ax line
V6 – Lat to V4 and V5, Mid Ax
On a standard EKG mounting, the six chest leads and six limb leads are typically arrayed in columns:
<table>
<thead>
<tr>
<th>Area of Infarction</th>
<th>Leads Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior wall</td>
<td>V1, V2, V3, V4</td>
</tr>
<tr>
<td>*Anteroseptal</td>
<td>V1, V2</td>
</tr>
<tr>
<td>Lateral wall</td>
<td>I, AVL, V5, V6</td>
</tr>
<tr>
<td>Inferior wall</td>
<td>II, III, AVF</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>V4 R</td>
</tr>
<tr>
<td>Posterior wall</td>
<td>V7, V8, V9 +</td>
</tr>
<tr>
<td></td>
<td>Tall R &amp; ST ↓ V1, V2</td>
</tr>
</tbody>
</table>
Limb Leads

To obtain the 6 limb leads, electrodes are placed on the right arm, the left arm & the left leg forming a triangle.
Bipolar Limb Leads

Leads I, II, III are formed by a pair of electrodes.

Each records from a different perspective: going away from the (-), and lead toward (+) lead.
Bipolar Limb Leads

Leads I, II, III are formed by a *pair* of electrodes.

Figure 2.2. A. The equiangular (60-degree) Einthoven triangle formed by leads I, II, and III. B. The equiangular (60-degree) triangle formed by leads I, II, and III.
Bipolar Limb Leads

Leads I, II, III are formed by a pair of electrodes.
“Augmented” limb leads

- Are unipolar limb leads, stressing the importance of the (+) electrode

- **AVR** - *Right* arm positive
- **AVL** - *Left* arm positive
- **AVF** - *Foot* (left) positive
“Augmented Limb leads”
Frontal Plane leads
Limb Leads

- Leads I and AVL view the: *high lateral wall* of the heart

- Leads II, III & AVF view the: *inferior wall* of the heart
Limb Leads

- Lead AVR looks “away” from the heart

Therefore the “P”, “QRS” & “T waves” should be *inverted*

- If they are *upright* in AVR, then the electrodes are likely misplaced.
ECG - Chest Leads

Chest Leads: V1 – V6

Each lead gives a different perspective of the heart... sees the electrical activity from a slightly different view.
Figure 2.7: Figure 2.7 shows the orientation of the six precordial leads indicated by.

Chest leads
Chest Leads

The ECG tracing from V1-V6 shows gradual changes in all the waves as the position of each lead changes.
Right sided chest lead: V4 R

- Looks at right ventricle
- 5th ICS, Rt. midclavicular line
Left posterior leads: V7, V8, V9

- Look at the *posterior wall*

- V7 - 5th ICS, post axillary line
- V8 - 5th ICS, midscapular line
- V9 - 5th ICS, 2cm left of vert column
Myocardial Ischemia & Infarction
ECG: Ischemia / Injury

- Identify the most SEVERE abnormality – this is the ‘name’ injury:
  eg: Anterior STEMI

- Look for ‘RECIProCAL’ findings – typically ST depression or T wave inversion in the setting of ST elevation.
Myocardial Infarction
Problems with diagnosis

- History: symptoms & signs often vague
- Enzyme markers: take time to detect
- EKG: *non-*diagnostic in up to 60%
- 0.4 - 3% of patients are sent home with MI & up to 25% of these die!
Myocardial Infarction
Acute Injury Phase

- Isoelectric point: somewhere in T-P interval
- Measure ST elevation: J point + 60 mSec
Myocardial Infarction
Acute Injury Phase

- Initially see tall *peaked* T waves and ST segment elevation
Myocardial Infarction
Acute Injury Phase
Myocardial Infarction
Acute Injury Phase
Myocardial Infarction
Acute Injury Phase
Localization of MI

**Area of Infarction**

- Anterior wall
- *Anteroseptal*
- Lateral wall
- Inferior wall
- Right ventricle
- Posterior wall

**Leads Involved**

- V1, V2, V3, V4
- V1, V2
- I, AVL, V5, V6
- II, III, AVF
- V4 R
- V7, V8, V9 +
- Tall R & ST ↓ V1, V2
Myocardial Infarction
Acute Injury Phase
Myocardial Infarction
Acute Injury Phase
Posterior wall infarction

If an Anterior wall MI is manifested by Q waves & ST segment elevation

Then a Posterior wall MI will appear just the opposite (R waves & ST depression)
Posterior wall infarction

In acute posterior infarctions, there is a large R wave with ST depression in: V1, V2 and / or V3
Myocardial Infarction

Posterior wall MI

Note that the electrical activity of the anterior and posterior wall of the LV is in opposite directions.
ST Segment Elevation

Not as easy as it sounds
– Inconsistent interpretation
  - Interobserver and intraobserver
  - Up to 14% inconsistently classified

– Many reasons for STE
  - 29% of prehospital ECGs in CP pts have at least 100 uV of STE on 2 contiguous limb leads or 200 uV of STE on 2 contiguous precordial leads
  - But only 49% and 15% (limb/ precord) have AMI
  - Majority have LVH, LBBB, BER, or ventricular aneurysm
ST Segment Elevation

How often are we right/wrong in initiating reperfusion therapy?
- 11% of lytic patients did not have AMI
- 9 of 83 lytic treated pts – exposed to risk of Rx

If STE is minor, it is more difficult to definitively call, and leads to delay in Rx
- D2Drug < 30 min: ST Segment Sum 21.5 mm
- D2Drug > 30 min: ST Segment Sum 11.5
The ST Segment

- Myocardial Infarction/ Ischemia
- Ventricular aneurysm
- LVH
- LBBB
- Early repolarization/ normal variant
- Acute pericarditis
- Hyperkalemia
- Hypothermia
- Hypercalcemia
- Post cardioversion
Early Repolarization
Early Repolarization

- Usually mid-precordial leads
- Elevated J point (up to ~300 uV)
- ST usually concave
- Notching in downstroke of QRS
- Large symmetric T waves
- Relatively fixed pattern
Early Repolarization

- 1% of general population
- 13% of Chest Pain pts
- 23-48% of Cocaine CP pts
- All ages, races
- Mean age 39 yr (16-80)
- Rare in those > 70 (3%)
Early Repolarization

- Limb leads involved ~ 45% of cases
- “Isolated” BER in limb leads is VERY RARE

Think of other causes for STE
Early Repolarization
LBBB
LBBB

Discordant ST-Segments and T-Waves

Normal for LBBB and paced rhythm
LBBB + Injury

Sgarbosa’s Criteria
LBBB / Paced Rhythm

V1, V2, V3

≥ 5 mm
LBBB + Injury
LBBB + Injury

Concordant ST-elevation > 1 mm in leads II, V5 and V6
LBBB + Injury

Discordant ST-elevation > 0.2 the depth of the S-wave in leads III and aVF
LVH
Left Ventricular Hypertrophy

- A number of different ECG criteria proposed
- Vary in sensitivity and specificity
- Easiest: Sokolow – Lyon
  - $R_{aVL} > 1.1 \text{ mV or}$
  - $S_{V1} + (R_{V5} \text{ or } R_{V6}) > 3.5 \text{ mV}$
  - Sensitivity 10 – 35%; Specificity 85%
- Repolarization abnormalities increase the assoc with anatomic LVH
Standard LVH

Expected findings in LVH:

* STE discordant with QRS – panels A and B
* STD and T inversion discordant with QRS – panels C and D
LVH with STE - AMI
Practice EKG’s
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>55 yr</td>
</tr>
<tr>
<td>Vent. rate</td>
<td>83 BPM</td>
</tr>
<tr>
<td>PR interval</td>
<td>133 ms</td>
</tr>
<tr>
<td>QRS duration</td>
<td>104 ms</td>
</tr>
<tr>
<td>QT/QTe</td>
<td>371/436 ms</td>
</tr>
<tr>
<td>P–R–T axes</td>
<td>52 25  20</td>
</tr>
</tbody>
</table>

Referred by: ___________  Unconfirmed
12-Lead 1

HR 53 bpm
11:57:29
PR 0.160s
QRS 0.118s
0.408s/0.382s
66° 86° 55°

- Acute MI suspected
- Abnormal ECG unconfirmed
- Sinus bradycardia with sinus arrhythmia
- ST elevation consider anterolateral injury or acute infarct

ST elevation consider inferior injury or acute infarct
Questions??

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